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Xu et al.

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(54) **LOW-E MATCHABLE COATED ARTICLES HAVING ABSORBER FILM AND CORRESPONDING METHODS**

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(73) Assignee: **GUARDIAN GLASS, LLC**, Auburn Hills, MI (US)

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(51) **Int. Cl.**
B32B 15/04 (2006.01)
B32B 17/06 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***C03C 17/366*** (2013.01); ***B32B 17/06*** (2013.01); ***C03C 17/3618*** (2013.01); (Continued)

(58) **Field of Classification Search**
USPC 428/426, 428, 432, 434, 701, 702
See application file for complete search history.

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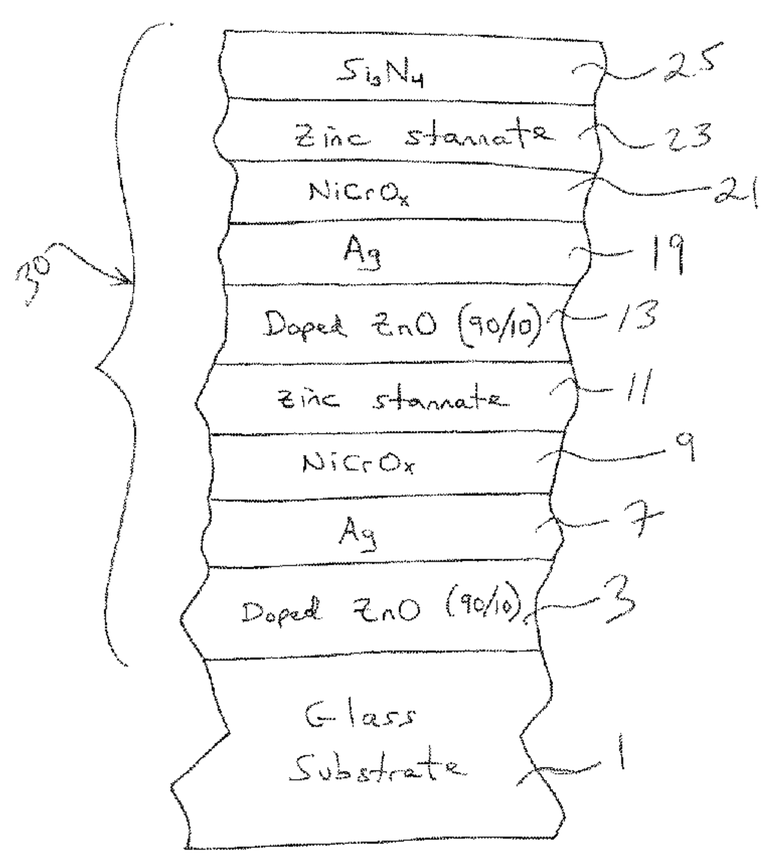
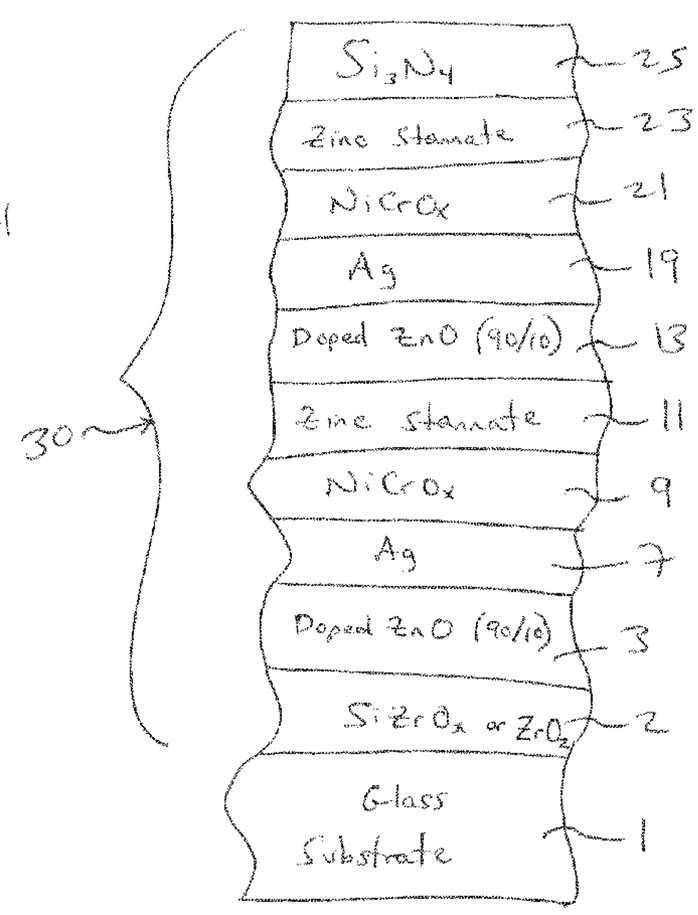
Primary Examiner — Lauren R Colgan

(57) **ABSTRACT**

A low-E coating has good color stability (a low ΔE* value) upon heat treatment (HT). Thermal stability may be improved by the provision of an as-deposited crystalline or substantially crystalline layer of or including zinc oxide, doped with at least one dopant (e.g., Sn), immediately under an infrared (IR) reflecting layer of or including silver; and/or by the provision of at least one dielectric layer of or including at least one of: (a) an oxide of silicon and zirconium, (b) an oxide of zirconium, and (c) an oxide of silicon. These have the effect of significantly improving the coating's thermal stability (i.e., lowering the ΔE* value). An absorber film may be designed to adjust visible transmission and provide desirable coloration, while maintaining durability and/or thermal stability.

52 Claims, 55 Drawing Sheets





Related U.S. Application Data

application No. 16/035,810, filed on Jul. 16, 2018, now Pat. No. 10,301,215.

(51) **Int. Cl.**

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C23C 14/08	(2006.01)

(52) **U.S. Cl.**

CPC ***C03C 17/3626*** (2013.01); ***C03C 17/3644*** (2013.01); ***C23C 14/0652*** (2013.01); ***C23C 14/083*** (2013.01); ***C23C 14/085*** (2013.01); ***C23C 14/086*** (2013.01); ***C23C 14/185*** (2013.01); ***C23C 14/34*** (2013.01); *B32B 2255/205* (2013.01); *B32B 2255/28* (2013.01); *B32B 2307/412* (2013.01); *B32B 2307/416* (2013.01); *B32B 2315/08* (2013.01); *B32B 2419/00* (2013.01); *C03C 2218/154* (2013.01)

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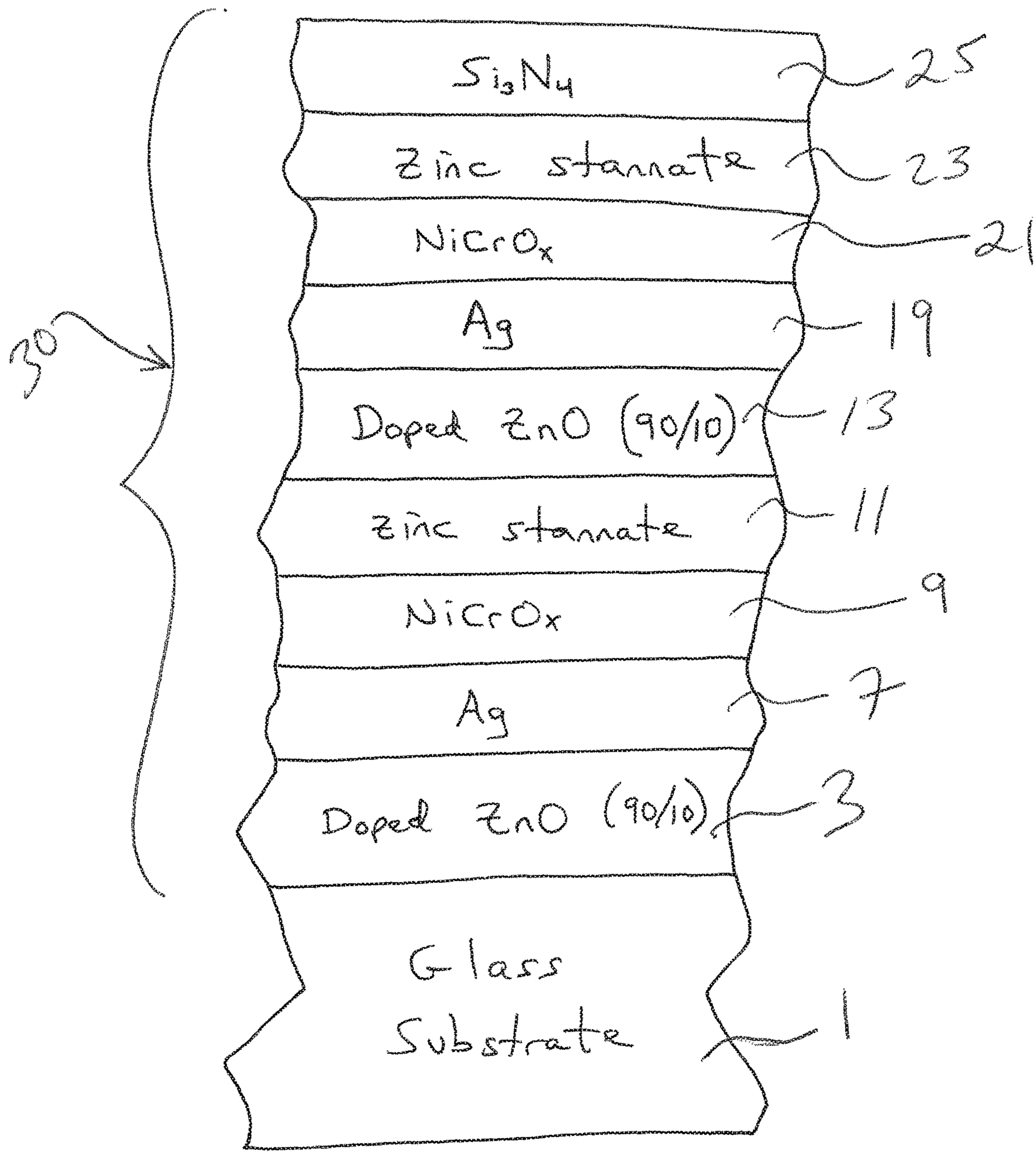
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Zinc stannate
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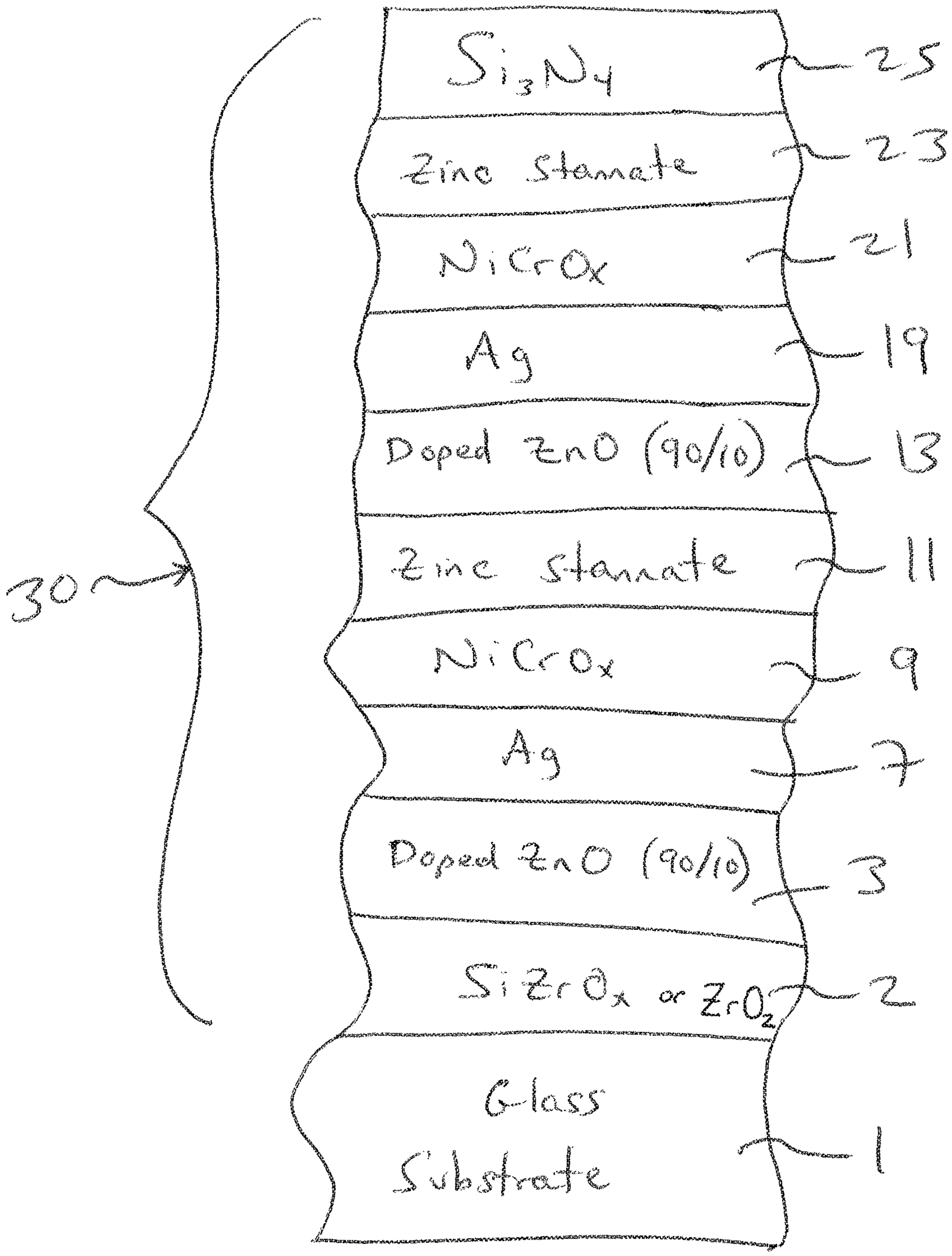
21
Ag
19
Doped ZnO (90/10)
13
zinc stannate
11
$NiCrO_x$
9
Ag
7
Doped ZnO (90/10)
3
Glass Substrate
1
30

Fig. 1(a)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Ag
19
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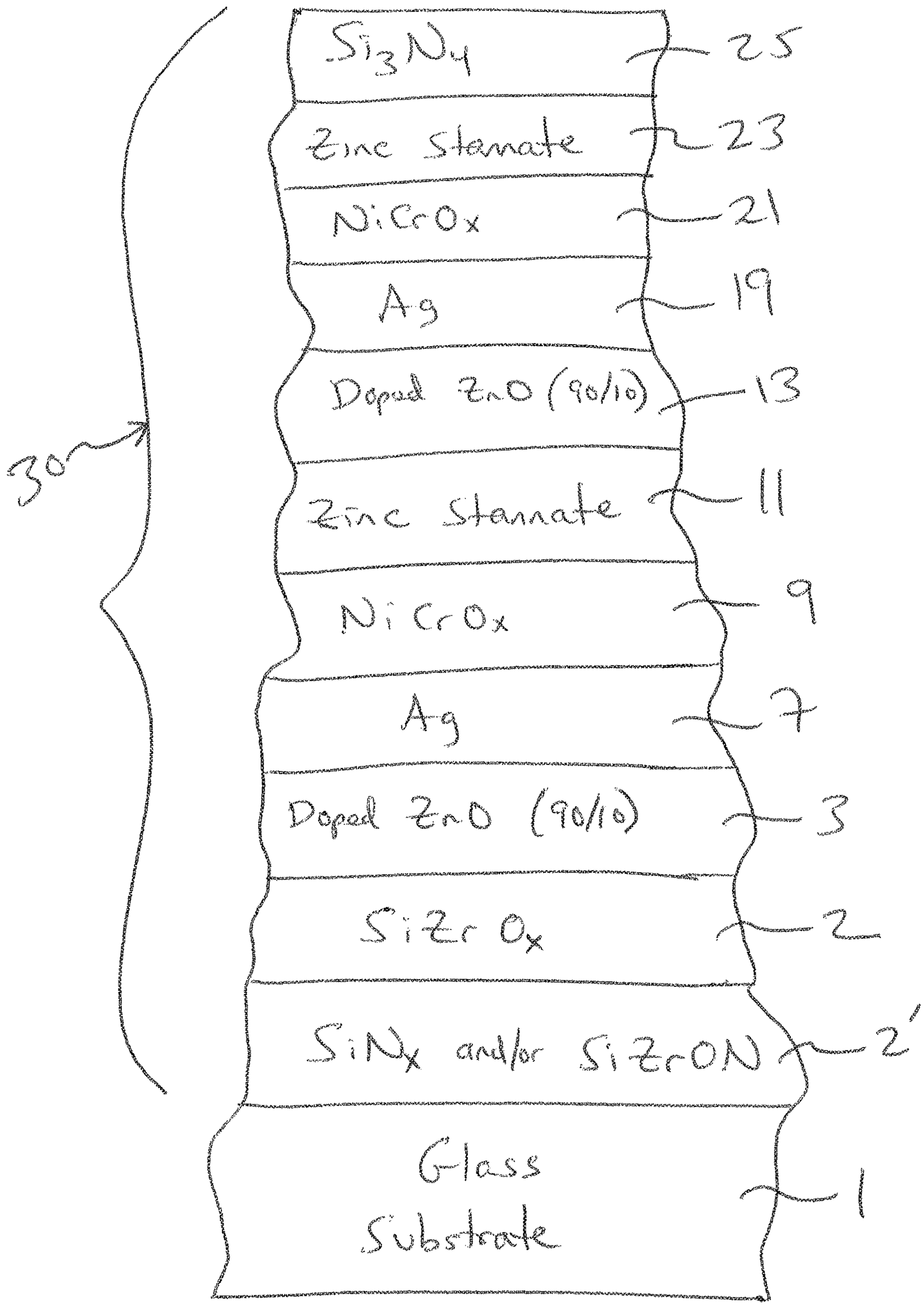
13
Zinc Stannate
11
NiCrOx
9
Ag
7
Doped ZnO (90/10)
3
SiZrOx or ZrO_2
2
Glass Substrate
1
30

Fig. 1(b)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Ag
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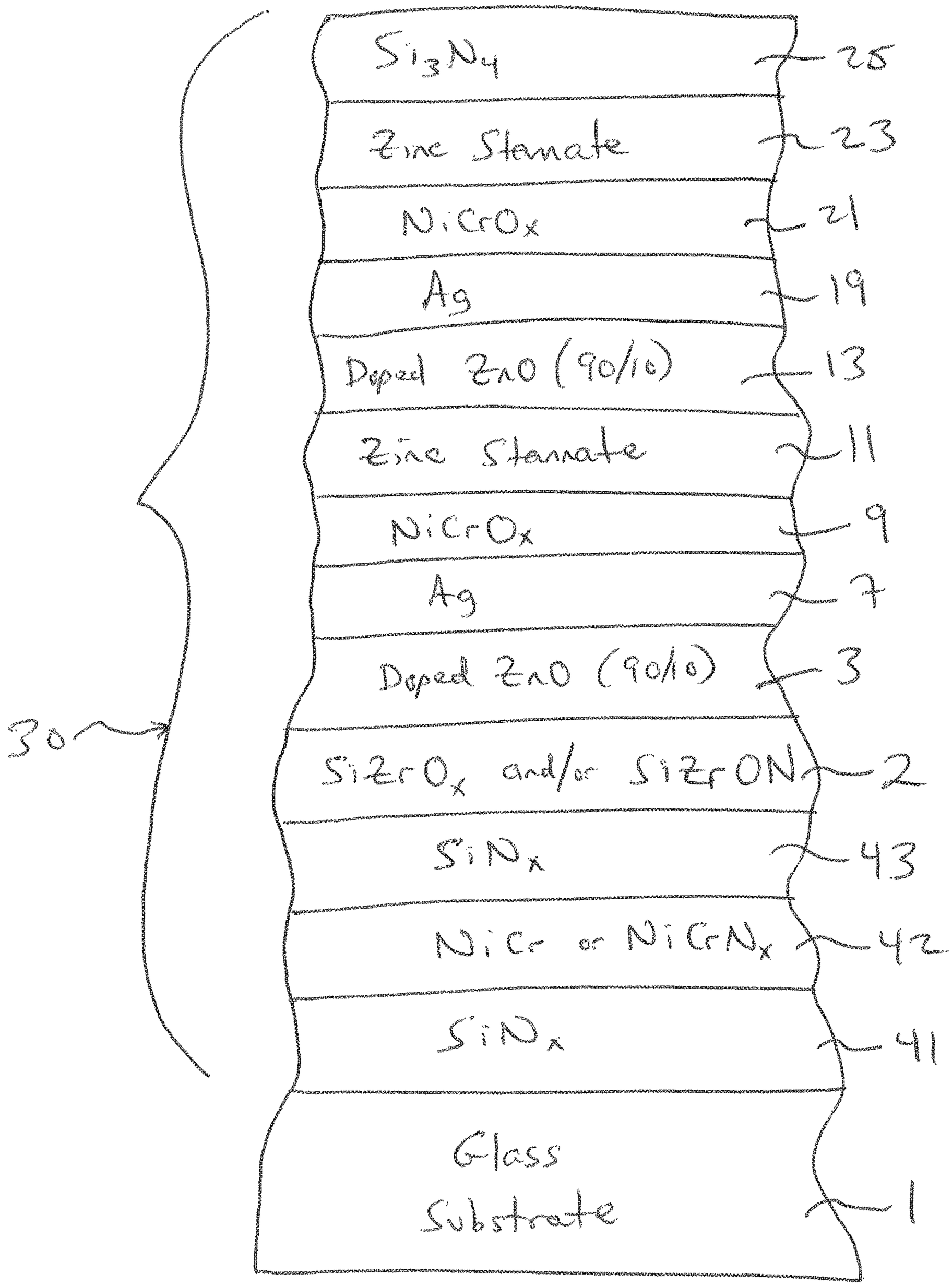
Doped ZnO (90/10)
13
30
Zinc Stannate
11
NiCrOx
9
Ag
7
Doped ZnO (90/10)
3
SiZrOx
2
SiNx and/or SiZrON
2'
Glass Substrate
1

Fig. 1(c)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Ag
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Zinc Stannate
11
NiCrOx
9
Ag
7
Doped ZnO (90/10)
3
30
SiZrOx and/or SiZrON
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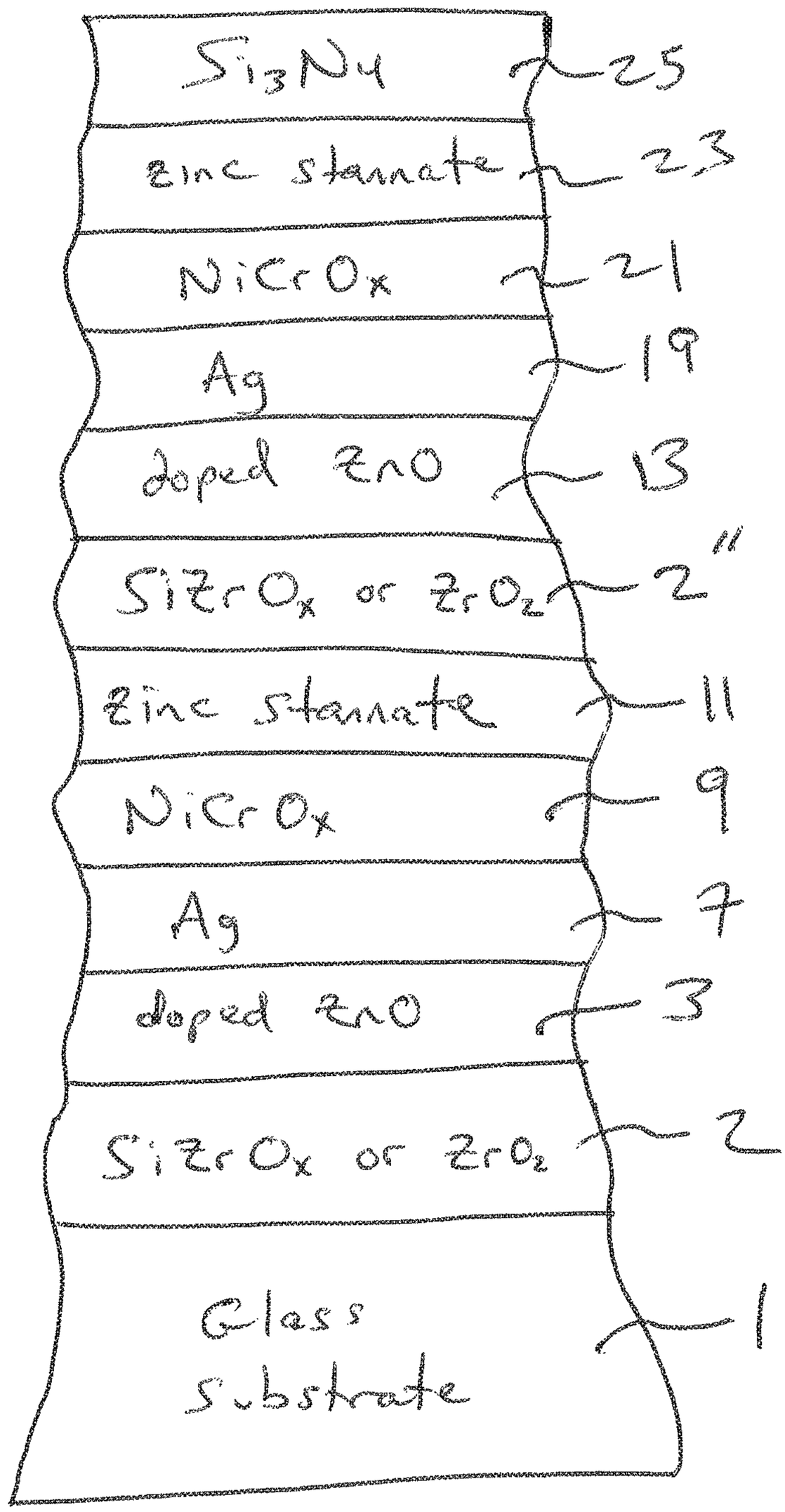
SiNx
43
NiCr or NiCrNx
42
SiNx
41
Glass Substrate
1

Fig. 1 (d)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doped ZnO
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SiZrOx or ZrO2
2"
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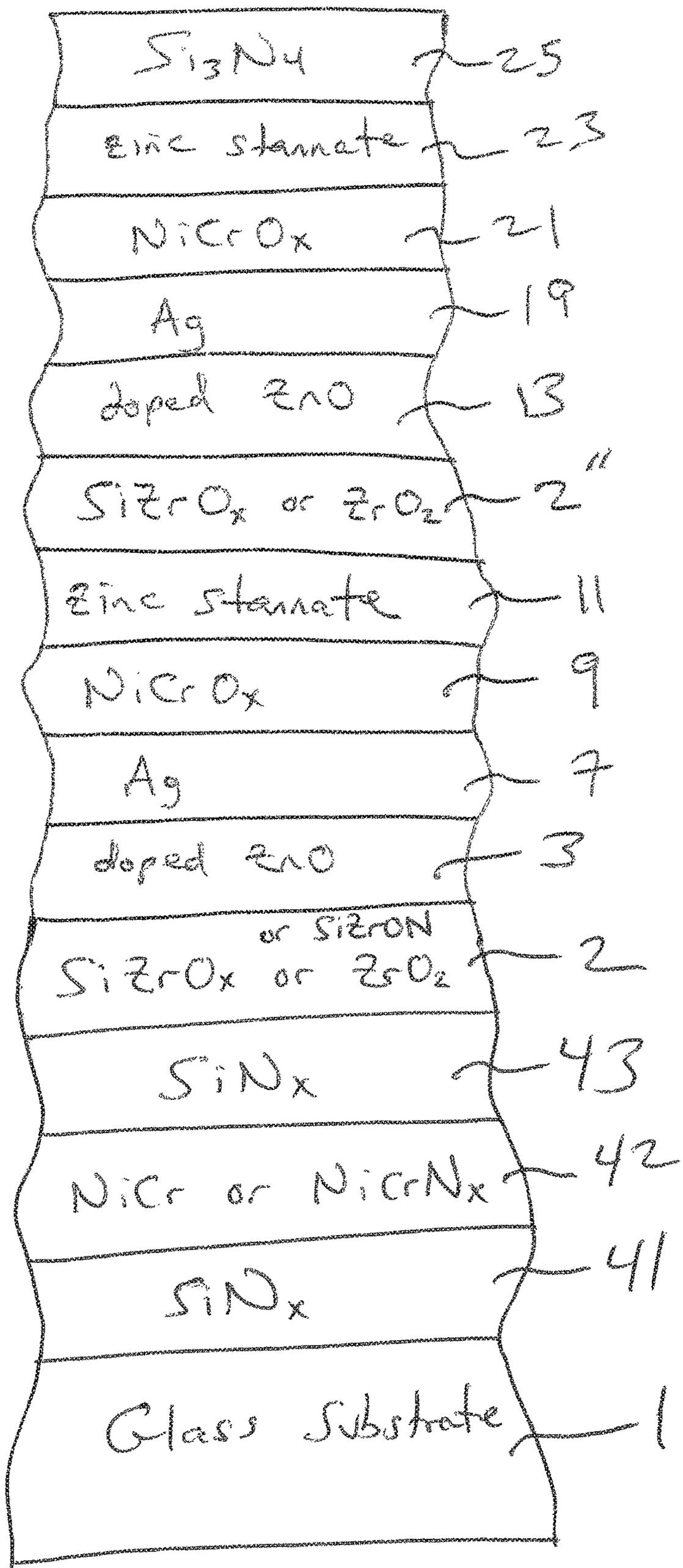
11
NiCrOx
9
Ag
7
doped ZnO
3
SiZrOx or ZrO2
2
Glass substrate
1

Fig. 1(e)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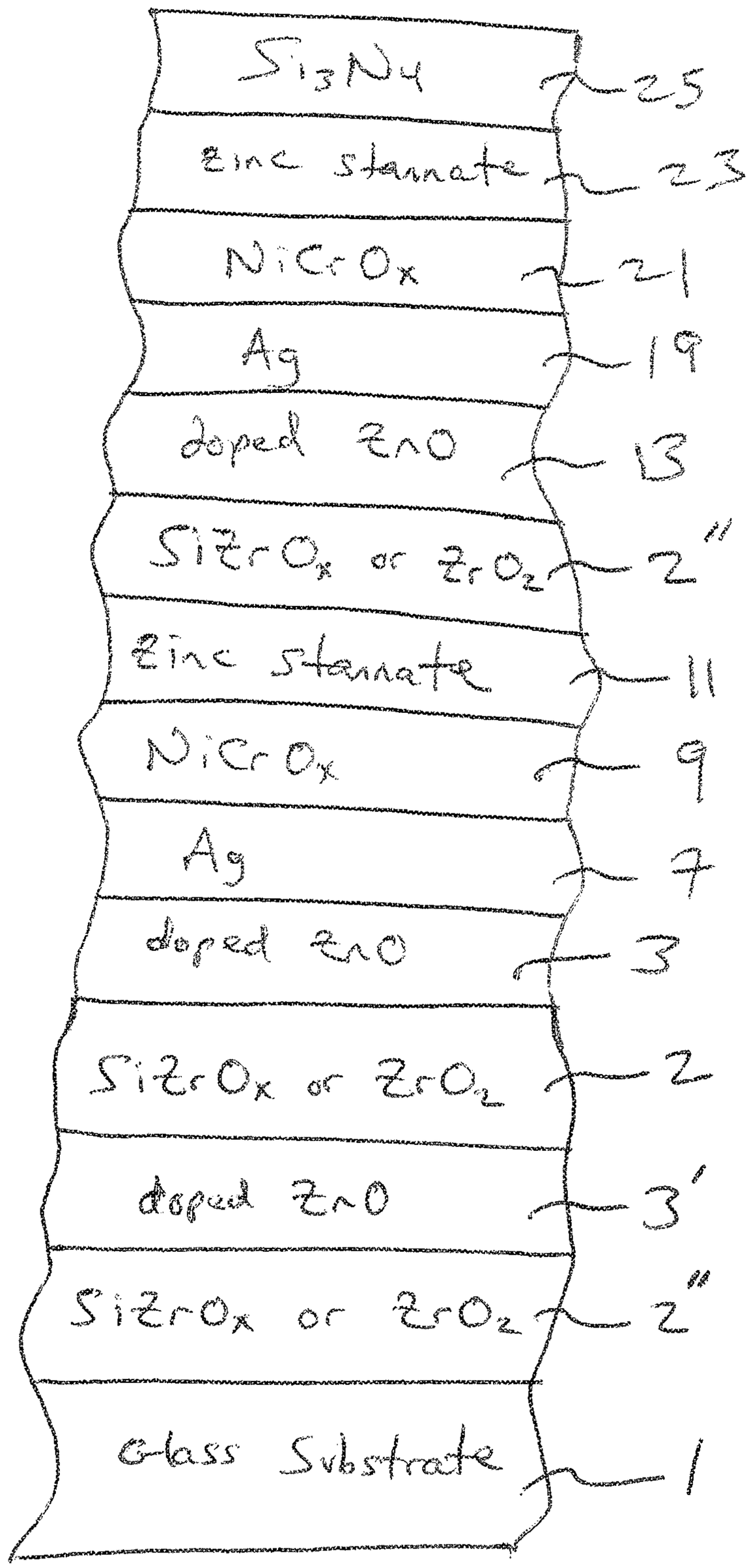
NiCrOx
21
Ag
19
doped ZnO
13
SiZrOx or ZrO2
2''
zinc stannate
11
NiCrOx
9
Ag
7
doped ZnO
3
or SiZrON
SiZrOx or ZrO2
2
SiNx
43
NiCr or NiCrNx
42
SiNx
41
Glass Substrate
1

Fig. 1(f)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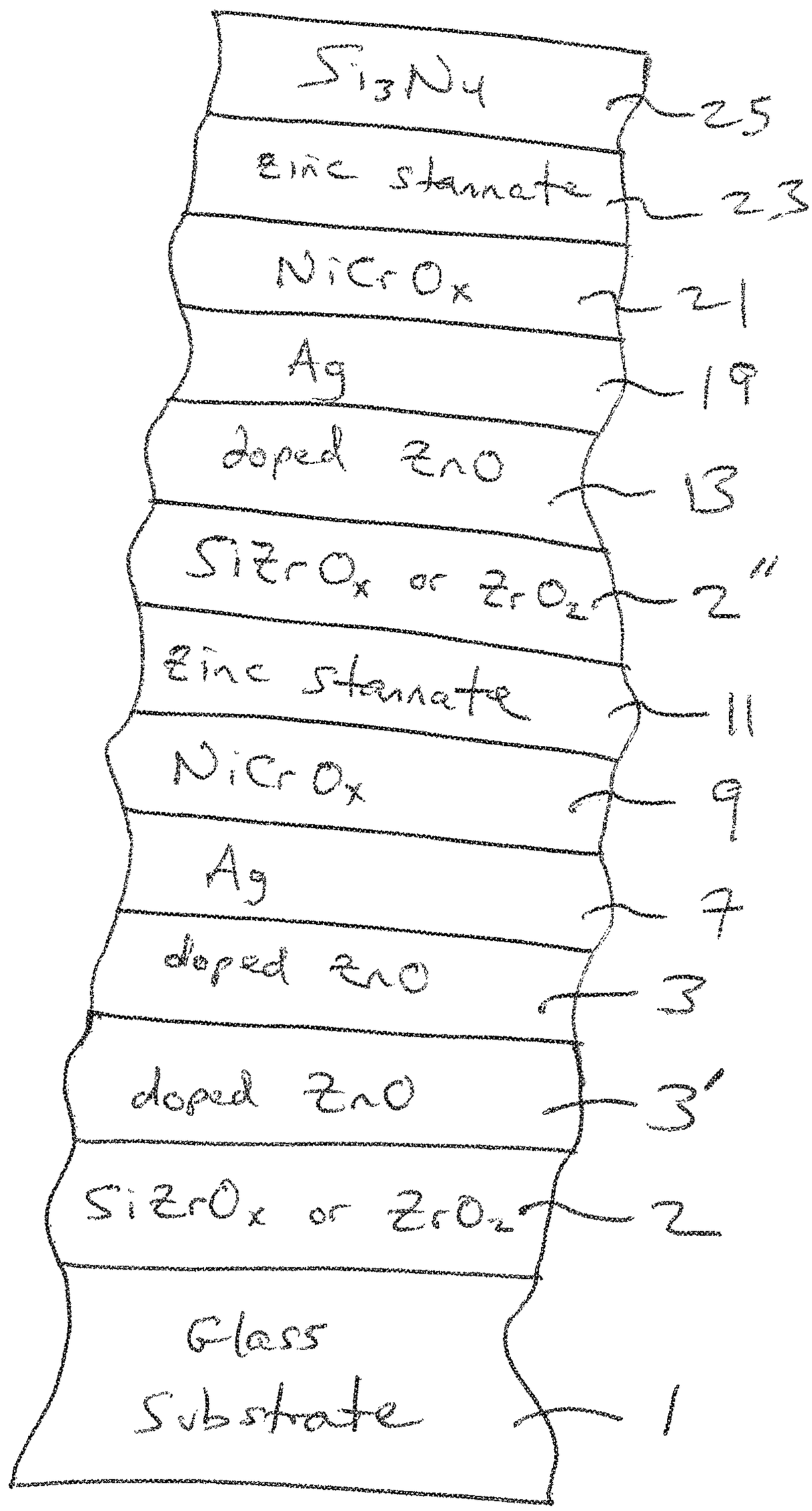
NiCrOx
21
Ag
19
doped ZnO
13
SiZrOx or ZrO2
2''
zinc stannate
11
NiCrOx
9
Ag
7
doped ZnO
3
SiZrOx or ZrO2
2
doped ZnO
3'
SiZrOx or ZrO2
2''
Glass Substrate
1

Fig. 1(9)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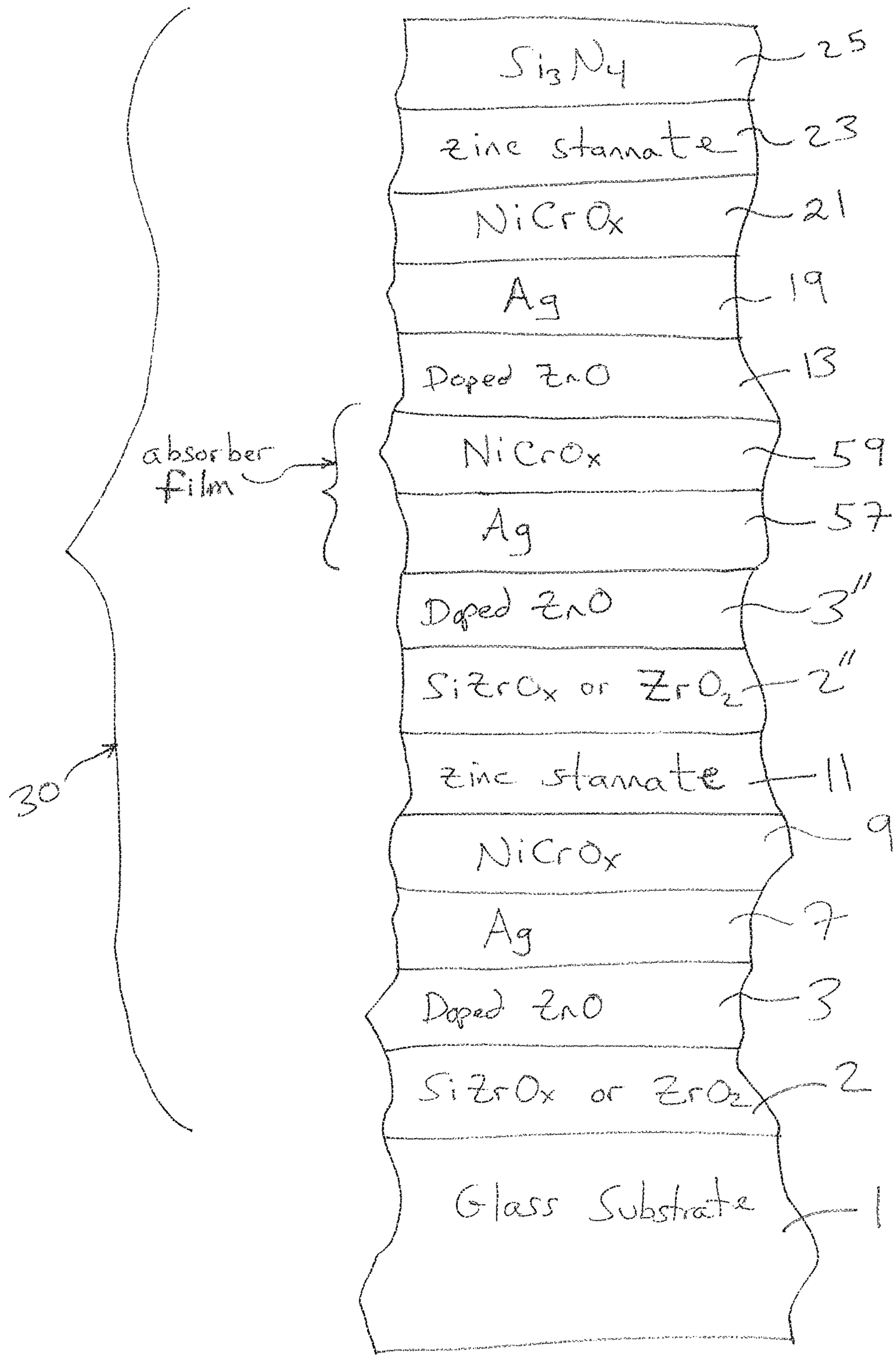
zinc stannate
23
NiCrOx
21
Ag
19
doped ZnO
13
SiZrOx or ZrO2
2''
zinc stannate
11
NiCrOx
9
Ag
7
doped ZnO
3
doped ZnO
3'
SiZrOx or ZrO2
2
Glass Substrate
1

Fig. 1(h)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23
NiCrOx
21
Ag
19
Doped ZnO
13
NiCrOx
59
Ag
57
Doped ZnO
3''
SiZrOx or ZrO_2
2''
zinc stannate
11
NiCrOx
9
Ag
7
Doped ZnO
3
SiZrOx or ZrO_2
2
Glass Substrate
1
absorber film
30

Fig. 1(i)

Example 1

	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-16	60	650	600	840	0	250		130		2.26	16	47.0
P2	Ag, C-8	7.89	429	700		0	0				6		15.1
	NiCr, C-10	16.4		150	66	0	66				6		4.1
	ZnSn, C-14	60	522	400	1200	0	250		130		0.88	22	73.6
P2 Rev	ZnSn90, C-16	60	650	600	840	0	250		130		6	16	17.7
P3	Ag, C-8	12.12	422	700	0	0	0				6		23.2
	NiCr, C-10	16.4		150	66	0	66				6		4.1
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	10.8
P4	SiAl, C-12	60	621	400	0	420		250		130	3.37	9	19.1

Fig. 2

Example 2

	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-16	60	650	600	840	0	250		130		2.26	16	47.0
P2	Ag, C-8	7.89	429	700		0	0				6		15.1
	NiCr, C-10	16.4	511/269mv	150	61	0	61				6		4.1
	ZnSn, C-14	60	522	400	1200	0	250		130		0.88	22	73.6
P2 Rev	ZnSn90, C-16	60	650	600	840	0	250		130		6	16	17.7
P3	Ag, C-8	11.12	422	700	0	0	0				6		23.2
	NiCr, C-10	16.4	511/269mv	150	61	0	61				6		4.1
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	10.8
P4	SiAl, C-12	60	621	400	0	420		250		130	3.37	9	19.1

Fig. 3

Example 1

Optics	9176	HT	HTX	HTXXX
TY	74.7	77.0	77.0	75.9
L*	89.3	90.3	90.3	89.8
a*	-4.7	-3.5	-3.5	-3.2
b*	5.8	4.9	4.4	2.2
RgY	9.6	9.8	10.5	11.3
L*	37.1	37.5	38.6	40.1
a*	-1.1	-0.7	-3.6	-8.2
b*	-10.1	-10.5	-9.2	-4.4
RfY	9.9	10.2	10.7	11.0
L*	37.7	38.1	39.0	39.6
a*	-1.5	-1.4	-3.1	-5.6
b*	-5.7	-8.0	-7.6	-4.5
SR	2.09	1.75	1.71	1.69
ΔET		1.8	2.1	3.9
ΔE Rg		0.7	3.1	9.6
ΔE Rf		2.4	2.8	4.7
Sum ΔE		4.9	8.0	18.2

Fig. 4

Example 2

9214	HT	HTX	HTXXX
73.8	76.1	76.8	76.2
88.8	89.9	90.2	90.0
-4.7	-3.4	-3.4	-3.7
7.8	6.6	5.9	3.5
11.3	11.3	11.4	11.1
40.1	40.1	40.2	39.7
-0.6	-0.1	-2.3	-5.4
-13.5	-13.6	-12.9	-8.6
11.8	12.0	11.8	11.0
40.8	41.2	40.9	39.6
-2.7	-2.8	-3.8	-3.7
-7.2	-8.7	-10.1	-8.5
2.05	0.00	0.00	1.79
	2.1	2.7	4.6
	0.5	1.8	6.9
	1.5	3.1	2.0
	4.2	7.7	13.5

Fig. 5

Example 3

	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-14	60	650	600	840	0	250		130		2.64	16	42.50
P2	Ag, C-8	7.52	429	700		0	0				6		7.52
	NiCr, C-10	19.2	?	150	69	0	69				6		4.80
	ZnSn, C-16	60	522	400	1200	0	250		130		0.90	22	72.67
P3	ZnSn90, C-14	60	650	600	840	0	250		130		6.17	16	18.18
P4	Ag, C-8	12.3	422	700	0	0	0				6		12.30
	NiCr, C-10	19.2	?	150	69	0	69				6		4.80
	ZnSn, C-16	60	522	400	1200	0	250		130		6	22	10.90
P5	SiAl, C-12	60	621	400	0	420		250		130	3.10	9	20.90

Fig 6

Example 4

	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-14	60	650	600	840	0	250		130		2.64	16	42.50
P2	Ag, C-8	7.52	429	700		0	0				6		7.52
	NiCr, C-10	15.3	?	150	55	0	55				6		3.83
	ZnSn, C-16	60	522	400	1200	0	250		130		0.90	22	72.67
P3	ZnSn90, C-14	60	650	600	840	0	250		130		6.17	16	18.18
P4	Ag, C-8	12.3	422	700	0	0	0				6		12.30
	NiCr, C-10	15.3	?	150	55	0	55				6		3.83
	ZnSn, C-16	60	522	400	1200	0	250		130		6	22	10.90
P5	SiAl, C-12	60	621	400	0	420		250		130	3.10	9	20.90

Fig. 7

	Example 3				Example 4			
Optics	9502	HT	HTX	HTXXX	9514	HT	HTX	HTXXX
TY	75.8	77.9	78.5	77.7	75.5	78.0	78.8	77.4
L*	89.8	90.7	91.0	90.6	89.6	90.8	91.1	90.5
a*	-4.6	-3.2	-2.9	-2.1	-4.6	-3.1	-3.0	-2.1
b*	5.3	3.9	3.3	1.8	4.9	3.6	3.1	1.8
RgY	10.5	10.4	11.0	11.9	10.5	10.3	10.4	12.0
L*	38.7	38.5	39.6	41.1	38.6	38.4	38.5	41.2
a*	1.6	1.5	-1.9	-7.1	0.0	0.2	-1.5	-7.5
b*	-9.1	8.5	-6.8	-2.7	-7.6	-6.0	-6.3	-2.3
RfY	9.8	9.8	10.6	11.2	9.7	9.9	10.1	11.2
L*	37.5	37.6	38.9	40.0	37.3	37.6	37.9	39.9
a*	2.3	0.7	-2.5	-6.7	1.4	0.7	-1.2	-6.3
b*	-2.5	-3.3	-2.5	1.1	-2.6	-1.6	-2.1	1.1
SR	2.18	1.70	1.63	1.68	2.11	1.74	1.66	1.74
ΔET		2.2	2.9	4.4		2.3	2.8	4.1
ΔE Rg		0.6	4.2	11.0		1.6	2.0	9.5
ΔE Rf		1.7	5.0	9.9		1.3	2.8	8.9
Sum ΔE		4.6	12.2	25.3		5.2	7.5	22.5

Fig. 8

Example 5

	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-1	60	650	600	840	0	250		130		2.58	16	45.3
	Ag, C-8	8.36	429	700	0	0	0				6		8.4
	NiCr, C-10	9.54		150	30	0	30				6		2.4
	ZnSn, C-14	60	522	400	1200	0	250		130		0.86	22	69.8
P2	ZnSn90, C-1	60	650	600	840	0	250		130		6	16	19.5
	Ag, C-8	12.27	422	700	0	0	0				6		12.3
	NiCr, C-10	9.54		150	28	0	28				6		2.4
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	10.0
	SiAl, C-16	60	621	400	0	420		250		130	6	9	10.3
P3	SiAl, C-16	60	621	400	0	420		250		130	4.65	9	13.3

Fig. 9

Example 5

Optics	9964	HT	HTX	HTXXX
TY	73.2	78.3	79.3	79.6
L*	88.5	90.9	91.4	91.5
a*	-5.0	-3.0	-3.0	-2.7
b*	4.7	4.4	4.3	3.1
RgY	8.8	8.8	9.0	9.6
L*	35.6	35.7	36.1	37.1
a*	-1.2	-0.3	-1.1	-5.2
b*	-11.9	-11.1	-11.9	-7.9
RfY	8.5	9.0	9.3	9.5
L*	34.9	36.0	36.5	36.8
a*	-0.5	-1.5	-2.5	-5.6
b*	-8.4	-7.9	-9.0	-5.9
SR	2.27	1.75	1.64	1.69
ΔET		3.2	3.5	4.1
ΔE Rg		1.3	0.5	5.9
ΔE Rf		1.5	2.6	6.0
Sum ΔE		5.9	6.6	16.0

Fig. 10

Example 6

	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-1	60	650	600	840	0	250		130		2.58	16	42.9
	Ag, C-8	8.36	429	700	0	0	0				6		8.4
	NiCr, C-10	10.6	553/271	150	0	0	59				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		0.84	22	70.9
P2	ZnSn90, C-1	60	650	600	840	0	250		130		6	16	18.5
	Ag, C-8	12.8	422	700	0	0	0				6		12.8
	NiCr, C-10	10.6	553/271	150	0	0	59				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	9.9
	SiAl, C-16	60	621	400	0	420		250		130	6	9	10.5
P3	SiAl, C-16	60	621	400	0	420		250		130	4.65	9	13.5

Fig. 11

Example 6

Optics	43	HT	HTX	HTXXX
TY	74.0	76.9	77.8	77.5
L*	88.9	90.3	90.7	90.6
a*	-4.8	-2.9	-2.8	-2.6
b*	4.5	3.7	3.6	2.5
RgY	9.5	9.4	10.2	10.9
L*	36.9	36.7	38.1	39.3
a*	-1.4	-0.4	-3.0	-6.9
b*	-8.8	-9.3	-8.1	-5.4
RfY	9.0	9.4	10.2	10.5
L*	35.9	36.7	38.1	38.6
a*	0.4	-1.5	-4.1	-7.1
b*	-5.3	-5.3	-4.5	-2.2
SR	2.23	1.83	1.76	1.75
ΔET		2.5	2.8	3.5
ΔE Rg		1.1	2.1	6.9
ΔE Rf		2.0	5.1	8.6
Sum ΔE		5.6	10.0	19.0

Fig. 12

Example 7

	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-1	60	529	600	840	0	250		130		2.32	16	47.6
	Ag, C-8	7.4	429	700	0	0	0				6		7.4
	NiCr, C-10	11.2	488/340	150	48	0	48				6		2.8
	ZnSn, C-16	60	435	400	1200	0	250		130		0.782	22	76.0
P2	ZnSn90, C-1	60	525	600	840	0	250		130		6	16	18.4
	Ag, C-8	12.06	422	700	0	0	0				6		12.1
	NiCr, C-10	11.2	488/340	150	48	0	48				6		2.8
	ZnSn, C-16	60	522	400	1200	0	250		130		5.76	22	10.3
P3	SiAl, C-14	60	621	400	0	420		250		130	3.09	9	21.2

Fig. 13

Example 7

Optics	635	HT	HTX	HTXXX
TY	73.2	77.8	77.8	76.9
L*	88.6	90.7	90.7	90.3
a*	-4.9	-3.0	-3.0	-2.1
b*	4.3	3.8	3.7	2.3
RgY	10.1	10.1	10.0	12.2
L*	38.0	37.9	37.9	41.6
a*	-0.5	0.0	-4.0	-7.2
b*	-8.6	-7.6	-8.5	-2.1
RfY	9.7	10.4	11.2	12.4
L*	37.2	38.6	40.0	41.8
a*	0.6	-1.5	-3.6	-7.0
b*	-2.5	-1.6	-1.5	1.9
SR	2.16	1.63	1.63	1.65
ΔET		2.9	3.0	3.9
ΔE Rg		1.1	3.5	10.0
ΔE Rf		2.6	5.1	9.8
Sum ΔE		6.7	11.6	23.7

Fig. 14

Example 8

5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-12	60	650	600	840	0	250		130		2.6	16	42.7
P2	Ag, C-8	9.25	429	700		0	0				6		17.7
	NiCr, C-10	14.5	552/264.4	150	49	0	49				6		3.6
	ZnSn, C-14	60	522	400	1200	0	250		130		0.88	22	68.2
P3	ZnSn90, C-12	60	650	600	840	0	250		130		6	16	18.5
P4	Ag, C-8	13.89	422	700	0	0	0				6		26.6
	NiCr, C-10	14.5	551/264.5	150	49	0	49				6		3.6
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	10.0
	SiAl, C-16	60	621	400	0	420		250		130	6	9	10.2
P5	SiAl, C-16	60	621	400	0	420		250		130	4.25	9	14.4

Fig. 15

Example 8

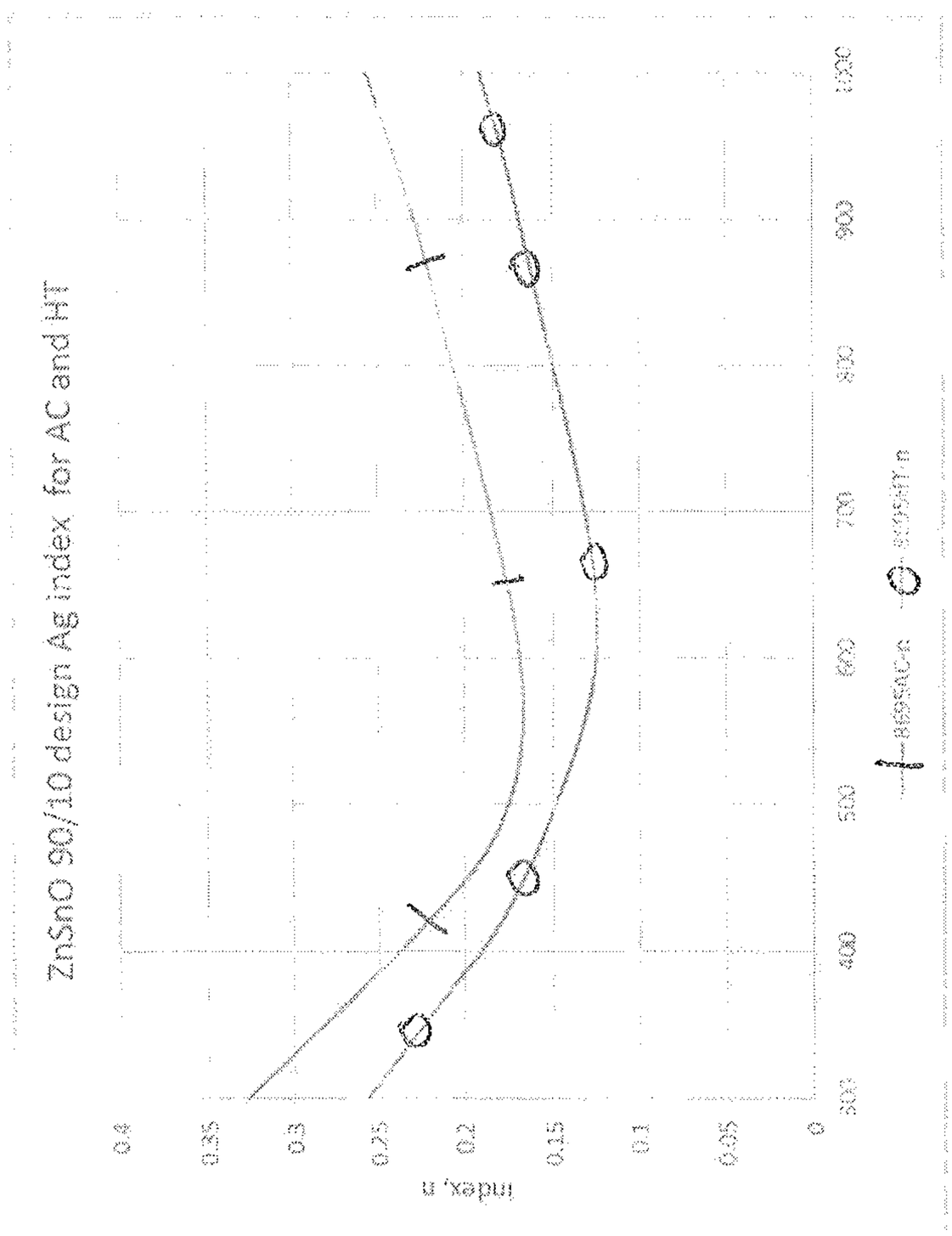

Fig. 16

Example 9

Layer stack	thickness, nm
SiAlN	24.1
Zn2SnO4	10.0
NiCrOx	3.9
Ag2	15.6
ZnO [illegible] doped	18.2
Zn2SnO4	72.3
NiCrOx	3.9
Ag1	9.8
ZnO [illegible] doped	45.2
Glass	

Fig. 17

Example 9

	AC	HT	HTK
TY	74.9	77.8	78.7
L*	89.3	90.7	91.1
a*	-4.4	-2.9	-2.7
b*	4.7	4.0	4.1
RgY	10.6	10.4	10.8
L*	39.0	38.5	39.2
a*	-0.4	0.9	-0.9
b*	-8.2	-7.7	-7.8
RfY	9.9	10.3	11.1
L*	37.7	38.4	39.7
a*	1.6	1.4	-1.1
b*	-5.3	-4.2	-4.0
SR	2.08	1.90	1.71
ΔEY		2.2	2.6
ΔE Rg		1.5	0.7
ΔE Rf		1.3	3.6
Sum ΔE		4.9	6.9

Fig. 18

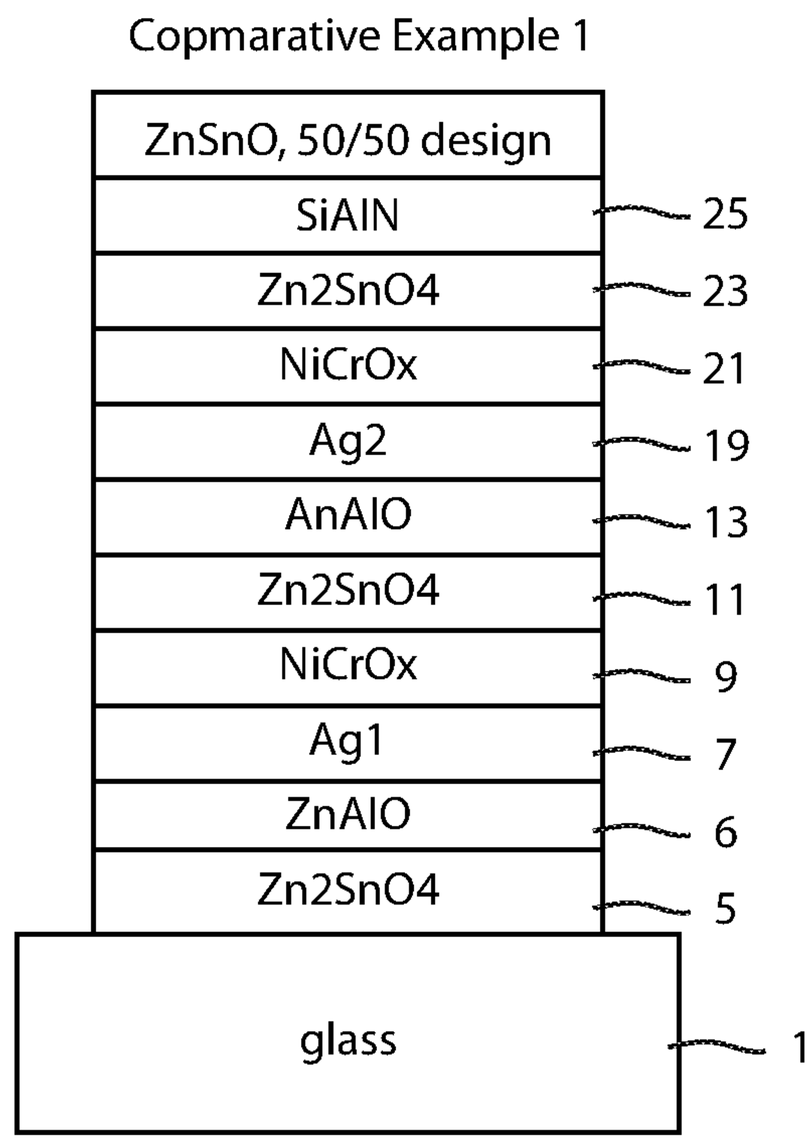
Copmarative Example 1
ZnSnO, 50/50 design
SiAlN
25
Zn2SnO4
23
NiCrOx
21
Ag2
19
AnAlO
13
Zn2SnO4
11
NiCrOx
9
Ag1
7
ZnAlO
6
Zn2SnO4
5
glass
1

FIG. 19

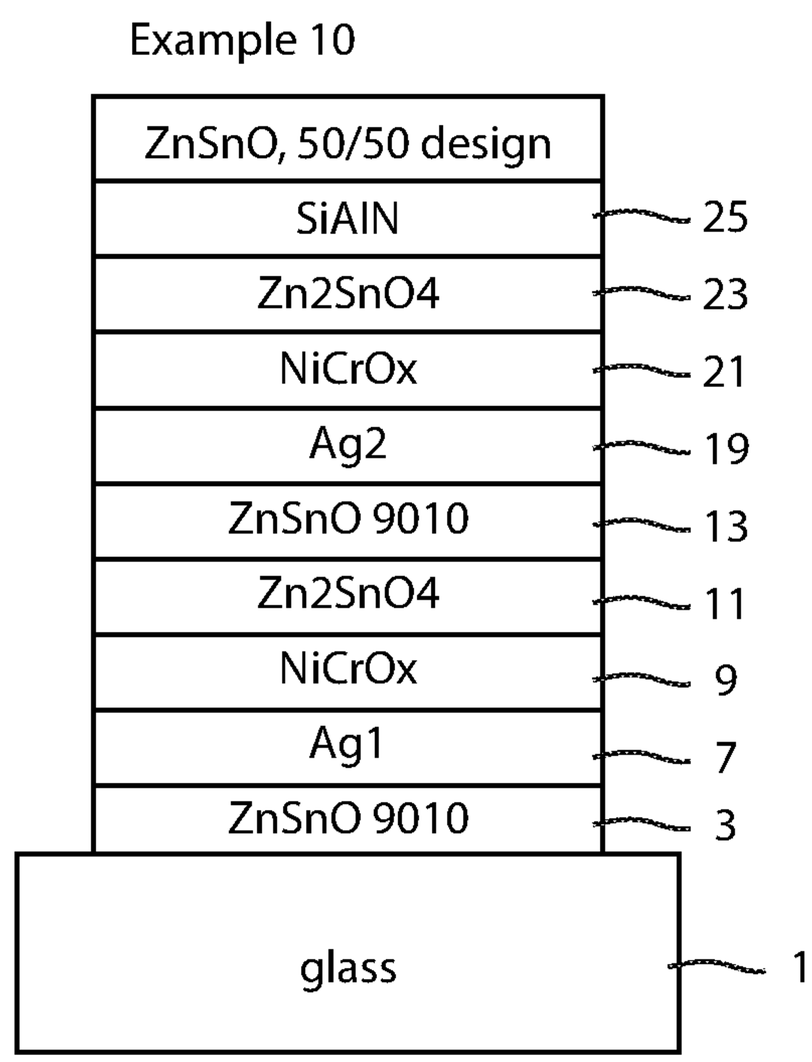
Example 10
ZnSnO, 50/50 design
SiAlN
25
Zn2SnO4
23
NiCrOx
21
Ag2
19
ZnSnO 9010
13
Zn2SnO4
11
NiCrOx
9
Ag1
7
ZnSnO 9010
3
glass
1

FIG. 20

Example 10

XU 5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-12	60	650	600	840	0	250		130		2.48	16	45.2
P2	Ag, C-8	9.83	429	700		0	0				6		9.8
	NiCr, C-10	15.4		150	49	0	49				6		3.9
	ZnSn, C-14	60	522	400	1200	0	250		130		0.83	22	72.3
P3	ZnSn90, C-12	60	650	600	840	0	250		130		6.15	16	18.2
P4	Ag, C-8	15.64	422	700	0	0	0				6		15.6
	NiCr, C-10	15.4		150	49	0	49				6		3.9
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	10.0
	SiAl, C-16	60	621	400	0	420		250		130	6	9	10.9
P5	SiAl, C-16	60	621	400	0	420		250		130	4.9	9	13.4

Fig. 21

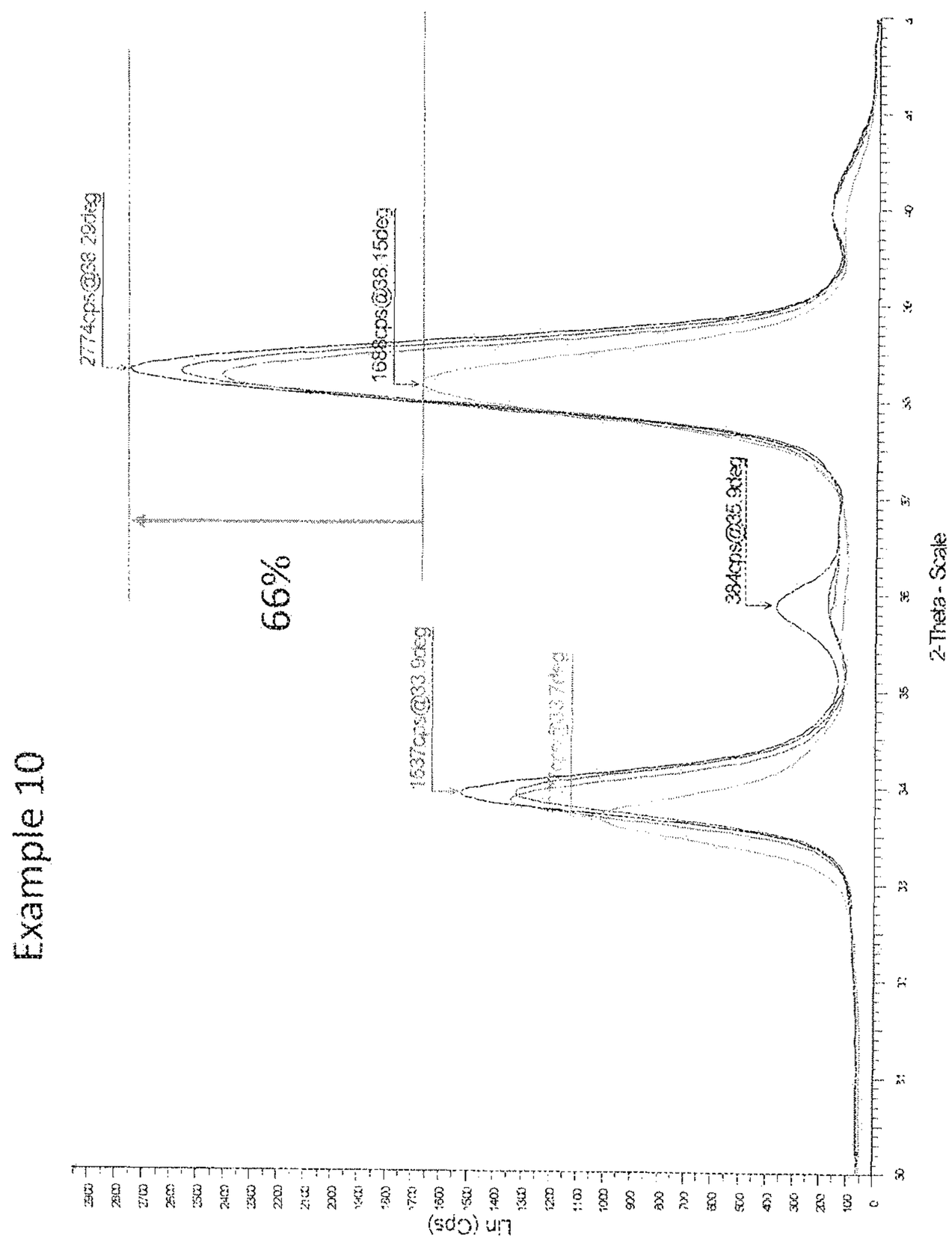
Example 10
2774cps@38.29deg
1688cps@38.15deg
66%
1537cps@33.9deg
384cps@35.9deg
Lin (Cps)
2-Theta - Scale

Fig. 22

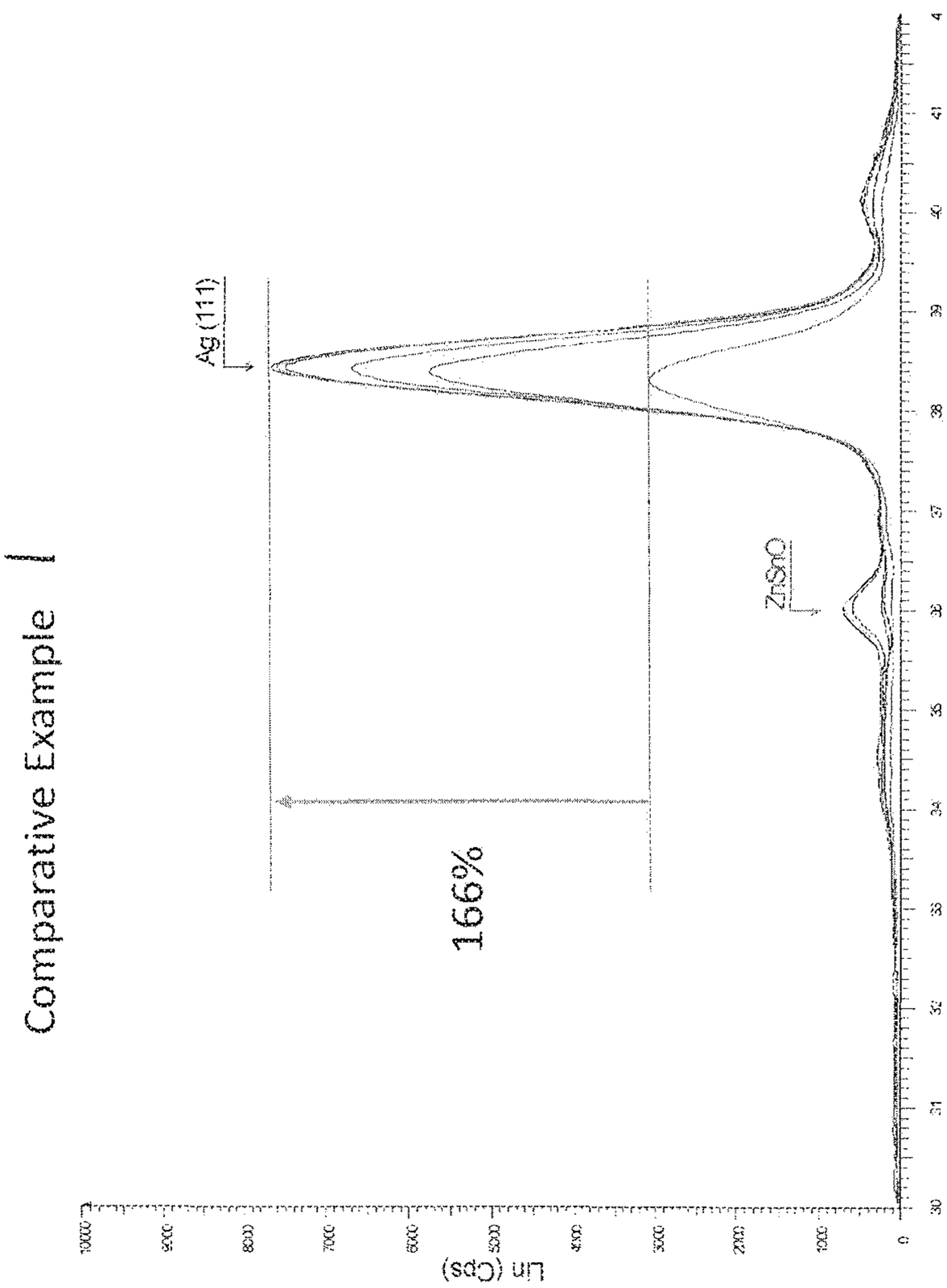
Comparative Example
Ag (111)
ZnSnO
166%
Lin (Cps)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
30
31
32
33
34
35
36
37
38
39
40
41
42

Fig. 23

Example 11

XU 5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
reverse	SiZrO, C-3	60		600	490	0	150	0	0	0	7.20	8.5	5.0
P1	ZnSn90, C-1	60	650	600	840	0	250		130		2.63	16	42.1
	Ag, C-8	8.36	429	700	0	0	0				6		8.4
	NiCr, C-10	10.6		150	0	0	54				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		0.84	22	70.9
P2	ZnSn90, C-1	60	650	600	840	0	250		130		6	16	18.5
	Ag, C-8	12.8	422	700	0	0	0				6		12.8
	NiCr, C-10	10.6		150	0	0	54				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	9.9
	SiAl, C-16	60	621	400	0	420		250		130	6	9	10.5
P3	SiAl, C-16	60	621	400	0	420		250		130	4.65	9	13.5

Fig. 24

Example 12

XU 5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
reverse	SiZrO, C-3	60		600	490	0	150	0	0	0	3.60	8.5	10.0
P1	ZnSn90, C-1	60	650	600	840	0	250		130		2.70	16	41.0
	Ag, C-8	8.36	429	700	0	0	0				6		8.4
	NiCr, C-10	10.6		150	0	0	54				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		0.84	22	70.9
P2	ZnSn90, C-1	60	650	600	840	0	250		130		6	16	18.5
	Ag, C-8	12.8	422	700	0	0	0				6		12.8
	NiCr, C-10	10.6		150	0	0	54				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	9.9
	SiAl, C-16	60	621	400	0	420		250		130	6	9	10.5
P3	SiAl, C-16	60	621	400	0	420		250		130	4.65	9	13.5

Fig. 25

Example 13

XU 5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
reverse	SiZrO, C-3	60		600	490	0	150	0	0	0	1.80	8.5	20.0
P1	ZnSn90, C-1	60	650	600	840	0	250		130		2.83	16	39.1
	Ag, C-8	8.36	429	700	0	0	0				6		8.4
	NiCr, C-10	10.6		150	0	0	54				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		0.84	22	70.9
P2	ZnSn90, C-1	60	650	600	840	0	250		130		6	16	18.5
	Ag, C-8	12.8	422	700	0	0	0				6		12.8
	NiCr, C-10	10.6		150	0	0	54				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	9.9
	SiAl, C-16	60	621	400	0	420		250		130	6	9	10.5
P3	SiAl, C-16	60	621	400	0	420		250		130	4.65	9	13.5

Fig. 26

	Ex. 11				Ex. 12				Ex. 13			
glass thx	SiZrO5nmUC		10.6kW/0-54O2		SiZrO10nmUC		10.6kW/0-54O2		SiZrO20nmUC		10.6kW/0-54O2	
TY	72.3	78.0	78.4	77.6	72.0	77.3	78.3	79.0	71.9	76.5	77.7	78.7
L*	88.1	90.8	91.0	90.6	88.0	90.5	90.9	91.2	87.9	90.1	90.6	91.1
a*	-5.3	-3.8	-3.6	-3.3	-5.2	-3.7	-3.8	-3.7	-5.1	-3.6	-3.8	-3.8
b*	5.3	5.2	5.2	4.5	5.0	5.1	5.3	4.4	5.2	5.2	5.6	5.2
RgY	9.5	9.7	9.9	10.8	9.6	9.7	9.7	9.4	9.7	9.8	9.6	9.1
L*	36.9	37.3	37.7	39.2	37.0	37.3	37.3	36.8	37.3	37.6	37.0	36.1
a*	0.0	0.7	-0.2	-2.7	-0.7	0.4	0.3	-1.2	-0.9	0.3	0.8	0.4
b*	-11.5	-9.8	-10.7	-8.4	-10.6	-8.6	-9.5	-8.9	-10.9	-8.8	-10.4	-10.5
RfY	8.8	9.7	10.0	10.6	8.7	9.5	9.7	9.3	8.8	9.6	9.4	8.9
L*	35.5	37.3	37.8	39.0	35.4	37.0	37.2	36.6	35.6	37.0	36.8	35.7
a*	1.9	0.5	-0.5	-2.1	1.4	0.7	0.2	-0.6	0.9	0.9	0.7	0.9
b*	-7.8	-6.4	-7.6	-6.4	-6.6	-5.2	-6.2	-6.9	-6.9	-5.6	-7.1	-8.3
SR	2.41	1.83	1.88	1.88	2.40	1.95	1.85	1.88	2.44	2.06	1.92	1.97
ΔET		3.1	3.3	3.3		2.9	3.3	3.6		2.7	3.0	3.4
ΔE Rg		1.8	1.2	4.7		2.2	1.4	1.8		2.4	1.7	1.8
ΔE Rf		2.6	3.3	5.5		2.3	2.2	2.3		2.0	1.3	1.4
Sum ΔE		**7.6**	**7.8**	**13.5**		**7.4**	**6.9**	**7.7**		**7.0**	**6.1**	**6.6**
Brush Score												
Haze		0.17	0.17	0.69		0.21	0.2	0.46		0.23	0.18	0.38
SHGC, PE												
		HT	HTX	HTXXX		HT	HTX	HTXXX		HT	HTX	HTXXX

Fig. 27

Example 14

XU 5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
P1	ZnSn90, C-1	60	529	600	840	0	250		130		2.56	16	30.0
	Ag, C-8	8.68	429	700	0	0	0				6		40.9
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		8.7
	ZnSn, C-16	60	435	400	1200	0	250		130		0.79	22	2.7
P2	ZnSn90, C-1	60	525	600	840	0	250		130		6	16	69.3
	Ag, C-8	13.81	422	700	0	0	0				6		17.4
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		13.8
	ZnSn, C-16	60	522	400	1200	0	250		130		6	22	2.7
P3	SiAl, C-14	60	621	400	0	420		250		130	3.09	9	9.1
													21.0

Fig. 2P

Ex. 14

Glass mix	30nm SiZrO		48-48	
TY	72.5	75.5	77.4	78.0
L*	88.2	89.6	90.5	90.8
a*	-4.9	-3.1	-3.6	-3.9
b*	5.1	5.4	5.7	5.5
RgY	9.7	9.5	9.5	9.6
L*	37.4	36.9	37.0	37.1
a*	-0.4	1.0	0.7	-0.3
b*	-9.6	-9.0	-9.2	-9.6
RfY	9.2	9.7	9.8	9.7
L*	36.4	37.3	37.5	37.3
a*	-0.1	-0.5	-0.5	-0.1
b*	-3.7	-3.7	-4.9	-7.5
SR	2.39	2.01	1.85	1.86
ΔET		2.4	2.7	2.8
ΔE Rg		1.6	1.1	0.3
ΔE Rf		0.9	1.7	3.9
Sum ΔE		4.8	5.5	7.0
Brush Score				
Haze		0.16	0.17	0.24
SHGC, PE				

HT HTX HTXXX

Fig. 29

Example 16

XU 5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
reverse	ZrO2, C-3	60		600	10	0	35	0	0	0	2.85	8.5	20.0
P1	ZnSn90, C-1	60	529	600	840	0	250		130		5.00	16	20.9
	Ag, C-8	8.68	429	700	0	0	0				6		8.7
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		2.7
	ZnSn, C-16	60	435	400	1200	0	250		130		0.79	22	69.3
P2	ZnSn90, C-1	60	525	600	840	0	250		130		6	16	17.4
	Ag, C-8	13.81	422	700	0	0	0				6		13.8
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		2.7
	ZnSn, C-16	60	522	400	1200	0	250		130		6	22	9.1
P3	SiAl, C-14	60	621	400	0	420		250		130	3.20	9	20.3

435 LO

Example 15

XU 5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
reverse	ZrO2, C-3	60		600	10	0	35	0	0	0	11.40	8.5	5.0
P1	ZnSn90, C-1	60	529	600	840	0	250		130		2.90	16	36.1
	Ag, C-8	8.68	429	700	0	0	0				6		8.7
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		2.7
	ZnSn, C-16	60	435	400	1200	0	250		130		0.79	22	69.3
P2	ZnSn90, C-1	60	525	600	840	0	250		130		6	16	17.4
	Ag, C-8	13.81	422	700	0	0	0				6		13.8
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		2.7
	ZnSn, C-16	60	522	400	1200	0	250		130		6	22	9.1
P3	SiAl, C-14	60	621	400	0	420		250		130	3.20	9	20.3

Fig. 30

	Ex. 15				Ex. 16			
	ZrO2, 5nm		48-48		ZrO2, 20nm		48-48	
	[illegible]	RT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TY	74.8	79.1	80.0	80.5	75.0	80.0	80.0	80.2
L*	89.3	91.3	91.7	91.9	89.4	91.7	91.7	91.8
a*	-4.1	-2.4	-2.6	-2.8	-3.7	-2.7	-2.7	-2.8
b*	4.2	4.2	4.1	3.7	2.3	2.7	2.6	2.1
RgY	9.7	9.8	10.2	9.8	9.6	10.1	10.3	9.9
L*	37.3	37.4	38.1	37.5	37.2	38.1	38.3	37.6
a*	0.0	0.8	-0.2	-0.2	0.5	0.2	-0.2	-0.2
b*	-8.5	-7.3	-7.3	-8.3	-5.6	-3.3	-3.2	-3.8
RfY	9.7	10.4	10.8	10.4	9.5	10.6	10.8	10.3
L*	37.4	38.6	39.2	38.6	37.0	38.9	39.2	38.4
a*	-0.2	-0.8	-1.2	-0.1	0.7	-0.2	-0.5	0.6
b*	-3.5	-3.7	-4.4	-6.7	0.4	0.0	-0.2	-2.2
SR	2.26	1.74	1.74	1.68	2.22	1.67	1.66	1.65
ΔET		2.6	2.8	2.9		2.5	2.6	2.6
ΔE Rg		1.4	1.4	0.4		2.5	2.7	1.9
ΔE Rf		1.4	2.3	3.5		2.2	2.6	3.0
Sum ΔE		5.4	6.5	6.7		7.2	7.9	7.5
Brush Score								
Haze		0.25	0.22	0.35		0.26	0.28	0.31
SHGC, PE								

Fig. 31

Fig. 32

Example 17

XU 5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	thickness , nm
reverse	SiAl, C-14	60		400	305	0	250	0	130	0	1.33	8.5	20.0
P2	ZnSn90, C-1	60	529	600	840	0	250		130		2.30	16	45.5
	Ag, C-8	8.68	429	700	0	0	0				6		8.7
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		2.7
	ZnSn, C-16	60	435	400	1200	0	250		130		0.79	22	69.3
P3	ZnSn90, C-1	60	525	600	840	0	250		130		6	16	17.4
	Ag, C-8	13.81	422	700	0	0	0				6		13.8
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		2.7
	ZnSn, C-16	60	522	400	1200	0	250		130		6	22	9.1
P4	SiAl, C-14	60	621	400	0	420		250		130	3.09	9	21.0

Example 18

XU 5450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	thickness , nm
reverse	SiAl, C-14	60		400	305	0	250	0	130	0	1.33	8.5	30.1
P2	ZnSn90, C-1	60	529	600	840	0	250		130		2.35	16	44.5
	Ag, C-8	8.68	429	700	0	0	0				6		8.7
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		2.7
	ZnSn, C-16	60	435	400	1200	0	250		130		0.79	22	69.3
P3	ZnSn90, C-1	60	525	600	840	0	250		130		6	16	17.4
	Ag, C-8	13.81	422	700	0	0	0				6		13.8
	NiCr, C-10	10.6	516/340.7	150	48	0	48				6		2.7
	ZnSn, C-16	60	522	400	1200	0	250		130		6	22	9.1
P4	SiAl, C-14	60	621	400	0	420		250		130	3.09	9	21.0

	Ex. 17				Ex. 18			
glass thx	20nm SiO		48-48		30nm SiO		48-48	
Optics	410	HT	HTX	HTXXX	411	HT	HTX	HTXXX
TY	72.5	76.8	77.6	78.0	72.4	76.3	77.2	77.7
L*	88.2	90.3	90.6	90.8	88.2	90.0	90.4	90.7
a*	-5.4	-3.8	-4.1	-4.0	-5.5	-3.7	-4.1	-4.3
b*	5.7	5.6	5.7	5.1	5.6	5.3	5.6	5.6
RgY	9.6	9.6	9.8	10.2	9.7	9.7	9.8	9.7
L*	37.2	37.0	37.4	38.2	37.4	37.3	37.4	37.4
a*	1.1	2.1	1.6	-0.9	1.4	2.6	2.2	1.5
b*	-10.7	-8.4	-8.3	-7.8	-10.0	-7.7	-8.0	-9.7
RfY	9.4	9.9	10.1	10.3	9.4	10.0	10.1	10.0
L*	36.7	37.6	37.9	38.4	36.8	37.8	37.9	37.8
a*	1.2	1.4	1.4	0.3	1.9	2.1	2.1	2.1
b*	-6.0	-5.0	-5.8	-7.3	-5.5	-4.3	-5.6	-8.8
SR	2.51	1.98	1.96	2.08	2.45	2.04	1.91	2.09
ΔET		2.6	2.7	3.0		2.6	2.7	2.8
ΔE Rg		2.5	2.5	3.7		2.6	2.2	0.3
ΔE Rf		1.3	1.3	2.4		1.6	1.2	3.5
Sum ΔE		6.4	6.5	9.0		6.7	6.0	6.5

Fig. 33

Comparative Example 2

KU S450	materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	LS, m/min	RC	Thickness (nm)
reverse	SiAl, C-16	60	621	400	0	420		250		130	6	9	10.5
P1	ZnSn90, C-1	60	650	600	840	0	250		130		3.40	16	32.6
	Ag, C-8	8.36	429	700	0	0	0				6		8.4
	NiCr, C-10	10.6		150	0	0	54				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		0.84	22	70.9
P2	ZnSn90, C-1	60	650	600	840	0	250		130		6	16	18.5
	Ag, C-8	12.8	422	700	0	0	0				6		12.8
	NiCr, C-10	10.6		150	0	0	54				6		2.7
	ZnSn, C-14	60	522	400	1200	0	250		130		6	22	9.9
	SiAl, C-16	60	621	400	0	420		250		130	6	9	10.5
P3	SiAl, C-16	60	621	400	0	420		250		130	4.65	9	13.5

Fig. 34

Comparative Example 2

	SiN10nmUC		10.6kW/0-54C2	
	4x	4HT	8HX	8HXX
TY				
L*	72.3	78.1	77.5	78.2
a*	88.1	90.8	90.5	90.9
b*	-4.9	-3.4	-3.2	-3.1
RgY	4.6	4.2	4.2	3.2
L*	9.5	10.4	10.7	9.6
a*	37.0	38.6	39.0	37.1
b*	-0.9	-2.3	-3.0	-3.3
RfY	-10.8	-6.3	-6.4	-5.7
L*	8.8	10.4	10.6	9.4
a*	35.6	38.5	38.8	36.8
b*	0.4	-2.4	-2.7	-2.3
SR	-6.4	-2.7	-3.1	-3.2
ΔET	2.39	1.80	1.80	1.87
ΔE Rg		3.3	3.0	3.6
ΔE Rf		4.9	5.2	5.6
Sum ΔE		5.5	5.6	4.3
Brush Score		13.5	13.8	13.5
Haze				
SHGC, PE		0.30	0.3	0.36

Fig. 35

Fig. 36

Example 19

	Target Materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	**SiZrOx, C5**	60	515	600	490		150		130		20.0
P3	ZnSn90, C-1	60	650	600	490		600		130		39.10
	Ag, C-8	**8.45**	379	700							10.72
	NiCr, C-10	13	563	150	**55**		**55**				3.79
	ZnSn50, C-16	60	520	400	1200		250		130		67.17
P4-rev	**ZnSn85, C-12**	60	643	600	840		250		130		18.35
P5	Ag, C-8	**11.61**	396	700							14.73
	NiCr, C-10	13	567	150	**55**		**55**				3.79
	ZnSn50, C-16	60	522	400	1200		250		130		9.41
P7	SiAl, C-3	60	563	400		420		250		130	21.08

	TY(%)	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	74.80	6.90	-2.83	-7.21	7.90	-0.11	-12.92	2.31			
HT	78.70	7.30	-3.65	-7.72	7.60	0.53	-12.79		0.9	1.3	2.3
HTX	79.80	7.50	-4.13	-7.65	7.80	-0.81	-11.66	1.83	1.5	1.9	2.6
HTXX	80.40	7.10	-2.93	-9.17	7.60	-1.66	-10.63	1.82	2.8	2.0	2.8

Fig. 37

Example 20

	Target Materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	SiZrOx, C5	60	515	600	490		150		130		20.0
P3	ZnSn90, C-1	60	650	600	490		600		130		39.10
	Ag, C-8	8.45	379	700							10.72
	NiCr, C-10	13	563	150	55		55				3.79
	ZnSn50, C-16	60	520	400	1200		250		130		62.42
P4 rev	**SiZrOx, C5**	60	515	600	490		150		130		5.0
P5	ZnSn90, C-1	60	650	600	490		600		130		18.35
	Ag, C-8	11.61	396	700							14.73
	NiCr, C-10	13	567	150	55		55				3.79
	ZnSn50, C-16	60	522	400	1200		250		130		9.41
P7	SiAl, C-3	60	563	400		420		250		130	22.91

	TY(%)	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	74.70	6.80	-1.57	-6.20	8.00	0.29	-13.09	2.35			
HT	78.70	7.00	-2.55	-6.07	7.60	1.25	-12.79	1.94	1.3	1.1	2.2
HTX	78.60	7.20	-2.92	-6.62	7.70	0.36	-12.32	1.88	1.0	1.7	2.2
HTXXX	79.40	7.10	-2.30	-8.21	7.70	-0.46	-11.31	1.88	2.0	2.2	2.4

Fig. 38

Example 21

	Target Materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	SiZrOx, C5	60	515	600	490		150		130		20.0
P3	ZnSn90, C-1	60	650	600	490		600		130		39.10
	Ag, C-8	8.45	379	700							10.72
	NiCr, C-10	13	563	150	55		55				3.79
	ZnSn50, C-16	60	520	400	1200		250		130		59.90
P4 rev	**SiZrOx, C5**	60	515	600	490		150		130		15.0
P5	ZnSn90, C-1	60	650	600	490		600		130		18.35
	Ag, C-8	11.61	396	700							14.73
	NiCr, C-10	13	567	150	55		55				3.79
	ZnSn50, C-16	60	522	400	1200		250		130		9.41
P7	SiAl, C-3	60	563	400		420		250		130	22.91

	TY(%)	RFY(%)	RFa*	RFb*	RGY(%)	**RGa***	**RGb***	Rs	**ΔE^*_G**	**ΔE^*_F**	**ΔE^*_T**
AC	73.2	8.4	1.3	-6.4	10.0	**2.1**	**-16.0**	2.44			
HT	74.8	8.2	0.9	-5.8	9.4	**3.8**	**-15.6**	2.2	2.1	0.8	2.3
HTX	76.5	8.6	-0.4	-5.1	9.4	**2.5**	**-14.1**	2.04	2.2	2.2	2.2
HTXXX	76.9	8.6	-2.4	-6.4	9.4	**1.1**	**-13.7**	2.07	2.7	3.7	2.7

Fig. 39
Example 22

	Target Materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	Si3N4, C3	60		400		420		250		130	10.01
P2 rev	NiCr-N, C10	**4.5**		150		10		10			1.48
	Si3N4, C3	60		400		420		250		130	10.01
P4 rev	SiZrOx, C5	60	449	600	490	0	150		130		4.00
P5	ZnSn90, C1	60	650	600	490	0	600		130		10.73
	Ag, C-8	8.45	429	700	0	0	0				9.70
	NiCr, C-10	13	552/336.3	150	**58**	0	**58**				4.91
	ZnSn, C-16	60	522	400	1200	0	250		130		66.28
P7	ZnSn90, C-1	60	650	600	490	0	600		130		15.20
	Ag, C-8	11.61	422	700	0	0	0				13.30
	NiCr, C-10	13	552/336.3	150	55	0	55				4.91
	ZnSn, C-16	60	522	400	1200	0	250		130		9.50
P9	SiAl, C-3	60	621	400	0	420		250		130	23.59

	TY	RFY	RFa*	RFb*	RGY	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	72.4	6.4	-6.0	-7.6	7.7	**-0.2**	**-13.3**	2.18			
HT	76.1	6.9	-7.3	-7.2	7.6	**-1.4**	**-11.4**	1.76	2.3	1.9	2.2
HTX	76.6	7.1	-7.7	-8.3	7.9	**-2.8**	**-10.6**	1.69	3.8	2.5	2.2
HTXXX	76.3	6.6	-5.9	-9.6	7.8	**-3.6**	**-9.3**	1.69	5.2	2.1	2.2

Fig. 40
Example 23

	Target Materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	Si3N4, C3	60		400		420		250		130	10.01
P2 rev	NiCr-N, C10	**4.5**		150		10		10			1.48
	Si3N4, C3	60		400		420		250		130	10.01
P4 rev	SiZrOx, C5	60	449	600	490	0	150		130		4.00
P5	ZnSn90, C1	60	650	600	490	0	600		130		10.73
	Ag, C-8	8.45	429	700	0	0	0				9.70
	NiCr, C-10	13	552/336.3	150	**58**	0	**58**				4.91
	ZnSn, C-16	60	522	400	1200	0	250		130		63.28
P6 rev	SiZrOx, C5	60	449	600	490	0	150		130		15.00
P7	ZnSn90, C-1	60	650	600	490	0	600		130		15.20
	Ag, C-8	11.61	422	700	0	0	0				13.30
	NiCr, C-10	13	552/336.3	150	55	0	55				4.91
	ZnSn, C-16	60	522	400	1200	0	250		130		9.50
P9	SiAl, C-3	60	621	400	0	420		250		130	23.59

	TY	Ta*	Tb*	RFY	RFa*	RFb*	RGY	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	69.2	-4.4	8.4	10.1	-2.1	-7.8	12.0	**-0.3**	**-15.3**	2.32			
HT	69.8	-3.4	7.1	9.5	-2.6	-7.8	11.4	**0.4**	**-14.7**	2.09	1.3	1.2	1.7
HTX	70.0	-4.1	6.7	9.6	-3.4	-8.5	11.7	**0.2**	**-13.6**	2.07	1.8	1.7	1.8
HTXXX	69.5	-5.2	4.7	9.3	-2.9	-9.6	12.2	**-0.6**	**-10.5**	2.07	4.7	2.5	3.8

Fig. 41
Example 24

	Target Materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	Si3N4, C3	60		400		420		250		130	10.01
P2 rev	NiCr-N, C10	**4.5**		150		10		10			1.48
	Si3N4, C3	60		400		420		250		130	10.01
P4 rev	SiZrOx, C5	60	449	600	490	0	150		130		4.00
P5	ZnSn90, C1	60	650	600	490	0	600		130		10.73
	Ag, C-8	8.45	429	700	0	0	0				9.70
	NiCr, C-10	13	552/336.3	150	**58**	0	**58**				4.91
	ZnSn, C-16	60	522	400	1200	0	250		130		61.28
P6 rev	SiZrOx, C5	60	449	600	490	0	150		130		25.00
P7	ZnSn90, C-1	60	650	600	490	0	600		130		15.20
	Ag, C-8	11.61	422	700	0	0	0				13.30
	NiCr, C-10	13	552/336.3	150	55	0	55				4.91
	ZnSn, C-16	60	522	400	1200	0	250		130		9.50
P9	SiAl, C-3	60	621	400	0	420		250		130	23.59

	TY	Ta*	Tb*	RFY	RFa*	RFb*	RGY	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	66.4	-4.5	10.3	13.0	0.8	-6.9	15.4	**0.0**	**-14.3**	2.34			
HT	67.5	-3.5	8.8	12.1	-0.1	-5.8	14.6	**0.7**	**-13.4**	2.15	1.5	2.0	1.8
HTX	67.0	-4.2	8.3	11.7	-0.7	-7.0	14.6	**0.7**	**-13.7**	2.16	1.5	2.6	2.1
HTXXX	67.1	-5.2	6.8	12.5	-1.8	-8.7	16.0	**0.7**	**-12.3**	2.11	2.3	3.2	3.6

Fig. 42
Example 25

	Target Materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	SiZrOx, C8	60	515	600	490		150		130		20.0
P2 Rev	ZnSn90, C-1	60	650	600	490		600		130		29.1
P3	SiZrOx, C8	60	515	600	490		150		130		6.0
P4	ZnAl, C3	50	457	400	930		250		130		10.1
	Ag, C-10	8.8	379	700							10.9
	NiCr, C-12	14	563	150	70		70				3.7
P5 rev	ZnSn50, C-16	60	520	400	1200		250		130		60.0
	SiZrOx, C8	**60**	**515**	**600**	**490**		**150**		**130**		6.0
P6	ZnAl, C3	50	457	400	930		250		130		19.1
	Ag, C-10	11.85	396	700							14.9
	NiCr, C-12	14	567	150	70		70				3.7
P7 rev	ZnSn50, C-16	60	522	400	1200		250		130		9.4
P8	SiAl, C-14	30	563	400		150		250		130	20.3

	TY(%)	Ta*	Tb*	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	74.8	-5.0	6.4	6.8	-3.3	-9.6	7.6	**2.9**	**-18.3**	2.37			
HT	77.1	-3.4	5.3	7.2	-3.1	-9.7	7.6	**2.4**	**-16.5**	2.09	1.8	1.0	2.2
HTX	78.0	-3.4	5.7	7.3	-3.8	-10.3	7.4	**2.3**	**-17.4**	2.01	1.2	1.4	2.2
HTXXX	79.1	-3.8	6.2	7.4	-3.9	-12.2	7.5	**2.1**	**-17.8**	2.03	1.0	3.0	2.3

Fig. 43
Example 26

	Target Materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	SiZrOx, C8	60	515	600	490		150		130		20.0
P3	ZnSn90, C-1	60	650	600	490		600		130		27.5
	ZnAl, C3	50	457	600	930		250		130		13.5
	Ag, C-10	8.8	379	700							10.9
	NiCr, C-12	14	563	150	70		70				3.7
P4 rev	ZnSn50, C-16	60	520	400	1200		250		130		60.6
	SiZrOx, C8	**60**	**515**	**600**	**490**		**150**		**130**		6.0
P5	**ZnAl, C3**	50	457	600	930		250		130		19.1
	Ag, C-10	11.85	396	700							14.9
	NiCr, C-12	14	567	150	70		70				3.7
P6 rev	ZnSn50, C-16	60	522	400	1200		250		130		9.4
P7	SiAl, C-14	50	563	400		330		250		130	20.4

	TY(%)	Ta*	Tb*	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	74.5	-4.4	5.1	7.0	-3.5	-3.6	7.8	**0.1**	**-12.4**	2.37			
HT	75.9	-3.2	4.0	7.1	-2.5	-5.6	7.8	**0.2**	**-10.6**	2.15	1.8	2.2	1.7
HTX	76.9	-3.4	4.3	7.2	-2.7	-6.3	7.8	**-0.2**	**-10.5**	2.09	1.9	2.8	1.7
HTXXX	77.3	-3.9	3.9	7.0	-2.0	-7.6	7.6	**-0.6**	**-9.9**	2.09	2.6	4.3	1.8

Fig. 44
Example 27

	Target Material	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	SiZrOx, C8	60	515	600	490		150		130		20.0
P3	ZnSn90, C-1	60	650	600	490		600		130		39.10
	Ag, C-10	9.20	379	700							11.42
	NiCr, C-12	14	563	150	75		75				3.73
P4 rev	ZnSn50, C-16	60	520	400	1200		250		130		55.18
P5	ZnSn90, C-1	60	650	600	490		600		130		18.35
	Ag, C-10	**10.64**	396	700							13.34
	NiCr, C-12	14	567	150	75		75				3.73
P6 rev	ZnSn50, C-16	60	522	400	1200		250		130		9.41
P7	SiAl, C-14	30	563	400		150		250		130	20.80

	TY(%)	Ta*	Tb*	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	76.4	-4.0	2.8	4.8	-5.5	-6.7	6.1	**-0.2**	**-2.2**	2.32			
HT	78.0	-2.4	2.2	5.2	-3.3	-8.4	6.1	**-0.8**	**-2.9**	2.21	0.9	3.0	1.9
HTX	78.8	-2.6	2.6	5.4	-3.0	-8.5	6.3	**-0.9**	**-3.1**	2.12	1.3	3.6	1.8
HTXXX	79.8	-3.1	2.8	5.7	-1.5	-8.8	6.6	**-0.5**	**-3.6**	2.2	1.8	5.3	1.8

Fig. 45
Example 28

	Target Materials	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	SiZrOx, C8	60	515	600	490		150		130		20.0
P3	ZnSn90, C-1	60	650	600	490		600		130		39.10
	Ag, C-10	9.20	379	700							11.42
	NiCr, C-12	14	563	150	75		75				3.73
P4 rev	ZnSn50, C-16	60	520	400	1200		250		130		53.74
	SiZrOx, C8	60	515	600	490		150		130		5.0
P5	ZnSn90, C-1	60	650	600	490		600		130		18.35
	Ag, C-10	10.64	396	700							13.34
	NiCr, C-12	14	567	150	75		75				3.73
P6 rev	ZnSn50, C-16	60	522	400	1200		250		130		9.41
P7	SiAl, C-14	30	563	400		150		250		130	20.80

	TY(%)	Ta*	Tb*	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	76.6	-4.1	3.0	4.6	-5.8	-5.4	5.8	**1.2**	**-4.3**	2.39			
HT	76.8	-2.4	2.0	4.7	-3.8	-7.3	5.7	**0.4**	**-4.2**		0.8	2.7	2.0
HTX	78.2	-2.6	2.4	5.1	-3.1	-7.0	5.9	**0.1**	**-3.8**	2.21	1.2	3.4	1.7
HTXXX	79.1	-3.5	2.4	5.1	-1.1	-8.1	6.0	**-0.1**	**-4.2**	2.11	1.4	5.6	1.4

Fig. 46
Example 29

	Target Material	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
P1	SiZrOx, C8	60	515	600	490		150		130		20.0
P3	ZnSn90, C-1	60	650	600	490		600		130		26.3
	ZnAl, C3	50	457	600	930		250		130		12.8
	Ag, C-10	9.20	379	700							11.42
	NiCr, C-12	14	563	150	75		75				3.73
P4 rev	ZnSn50, C-16	60	520	400	1200		250		130		55.18
P5	ZnAl, C3	50	457	600	930		250		130		18.3
	Ag, C-10	10.64	396	700							13.34
	NiCr, C-12	14	567	150	75		75				3.73
P6 rev	ZnSn50, C-16	60	522	400	1200		250		130		9.41
P7	SiAl, C-14	30	563	400		150		250		130	20.80

	TY(%)	Ta*	Tb*	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	76.3	-3.7	1.4	3.6	-5.1	-3.2	5.7	**0.6**	**0.4**	2.21			
HT	77.3	-3.0	0.7	4.1	-1.9	-5.4	5.9	**-0.2**	**-0.5**	2.14	1.3	4.2	1.1
HTX	77.6	-3.5	0.7	4.4	-1.2	-5.2	5.6	**-0.1**	**-1.6**	2.09	2.1	5.0	0.9
HTXXX	77.7	-4.2	0.3	4.8	0.9	-5.2	6.4	**0.7**	**-0.2**	2.03	1.7	7.3	1.3

Fig. 47
Example 30

Target Materials (in order moving away from glass)	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
Zr, C-12	50	515	600	0		520				10.0
ZnSn90, C-1	60	650	600	840		250		130		22.3
Ag, C-8	13.55	379	700							15.3
NiCr, C-10	10.2	332mv/564v	150	56		56				4.0
ZnSn50, C-16	60	225mv/439v	400	1200		250		130		28.0
Zr, C12	50	515	600	0		520		0		10.0
ZnSn90, C-1	60	650	600	840		250		130		10.0
Ag, C-8	1.4	379	700							0.9
NiCr, C-10	10.2	332mv/564v	150	56		56				6.6
ZnSn90, C-1	60	228mv/700v	600	840		250		130		33.1
Ag, C-8	12.86	326mv/535v	700							15.6
NiCr, C-10	10.2	333mv/561v	150	56		56				4.0
ZnSn50, C-16	60	225mv/439v	400	1200		250		130		10.3
SiAl, C-3	60	563	400		420		250		130	21.4

	TY(%)	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	53.8	9.7	-13.2	-18.2	16.2	-1.3	-10.9	1.61			
HT	53.7	10.8	-14.6	-15.9	16.2	-0.9	-10.6	1.53	0.5	3.3	2.6
HTX	52.8	10.4	-14.2	-17.6	16.0	0.8	-10.9	1.5	2.1	1.7	3.0

Fig. 48
Example 31

Target Materials (in order moving away from glass)	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
Zr, C-12	50	515	600	0		520				10.0
ZnSn90, C-1	60	650	600	840		250		130		22.3
Ag, C-8	13.55	379	700							15.3
NiCr, C-10	10.2	332mv/564v	150	58		58				4.0
ZnSn50, C-16	60	225mv/439v	400	1200		250		130		28.0
Zr, C12	50	515	600	0		520		0		10.0
ZnSn90, C-1	60	650	600	840		250		130		10.0
Ag, C-8	1.4	379	700							0.9
NiCr, C-10	10.2	332mv/564v	150	58		58				6.6
ZnSn90, C-1	60	228mv/700v	600	840		250		130		33.1
Ag, C-8	12.86	326mv/535v	700							15.6
NiCr, C-10	10.2	333mv/561v	150	58		58				4.0
ZnSn50, C-16	60	225mv/439v	400	1200		250		130		10.3
SiAl, C-3	60	563	400		420		250		130	21.4

	TY(%)	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	53.8	10.8	-14.8	-16.3	17.1	-2.4	-10.0	1.6			
HT	51.8	11.4	-15.9	-15.5	17.2	-2.8	-9.6	1.52	0.6	1.8	3.0
HTX	51.8	10.8	-16.0	-18.1	17.2	-1.4	-10.1	1.5	1.0	2.2	3.1

Fig. 49
Example 32

Target Materials (in order moving away from glass)	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
Zr, C-5	50	515	600	0		520				10.0
ZnSn90, C-1	60	650	600	840		250		130		22.3
Ag, C-8	13.87	379	700							15.3
NiCr, C-10	10.4	337mv/552v	150	55		55				4.0
ZnSn50, C-16	60	225mv/439v	400	1200		250		130		28.0
Zr, C-5	50	515	600	0		520		0		10.0
ZnSn90, C-1	60	650	600	840		250		130		10.0
Ag, C-8	1.4	379	700							1.0
NiCr, C-10	10.4	332mv/564v	150	58		58				7.8
ZnSn90, C-1	60	228mv/700v	600	840		250		130		33.3
Ag, C-8	13.31	326mv/535v	700							15.6
NiCr, C-10	10.4	333mv/561v	150	55		55				4.0
ZnSn90, C-1	60	650	600	840		250		130		10.0
SiAl, C-12	60	563	400		420		250		130	21.5

	TY(%)	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	53.6	10.8	-12.4	-14.7	17.0	-0.8	-10.3	1.68			
HT	54.8	11.7	-13.2	-13.9	16.6	-1.8	-9.8	1.53	1.3	1.9	2.9
HTX	53.0	12.0	-12.4	-13.2	16.5	0.5	-10.2	1.52	1.4	2.6	3.7

Fig. 50
Example 33

Target Materials (in order moving away from glass)	Power, kW	Voltage	Ar, ml	O2 setpoint	N2 setpoint	O2 tune, ml	N2 tune	O2 offset, ml	N2 offset, ml	Layer Thickness (nm)
Zr, C-5	50	515	600	0		520				10.0
ZnSn90, C-1	60	650	600	840		250		130		22.3
Ag, C-8	13.95	379	700							15.3
NiCr, C-10	10.4	337mv/552v	150	56		56				4.0
ZnSn50, C-16	60	225mv/439v	400	1200		250		130		28.0
Zr, C-5	50	515	600	0		520		0		10.0
ZnSn90, C-1	60	650	600	840		250		130		10.0
Ag, C-8	1.4	379	700							1.1
NiCr, C-10	10.4	332mv/564v	150	58		58				8.1
ZnSn90, C-1	60	228mv/700v	600	840		250		130		33.8
Ag, C-8	13.24	326mv/535v	700							15.6
NiCr, C-10	10.4	333mv/561v	150	56		56				4.0
ZnSn90, C-1	60	650	600	840		250		130		10.0
SiAl, C-12	60	563	400		420		250		130	21.4

	TY(%)	RFY(%)	RFa*	RFb*	RGY(%)	RGa*	RGb*	Rs	ΔE^*_G	ΔE^*_F	ΔE^*_T
AC	52.6	11.9	-14.9	-11.6	18.0	-2.9	-8.4	1.66			
HT	52.9	11.5	-15.8	-12.6	17.5	-3.1	-8.6	1.54	0.7	1.5	2.4
HTX	52.8	12.5	-14.3	-11.2	18.4	-3.1	-8.5	1.72	0.5	1.2	0.5

LOW-E MATCHABLE COATED ARTICLES HAVING ABSORBER FILM AND CORRESPONDING METHODS

This application is a Continuation-in-Part (CIP) of U.S. application Ser. No. 16/035,810, filed Jul. 16, 2018, and U.S. application Ser. No. 16/220,037, filed Dec. 14, 2018, the disclosures of which are hereby incorporated herein by reference in their entireties.

This invention relates to low-E coated articles that have approximately the same color characteristics as viewed by the naked eye both before and after heat treatment (e.g., thermal tempering), and corresponding methods. Such articles may in certain example embodiments combine two or more of: (1) desirable visible transmission characteristics, (2) good durability before and/or after heat treatment, (3) a low ΔE* value which is indicative of color stability upon heat treatment (HT), and/or (4) an absorber film designed to adjust visible transmission and provide desirable coloration for the coated article, while maintaining durability and/or thermal stability. Such coated articles may be used monolithically for windows, in insulating glass (IG) window units, laminated window units, vehicle windshields, and/or other vehicle or architectural or residential window applications.

BACKGROUND OF THE INVENTION

There is a need for substantial matchability (before heat treatment vs. after heat treatment). Glass substrates are often produced in large quantities and cut to size in order to fulfill the needs of a particular situation such as a new multi-window office building, vehicle window needs, etc. It is often desirable in such applications that some of the windows and/or doors be heat treated (i.e., tempered, heat strengthened or heat-bent) while others need not be. Office buildings often employ IG units and/or laminates for safety and/or thermal control. It is desirable that the units and/or laminates which are heat treated (HT) substantially match their non-heat treated counterparts (e.g., with regard to color, reflectance, transmission, and/or the like, at least on the side to be viewed from outside the building) for architectural and/or aesthetic purposes.

Commonly owned U.S. Pat. No. 5,688,585 discloses a solar control coated article including: glass/Si_3N_4/NiCr/Si_3N_4. One object of the '585 patent is to provide a sputter coated layer system that after heat treatment (HT) is matchable colorwise with its non-heat treated counterpart. While the coating systems of the '585 patent are excellent for their intended purposes, they suffer from certain disadvantages. In particular, they tend to have rather high emissivity and/or sheet resistance values (e.g., because no silver (Ag) layer is disclosed in the '585 patent).

It has in the prior art been possible to achieve matchability in systems other than those of the aforesaid '585 patent, between two different layer systems, one of which is heat treated and the other is not. The necessity of developing and using two different layer systems to achieve matchability creates additional manufacturing expense and inventory needs which are undesirable.

U.S. Pat. Nos. 6,014,872 and 5,800,933 (see Example B) disclose a heat treatable low-E layer system including: glass/TiO_2/Si_3N_4/NiCr/Ag/NiCr/Si_3N_4. Unfortunately, when heat treated this low-E layer system is not approximately matchable colorwise with its non-heat treated counterpart (as viewed from the glass side). This is because this low-E layer system has a ΔE* (glass side) value greater than 4.1 (i.e., for Example B, Δa^*_G is 1.49, Δb^*_G is 3.81, and ΔL* (glass side) is not measured; using Equation (1) below then ΔE* on the glass side must necessarily be greater than 4.1 and is probably much higher than that).

U.S. Pat. No. 5,563,734 discloses a low-E coating system including: substrate/TiO_2/$NiCrN_x$/Ag/$NiCrN_x$/Si_3N_4. Unfortunately, it has been found that when high Nitrogen (N) flow rates are used when forming the $NiCrN_x$ layers (see the high N flow rate of 143 sccm in Table 1 of the '734 patent; translating into about 22 sccm/kW), the resulting coated articles are not color stable with heat treatment (i.e., they tend to have high ΔE* (glass side) values greater than 6.0). In other words, if subjected to HT, the '734 patent low-E layer system would not be approximately matchable colorwise with its non-heat treated counterpart (as viewed from the glass side).

Moreover, it is sometimes desirable for a coated article to have desitable visible transmission characteristics and/or good durability (mechanical and/or chemical). Unfortunately, certain known steps that are taken to adjust or improve visible transmission characteristics and/or pre-HT durability tend to degrade post-HT durability and thermal stability. Thus, it is often difficult to obtain a combination of desirable visible transmission values, thermal stability of color, and good durability.

In view of the above, it will be apparent to those skilled in the art that there exists a need for a low-E coating or layer system that after HT substantially matches in color and/or reflection (as viewed by a naked human eye) its non-heat treated counterpart. In other words, there exists a need in the art for a low-E matchable coating or layering system. There also exists a need in the art for a heat treatable system that can combine one or more of: (1) desirable visible transmission characteristics (e.g., from about 30-75% measured monolithically, and/or from 30-70% as measured in an IG unit), (2) good durability before and/or after heat treatment, (3) a low ΔE* value which is indicative of color stability upon heat treatment (HT), and/or (4) an absorber film designed to adjust visible transmission and provide desirable coloration for the coated article, while maintaining durability and/or thermal stability.

It is a purpose of this invention to fulfill one or more of the above-listed needs, and/or other needs which will become more apparent to the skilled artisan once given the following disclosure.

SUMMARY

An example object of this invention is to provide a low-E coating or layer system that has good color stability (a low ΔE* value) upon heat treatment (HT). Another example object of this invention is to provide a low-E matchable coating or layering system. Another example object is to provide an absorber film in the low-E coating which is designed to adjust visible transmission and provide desirable coloration for the coated article, while maintaining durability and/or thermal stability

Example embodiments of this invention relate to low-E coated articles that have approximately the same color characteristics as viewed by the naked eye both before and after heat treatment (e.g., thermal tempering), and corresponding methods. Such articles may in certain example embodiments combine two or more of: (1) desirable visible transmission characteristics, (2) good durability before and/or after heat treatment, (3) a low ΔE* value which is indicative of color stability upon heat treatment (HT), and/or (4) an absorber film designed to adjust visible transmission

and provide desirable coloration for the coated article, while maintaining durability and/or thermal stability.

In certain example embodiments, the absorber film may be a multi-layer absorber film including a first layer of or including silver (Ag), and a second layer of or including NiCr which may be partially or fully oxided ($NiCrO_x$). Such a multi-layer absorber film may thus, in certain example embodiments, be made up of a layer sequence of $Ag/NiCrO_x$. This layer sequence may be repeated in certain example instances. The silver based layer in the absorber film is preferably sufficiently thin so that its primary function is to absorb visible light and provide desirable coloration (as opposed to being much thicker and primarily function as an IR reflection layer). The NiCr or $NiCrO_x$ is provided over and contacting the silver of the absorber film in order to protect the silver, and also to contribute to absorption.

A single layer of NiCr (or other suitable material) may also be used as an absorber film in low-E coatings in certain example embodiments of this invention. However, it has surprisingly been found that using silver in an absorber film (single layer, or multi-layer, absorber film) provides for several unexpected advantages compared to a single layer of NiCr as the absorber. First, it has been found that a single layer of NiCr as the absorber tends to cause yellowish coloration in certain low-E coating coated articles, which may not be desirable in certain instances. In contrast, it has been surprisingly found that using silver in an absorber films tends to avoid such yellowish coloration and/or instead provide for more desirable neutral coloration of the resulting coated article. Thus, the use of silver in an absorber film has been found to provide for improved optical characteristics. Second, the use of a single layer of NiCr as the absorber tends to also involve providing silicon nitride based layers on both sides of the NiCr so as to directly sandwich and contact the NiCr therebetween. It has been found that the provision of silicon nitride in certain locations in a coating stack may lead to compromised thermal stability upon HT. In contrast, it has been surprisingly found that when using silver in an absorber film a pair of immediately adjacent silicon nitride layers are not needed, so that thermal stability upon HT may be improved. Thus, the use of silver in an absorber film has been found to provide for improved thermal stability including lower ΔE* values and therefor improved matchability between HT and non-HT versions of the same coating. The use of silver in an absorber film may also provide for improved manufacturability in certain situations.

In certain example embodiments, surprisingly, and unexpectedly, it has been found that the provision of an as-deposited crystalline or substantially crystalline (e.g., at least 50% crystalline, more preferably at least 60% crystalline) layer of or including zinc oxide, doped with at least one dopant (e.g., Sn), immediately under an infrared (IR) reflecting layer of or including silver in a low-E coating has effect of significantly improving the coating's thermal stability (i.e., lowering the ΔE* value). One or more such crystalline, or substantially crystalline (e.g., at least 50% crystalline, more preferably at least 60% crystalline), layers may be provided under one or more corresponding IR reflecting layers comprising silver, in various embodiments of this invention. Thus, the crystalline or substantially crystalline layer of or including zinc oxide, doped with at least one dopant (e.g., Sn), immediately under an infrared (IR) reflecting layer of or including silver may be used in single silver low-E coatings, double-silver low-E coatings, or triple silver low-E coatings in various embodiments of this invention. In certain example embodiments, the crystalline or substantially crystalline layer of or including zinc oxide is doped with from about 1-30% Sn, more preferably from about 1-20% Sn, most preferably from about 5-15% Sn, with an example being about 10% Sn (in terms of wt. %). The zinc oxide, doped with Sn, is in a crystallized or substantially crystallized phase (as opposed to amorphous or nanocrystalline) as deposited, such as via sputter deposition techniques from at least one sputtering target(s) of or including Zn and Sn. The crystallized phase of the doped zinc oxide based layer as deposited, combined with the layer(s) between the silver and the glass, allows the coated article to realize improved thermal stability upon optional HT (lower the ΔE* value). It is believed that the crystallized phase of the doped zinc oxide based layer as deposited (e.g., at least 50% crystalline, more preferably at least 60% crystalline), combined with the layer(s) between the IR reflecting layer and the glass, allows the silver of the IR reflecting layer to have improved crystal structure with texture but with some randomly oriented grains so that its refractive index (n) changes less upon optional HT, thereby allowing for improved thermal stability to be realized.

In certain example embodiments, it has also been surprisingly and unexpectedly found that the provision of a dielectric layer(s) of or including silicon oxide, zirconium oxide, silicon zirconium oxide and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, and/or $SiZrO_xN_y$) also provides for improved thermal stability of the coated article, and thus lower the ΔE* values upon heat treatment (HT) such as thermal tempering. In certain example embodiments, at least one dielectric layer(s) of or including silicon oxide, zirconium oxide, silicon zirconium oxide and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, and/or $SiZrO_xN_y$) may be provided: (i) in the bottom dielectric portion of the coating under all silver based IR reflecting layer(s), and/or (ii) in a middle dielectric portion of the coating between a pair of silver based IR reflecting layers. For example, the dielectric layer of or including silicon oxide, zirconium oxide, silicon zirconium oxide and/or silicon zirconium oxynitride may be provided directly under and contacting the lowermost doped zinc oxide based layer in certain example embodiments of this invention, and/or between a pair of zinc oxide inclusive layers in a middle dielectric portion of the low-E coating.

The dielectric layer(s) of or including silicon oxide, zirconium oxide, silicon zirconium oxide and/or silicon zirconium oxynitride may or may not be provided in combination with an as-deposited crystalline or substantially crystalline (e.g., at least 50% crystalline, more preferably at least 60% crystalline) layer(s) of or including zinc oxide, doped with at least one dopant (e.g., Sn), immediately under an infrared (IR) reflecting layer, in various example embodiments of this invention.

It has also been surprisingly and unexpectedly found that the provision of no silicon nitride based layer directly under and contacting the lowermost doped zinc oxide based layer between the glass substrate and the lowermost silver based layer, in combination with the crystallized phase of the doped zinc oxide based layer as deposited, allows for improved thermal stability upon heat treatment (lower ΔE* values) to be realized. It has also been surprisingly and unexpectedly found that the provision of no silicon nitride based layer in the middle section of the stack between the two silver-based IR reflecting layers allows for improved thermal stability upon heat treatment (lower ΔE* values) to be realized.

In certain example embodiments, measured monolithically, the coated article is configured to realize one or more

of: (i) a transmissive ΔE* value (where transmissive optics are measured) of no greater than 3.0 (more preferably no greater than 2.5, and most preferably no greater than 2.3) upon HT for 8, 12 and/or 16 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value (where glass side reflective optics are measured) of no greater than 3.0 (more preferably no greater than 2.5, more preferably no greater than 2.0, and most preferably no greater than 1.5 or 1.0) upon HT for 8, 12 and/or 16 minutes at a temperature of about 650 degrees C., and/or (iii) a film side reflective ΔE* value (where film side reflective optics are measured) of no greater than 3.5 (more preferably no greater than 3.0, and most preferably no greater than 2.0) upon HT for 8, 12, 16 and/or 20 minutes at a temperature of about 650 degrees C. Of course, in commercial practice the baking times may be for different/other time periods, and these are for reference purposes. In certain example embodiments, measured monolithically, the coated article is configured to have a visible transmission (T_{vis} or Y), before or after any optional HT, of at least about 30%, more preferably of at least about 40%, and most preferably of at least about 50% (e.g., from about 45-60%). Coated articles herein may have, for example, visible transmission from about 30-75% measured monolithically, and/or from 30-70% as measured in an IG unit. Among other things, the thickness, makeup, and/or number of layers of the absorber may be adjusted to adjust visible transmission. In certain example embodiments, measured monolithically, the coated article is configured to have a glass side visible reflection (R_gY or RGY), measured monolithically, before or after any optional HT, of no greater than about 20%.

In an example embodiment of this invention, there is provided a coated article including a coating on a glass substrate, wherein the coating comprises: a first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), provided on the glass substrate; a first infrared (IR) reflecting layer comprising silver located on the glass substrate and directly over and contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn; wherein no silicon nitride based layer is located directly under and contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn; at least one dielectric layer comprising at least one of: (a) an oxide of silicon and zirconium, (b) an oxide of zirconium, and (c) an oxide of silicon; wherein the at least one dielectric layer comprising at least one of (a), (b), and (c) is located: (1) between at least the glass substrate and the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), and/or (2) between at least the first IR reflecting layer comprising silver and a second IR reflecting layer comprising silver of the coating; an absorber film including a layer comprising silver, wherein a ratio of a physical thickness of the first IR reflecting layer comprising silver to a physical thickness of the layer comprising silver of the absorber film is at least 5:1 (more preferably at least 8:1, even more preferably at least 10:1, and most preferably at least 15:1); and wherein the coated article is configured to have, measured monolithically, at least two of: (i) a transmissive ΔE* value of no greater than 3.0 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

In an example embodiment of this invention, there is provided a coated article including a coating on a glass substrate, wherein the coating comprises: a first dielectric layer located on the glass substrate; a first infrared (IR) reflecting layer comprising silver located on the glass substrate and over the first dielectric layer; a second IR reflecting layer comprising silver located on the glass substrate, wherein the first IR reflecting layer comprising silver is located between the glass substrate and the second IR reflecting layer comprising silver; an absorber film including a layer comprising silver, at least a second dielectric layer between at least the first IR reflecting layer and the absorber film, and at least a third dielectric layer between at least the second IR reflecting layer and the absorber film; wherein a ratio of a physical thickness of the first IR reflecting layer comprising silver, and/or a physical thickness of the second IR reflecting layer comprising silver, to a physical thickness of the layer comprising silver of the absorber film is at least 5:1, more preferably at least 8:1, more preferably at least 10:1, and still more preferably at least 15:1.

Such coated articles may be used monolithically for windows, in insulating glass (IG) window units (e.g., on surface #2 or surface #3 in IG window unit applications), laminated window units, vehicle windshields, and/or other vehicle or architectural or residential window applications.

This invention will now be described with respect to certain embodiments thereof as illustrated in the following drawings, wherein:

IN THE DRAWINGS

FIGS. **1**(*a*), **1**(*b*), **1**(*c*), **1**(*d*), **1**(*e*), **1**(*f*), **1**(*g*), **1**(*h*), and **1**(*i*) are cross sectional views of coated articles according to example embodiments of this invention.

FIG. **2** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 1 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*a*).

FIG. **3** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 2 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*a*).

FIG. **4** is a chart illustrating optical characteristics of Example 1: as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column.

FIG. **5** is a chart illustrating optical characteristics of Example 2: as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column.

FIG. **6** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 3 on a 3.1 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*a*).

FIG. **7** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 4 on a 3.1 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*a*).

FIG. **8** is a chart illustrating optical characteristics of Examples 3-4: as coated (annealed) before heat treatment in

the left-most data column, after 8 minutes of heat treatment at 650 degrees C. (HT), after 12 minutes of HT at 650 degrees C. (HTX), and after 20 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column.

FIG. **9** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 5 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*a*).

FIG. **10** is a chart illustrating optical characteristics of Example 5: as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column.

FIG. **11** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 6 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*a*).

FIG. **12** is a chart illustrating optical characteristics of Example 6: as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column.

FIG. **13** is chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 7 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*a*).

FIG. **14** is a chart illustrating optical characteristics of Example 7: as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column.

FIG. **15** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 8 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*a*).

FIG. **16** is a wavelength (nm) vs. refractive index (n) graph illustrating the change in refractive index of the silver layer of Example 8 from the as coated (AC) state to the heat treated (HT) state.

FIG. **17** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 9 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*a*).

FIG. **18** is a chart illustrating optical characteristics of Example 9: as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), and after 16 minutes of HT at 650 degrees C. (HTX) in the far right data column.

FIG. **19** is a cross sectional view of a first Comparative Example coated article.

FIG. **20** is a cross sectional view of a coated article according to an embodiment of this invention, illustrating coatings of Examples 1-10.

FIG. **21** is chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 10 on a 3.1 mm thick glass substrate, where the low-E coating is illustrated in general by FIGS. **1**(*a*) and **10**.

FIG. **22** is an XRD Lin (Cps) vs. 2-Theta-Scale graph illustrating, for Example 10, the relative small 66% change in peak height of Ag (111) due to HT.

FIG. **23** is an XRD Lin (Cps) vs. 2-Theta-Scale graph illustrating, for the first Comparative Example (CE), the relative large 166% change in peak height of Ag (111) due to HT.

FIG. **24** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 11 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*b*).

FIG. **25** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 12 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*b*).

FIG. **26** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 13 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*b*).

FIG. **27** is a chart illustrating optical characteristics of Examples 11-13: as coated (annealed) before heat treatment in the left-most data column of each, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column of each.

FIG. **28** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 14 on a 6 mm thick glass substrate, where the low-E coating is illustrated in general by FIG. **1**(*b*).

FIG. **29** is a chart illustrating optical characteristics of Example 14: as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column.

FIG. **30** is chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coatings of Examples 15 and 16 on 6 mm thick glass substrates, where the low-E coatings of these examples are illustrated in general by FIG. **1**(*b*) with a bottommost dielectric layer of ZrO_2.

FIG. **31** is a chart illustrating optical characteristics of Examples 15 and 16: as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), and after 16 minutes of HT at 650 degrees C. (HTX) in the far right data column.

FIG. **32** is a chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coatings of Examples 17 and 18 on 6 mm thick glass substrates, where the low-E coatings of these examples are illustrated in general by FIG. **1**(*b*) with a bottommost dielectric layer of SiO_2 doped with about 8% Al (wt. %)

FIG. **33** is a chart illustrating optical characteristics of Examples 17 and 18: as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), and after 16 minutes of HT at 650 degrees C. (HTX) in the far right data column.

FIG. **34** is chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Comparative Example 2 (CE 2) on a 6 mm thick glass substrate.

FIG. **35** is a chart illustrating optical characteristics of Comparative Example 2 (CE 2): as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column.

FIG. **36** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 19 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*b*), and at the bottom portion illustrates optical characteristics of Example 19: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16

minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **37** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 20 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*e*), and at the bottom portion illustrates optical characteristics of Example 20: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **38** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 21 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*e*), and at the bottom portion illustrates optical characteristics of Example 21: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **39** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 22 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*d*), and at the bottom portion illustrates optical characteristics of Example 22: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **40** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 23 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*f*), and at the bottom portion illustrates optical characteristics of Example 23: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **41** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 24 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*f*), and at the bottom portion illustrates optical characteristics of Example 24: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **42** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 25 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*g*), and at the bottom portion illustrates optical characteristics of Example 25: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **43** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 26 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*h*), and at the bottom portion illustrates optical characteristics of Example 26: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **44** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 27 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*b*), and at the bottom portion illustrates optical characteristics of Example 27: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **45** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 28 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*e*), and at the bottom portion illustrates optical characteristics of Example 28: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **46** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 29 on a 6 mm thick glass substrate where the low-E coating is illustrated in general by FIG. **1**(*h*) except that no layer **2"** is provided in Example 29, and at the bottom portion illustrates optical characteristics of Example 29: as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX).

FIG. **47** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 30 on a 6 mm thick clear glass substrate where the low-E coating is illustrated in general by FIG. **1**(*i*); and at the bottom portion illustrates optical characteristics of Example 30 measured monolithically as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), and after 16 minutes of HT at 650 degrees C. (HTX).

FIG. **48** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 31 on a 6 mm thick clear glass substrate where the low-E coating is illustrated in general by FIG. **1**(*i*); and at the bottom portion illustrates optical characteristics of Example 31 measured monolithically as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), and after 16 minutes of HT at 650 degrees C. (HTX).

FIG. **49** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 32 on a 6 mm thick clear glass substrate where the low-E coating is illustrated in general by FIG. **1**(*i*); and at the bottom portion illustrates optical characteristics of Example 32 measured monolithically as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), and after 16 minutes of HT at 650 degrees C. (HTX).

FIG. **50** illustrates at the top portion sputter-deposition conditions for the sputter-deposition of the low-E coating of Example 33 on a 6 mm thick clear glass substrate where the low-E coating is illustrated in general by FIG. **1**(*i*); and at the bottom portion illustrates optical characteristics of Example 33 measured monolithically as coated (annealed; AC) before heat treatment, after 12 minutes of heat treatment at 650 degrees C. (HT), and after 16 minutes of HT at 650 degrees C. (HTX).

DETAILED DESCRIPTION OF CERTAIN EXEMPLARY EMBODIMENTS OF THE INVENTION

Referring now more particularly to the accompanying drawings in which like reference numerals indicate like parts/layers/materials throughout the several views.

Certain embodiments of this invention provide a coating or layer system that may be used in coated articles that may be used monolithically for windows, in insulating glass (IG) window units (e.g., on surface #2 or surface #3 in IG window unit applications), laminated window units, vehicle windshields, and/or other vehicle or architectural or residential window applications. Certain embodiments of this invention provide a layer system that combines one or more of high visible transmission, good durability (mechanical and/or chemical) before and/or after HT, and good color stability upon heat treatment. It will be shown herein how certain layers stacks surprisingly enable this unique combination.

With regard to color stability, certain embodiments of this invention have excellent color stability (i.e., a low value of ΔE*; where A is indicative of change in view of heat treatment) with heat treatment (e.g., thermal tempering or heat bending) monolithically and/or in the context of dual pane environments such as IG units or windshields. Such heat treatments (HTs) often necessitate heating the coated substrate to temperatures of at least about 1100° F. (593° C.) and up to 1450° F. (788° C.) [more preferably from about 1100 to 1200 degrees F., and most preferably from 1150-1200 degrees F.] for a sufficient period of time to insure the end result (e.g., tempering, bending, and/or heat strengthening). Certain embodiments of this invention combine one or more of (i) color stability with heat treatment, and (ii) the use of a silver inclusive layer for selective IR reflection.

Example embodiments of this invention relate to low-E coated articles that have approximately the same color characteristics as viewed by the naked eye both before and after heat treatment (e.g., thermal tempering), and corresponding methods. Such articles may in certain example embodiments combine one or more of: (1) desirable visible transmission characteristics, (2) good durability before and/or after heat treatment, (3) a low ΔE* value which is indicative of color stability upon heat treatment (HT), and/or (4) an absorber film designed to adjust visible transmission and provide desirable coloration for the coated article, while maintaining durability and/or thermal stability.

In certain example embodiments, the absorber film may be a multi-layer absorber film including a first layer **57** of or including silver (Ag), and a second layer **59** of or including NiCr which may be partially or fully oxided ($NiCrO_x$). See FIG. **1**(*i*) for example. Such a multi-layer absorber film **57**, **59** may thus, in certain example embodiments, be made up of a layer sequence of $Ag/NiCrO_x$. Elements from one layer may diffuse into an adjacent layer due to HT or other factors. The NiCr based layer **59** of the absorber may be initially deposited in metallic form, or as a suboxide, in certain example embodiments. The silver based layer **57** may be a continuous layer, and/or may optionally be doped, in certain example embodiments. Moreover, the silver based layer **57** of the absorber film is preferably sufficiently thin so that its primary function is to absorb visible light and provide desirable coloration (as opposed to being much thicker and primarily function as an IR reflection layer). The NiCr or $NiCrO_x$ **59** is provided over and contacting the silver **57** of the absorber film in order to protect the silver, and also to contribute to absorption. In certain example embodiments, the silver based layer **57** of the absorber film may be no more than about 60 Å thick, more preferably no more than about 30 Å thick, more preferably no greater than about 20 Å thick, and most preferably no greater than about 15 Å thick, and possibly no greater than about 12 Å thick, in certain example embodiments of this invention. In certain example embodiments, the NiCr based layer **59** of the absorber film may be from about 5-200 Å thick, more preferably from about 10-110 Å thick, and most preferably from about 40-90 Å thick.

A single layer of NiCr (or other suitable material) may also be used as an absorber film in low-E coatings in certain example embodiments of this invention. For example, see absorber film **42** in FIGS. **1**(*d*) and **1**(*f*). However, it has surprisingly been found that using silver **57** in an absorber film (single layer, or multi-layer, absorber film) provides for several unexpected advantages compared to a single layer of NiCr as the absorber. First, it has been found that a single layer of NiCr as the absorber tends to cause yellowish coloration in certain low-E coating coated articles, which may not be desirable in certain instances. In contrast, it has been surprisingly found that using silver **57** in an absorber films tends to avoid such yellowish coloration and/or instead provide for more desirable neutral coloration of the resulting coated article. Thus, the use of silver **57** in an absorber film has been found to provide for improved optical characteristics. Second, the use of a single layer of NiCr **42** as the absorber tends to also involve providing silicon nitride based layers on both sides of the NiCr so as to directly sandwich and contact the NiCr therebetween. For example, see FIGS. **1**(*d*) and **1**(*f*). It has been found that the provision of silicon nitride in certain locations in a coating stack may lead to compromised thermal stability upon HT. In contrast, it has been surprisingly found that when using silver in an absorber film a pair of immediately adjacent silicon nitride layers are not needed, so that thermal stability upon HT may be improved. Thus, the use of silver **57** in an absorber film has been found to provide for improved thermal stability including lower ΔE* values and therefor improved matchability between HT and non-HT versions of the same coating. The use of silver in an absorber film may also provide for improved manufacturability in certain situations.

Surprisingly, and unexpectedly, it has been found that the provision of an as-deposited crystalline or substantially crystalline layer **3**, **3"** (and/or **13**) (e.g., at least 50% crystalline, more preferably at least 60% crystalline) of or including zinc oxide, doped with at least one dopant (e.g., Sn), immediately under and directly contacting an infrared (IR) reflecting layer of or including silver **7** (and/or **19**) in a low-E coating **30** has the effect of significantly improving the coating's thermal stability (i.e., lowering the ΔE* value). "Substantially crystalline" as used herein means at least 50% crystalline, more preferably at least 60% crystalline, and most preferably at least 70% crystalline. One or more such crystalline, or substantially crystalline, layers **3**, **3"** **13** may be provided under one or more corresponding IR reflecting layers comprising silver **7**, **19**, in various example embodiments of this invention. Thus, the crystalline or substantially crystalline layer **3** (or **3"**) and/or **13** of or including zinc oxide, doped with at least one dopant (e.g., Sn), immediately under an infrared (IR) reflecting layer **7** and/or **19** of or including silver may be used in single silver low-E coatings, double-silver low-E coatings (e.g., such as shown in FIG. **1** or FIG. **20**), or triple silver low-E coatings in various embodiments of this invention. In certain example embodiments, the crystalline or substantially crystalline layer **3** and/or **13** of or including zinc oxide is doped with from about 1-30% Sn, more preferably from about 1-20% Sn, more preferably from about 5-15% Sn, with an example being about 10% Sn (in terms of wt. %). The zinc oxide, doped with Sn, is in a crystallized or substantially crystallized phase (as opposed to amorphous or nanocrystalline) in layer **3** and/or **13** as deposited, such as via sputter deposition techniques from at least one sputtering target(s) of or includ-

ing Zn and Sn. The crystallized phase of the doped zinc oxide based layer **3** and/or **13** as deposited, combined with the layer(s) between the silver **7** and/or **19** and the glass **1**, allows the coated article to realize improved thermal stability upon optional HT (lower the ΔE* value). It is believed that the crystallized phase of the doped zinc oxide based layer **3** and/or **13** as deposited, combined with the layer(s) between the silver and the glass, allows the silver **7** and/or **19** deposited thereover to have improved crystal structure with texture but with some randomly oriented grains so that its refractive index (n) changes less upon optional HT, thereby allowing for improved thermal stability to be realized.

It has also been surprisingly and unexpectedly found that the provision of a dielectric layer(s) (e.g., **2** and/or **2"**) of or including silicon oxide, zirconium oxide, silicon zirconium oxide and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, and/or $SiZrO_xN_y$) also provides for improved thermal stability of the coated article as shown for example in FIGS. **1**(*b*)-**1**(*i*), and thus lower the ΔE* values upon heat treatment (HT) such as thermal tempering. In certain example embodiments, at least one dielectric layer (e.g., **2** and/or **2"**) of or including silicon oxide, zirconium oxide, silicon zirconium oxide and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, and/or $SiZrO_xN_y$) may be provided: (i) in the bottom dielectric portion of the coating under all silver based IR reflecting layer(s) (e.g., see FIGS. **1**(*b*)-**1**(*i*)), and/or (ii) in a middle dielectric portion of the coating between a pair of silver based IR reflecting layers (e.g., see FIGS. **1**(*e*)-**1**(*i*)). For example, the dielectric layer (e.g., **2** and/or **2"**) of or including silicon oxide, zirconium oxide, silicon zirconium oxide and/or silicon zirconium oxynitride may be provided directly under and contacting the lowermost doped zinc oxide based layer (e.g., **3**) in certain example embodiments of this invention, and/or between a pair of zinc oxide inclusive layers (e.g., between **11** and **13**, or between **11** and **3"**) in a middle dielectric portion of the low-E coating.

The dielectric layer(s) (e.g., **2** and/or **2"**) of or including silicon oxide (e.g., SiO_2), zirconium oxide (e.g., ZrO_2), silicon zirconium oxide and/or silicon zirconium oxynitride may or may not be provided in combination with an as-deposited crystalline or substantially crystalline (e.g., at least 50% crystalline, more preferably at least 60% crystalline) layer(s) (e.g., **3** and/or **13**) of or including zinc oxide, doped with at least one dopant (e.g., Sn), immediately under an infrared (IR) reflecting layer, in various example embodiments of this invention. Both approaches, which may be used together, but need not be used together, improve thermal stability thereby lowering ΔE* values. For example, in certain embodiments where the dielectric layer(s) (e.g., **2** and/or **2"**) of or including silicon oxide (e.g., SiO_2), zirconium oxide (e.g., ZrO_2), silicon zirconium oxide and/or silicon zirconium oxynitride is used, the contact/seed layer immediately under one or both silver(s) may be of or including zinc oxide doped with aluminum (instead of with Sn) and that contact/seed layer need not be crystalline (e.g., see FIGS. **42**, **43** and **46**; and Examples 25, 26 and 29).

It has also been surprisingly and unexpectedly found that the provision of no silicon nitride based layer (e.g., Si_3N_4, optionally doped with 1-10% Al or the like) directly under and contacting the lowermost doped zinc oxide based layer **3** between the glass substrate **1** and the lowermost silver based layer **7**, in combination with the crystallized or substantially crystallized phase of the doped zinc oxide based layer **3** as deposited, allows for improved thermal stability upon heat treatment (lower ΔE* values) to be realized. For example, see the coatings of FIGS. **1**(*a*)-**1**(*d*) and **1**(*i*). Moreover, in certain example embodiments, there is no amorphous or substantially amorphous layer located between the glass substrate **1** and the first IR reflecting layer comprising silver **7**. It has also been surprisingly and unexpectedly found that the provision of no silicon nitride based layer in the middle section of the stack between the two silver-based IR reflecting layers **7** and **19** allows for improved thermal stability upon heat treatment (lower ΔE* values) to be realized (e.g., see FIGS. **1**(*a*)-**1**(*i*)).

In certain example embodiments, it has also been found that providing an absorber layer (e.g., NiCr, $NiCrN_x$, NbZr, and/or $NbZrN_x$) **42** between the glass substrate and the dielectric layer **2** of or including silicon oxide, zirconium oxide, silicon zirconium oxide and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, and/or $SiZrO_xN_y$) may advantageously reduce glass side visible reflection (R_gY) of the coated article in a desirable manner and allows the visible transmission to be tuned in a desirable manner. The absorber layer **42** may be provided between and contacting a pair of silicon nitride based layers **41** and **43** (e.g., of or including Si_3N_4, optionally doped with 1-10% Al or the like, and optionally including from 0-10% oxygen) in certain example embodiments, such as shown in FIGS. **1**(*d*) and **1**(*f*) for instance. See also FIG. **39** and Example 22 for instance. In other example embodiments, the stack made up of the absorber layer **42**, between nitride based dielectric layers **41** and **43**, may be located at other position(s) within the stack.

In certain example embodiments, measured monolithically, in view of the above structure (e.g., see FIGS. **1**(*a*)-**1**(*i*)), the coated article is configured to realize one or more of: (i) a transmissive ΔE* value (where transmissive optics are measured) of no greater than 3.0 (more preferably no greater than 2.5, and most preferably no greater than 2.3) upon HT for 8, 12 and/or 16 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value (where glass side reflective optics are measured) of no greater than 3.0 (more preferably no greater than 2.5, more preferably no greater than 2.0, even more preferably no greater than 1.5, and most preferably no greater than 1.0) upon HT for 8, 12 and/or 16 minutes at a temperature of about 650 degrees C., and/or (iii) a film side reflective ΔE* value (where film side reflective optics are measured) of no greater than 3.5 (more preferably no greater than 3.0, and most preferably no greater than 2.0) upon HT for 8, 12 and/or 16 minutes at a temperature of about 650 degrees C.

In certain example embodiments, measured monolithically, the coated article is configured to have a visible transmission (T_{vis} or Y), before or after any optional HT, of at least about 30%, more preferably of at least about 35%, more preferably of at least about 40%, more preferably of at least about 50%. In certain example embodiments, the low-E coating has a sheet resistance (SR or R_s) of no greater than 20 ohms/square, more preferably no greater than 10 ohms/square, and most preferably no greater than 2.5 or 2.2 ohms/square, before and/or after optional heat treatment. In certain example embodiments, the low-E coating has a hemispherical emissivity/emittance (E_h) of no greater than 0.08, more preferably no greater than 0.05, and most preferably no greater than 0.04.

The value ΔE* is important in determining whether or not upon heat treatment (HT) there is matchability, or substantial matchability, in the context of this invention. Color herein is described by reference to the conventional a*, b* values, which in certain embodiments of this invention are both negative in order to provide color in the desired substantially neutral color range tending to the blue-green quadrant. For

purposes of example, the term Δa* is simply indicative of how much color value a* changes due to heat treatment.

The term ΔE* (and ΔE) is well understood in the art and is reported, along with various techniques for determining it, in ASTM 2244-93 as well as being reported in Hunter et. al., *The Measurement of Appearance,* 2nd Ed. Cptr. 9, page 162 et seq. [John Wiley & Sons, 1987]. As used in the art, ΔE* (and ΔE) is a way of adequately expressing the change (or lack thereof) in reflectance and/or transmittance (and thus color appearance, as well) in an article after or due to heat treatment. ΔE may be calculated by the "ab" technique, or by the Hunter technique (designated by employing a subscript "H"). ΔE corresponds to the Hunter Lab L, a, b scale (or L_h, a_h, b_h). Similarly, ΔE* corresponds to the CIE LAB Scale L*, a*, b*. Both are deemed useful, and equivalent for the purposes of this invention. For example, as reported in Hunter et. al. referenced above, the rectangular coordinate/scale technique (CIE LAB 1976) known as the L*, a*, b* scale may be used, wherein:

L* is (CIE 1976) lightness units

a* is (CIE 1976) red-green units

b* is (CIE 1976) yellow-blue units

and the distance ΔE* between L^*_o a^*_o b^*_o and L^*_1 a^*_1 b^*_1 is:

$$\Delta E^*=[(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2} \quad (1)$$

where:

$$\Delta L^*=L^*_1-L^*_o \quad (2)$$

$$\Delta a^*=a^*_1-a^*_o \quad (3)$$

$$\Delta b^*=b^*_1-b^*_o \quad (4)$$

where the subscript "o" represents the coated article before heat treatment and the subscript "1" represents the coated article after heat treatment; and the numbers employed (e.g., a*, b*, L*) are those calculated by the aforesaid (CIE LAB 1976) L*, a*, b* coordinate technique. In a similar manner, ΔE may be calculated using equation (1) by replacing a*, b*, L* with Hunter Lab values a_h, b_h, L_h. Also within the scope of this invention and the quantification of ΔE* are the equivalent numbers if converted to those calculated by any other technique employing the same concept of ΔE* as defined above.

In certain example embodiments of this invention, the low-E coating **30** includes two silver-based IR reflecting layers (e.g., see FIGS. **1**(*a*)-**1**(*i*)), although this invention is not so limited in all instances (e.g., three silver based IR reflecting layers can be used in certain instances). It will be recognized that the coated articles of FIGS. **1**(*a*)-**1**(*i*) are illustrated in monolithic form. However, these coated articles may also be used in IG window units for example.

Because of materials stability, baking at high temperature (e.g., 580-650 degrees C.) causes change to chemical compositions, crystallinity and microstructures or even phases of dielectric layer materials. High temperature also causes interface diffusion or even reaction, as a consequence composition, roughness and index change at interface locations. As a result, optical properties such as index n/k and optical thickness change upon heat treatment. The IR materials, for example Ag, have undergone change too. Typically, Ag materials go through crystallization, grain growth or even orientation change upon heat treatment. These changes often cause conductivity and particularly index n/k changes which have big impact to the optical and thermal properties of a low-E coating. In addition, the dielectric and the change of dielectrics also has a significant impact on IR reflecting layers such as silver undergoing heat treatment. Moreover, silver may have more change in one layer stack than in others merely because of the materials and the layer stacks themselves. If the silver changes are beyond some limit, then it may not be acceptable aesthetically after heat treatment. We have found that to get thermal stability of a low-E coating, doped zinc oxide crystallized materials on glass either directly or indirectly with a thin modification layer(s) may be used under silver of an IR reflecting layer. Crystalline or substantially crystalline doped zinc oxide in these locations has been found to change less during heat treatment, and result in smaller silver changes with respect to properties such as indices (e.g., n and/or k) and thus less overall color change upon heat treatment.

FIG. **1**(*a*) is a side cross sectional view of a coated article according to an example non-limiting embodiment of this invention, where the low-E coating **30** has two silver-based IR reflecting layers **7** and **19**. The coated article includes substrate **1** (e.g., clear, green, bronze, or blue-green glass substrate from about 1.0 to 10.0 mm thick, more preferably from about 3.0 mm to 8.0 mm thick), and low-E coating (or layer system) **30** provided on the substrate **1** either directly or indirectly. The coating (or layer system) **30** includes, in FIG. **1**(*a*) for example: dielectric layer **3** of or including zinc oxide, doped with at least one metal dopant (e.g., Sn and/or Al), which is crystalline or substantially crystalline as deposited; infrared (IR) reflecting layer of or including silver **7** located over and directly contacting layer **3**; contact layer **9** of or including Ni and/or Cr (e.g., NiCr, $NiCrO_x$, $NiCrN_x$, NiCrON, NiCrM, $NiCrMoO_x$, etc.), Ti, or other suitable material, over and directly contacting the IR reflecting layer **7**; dielectric layer **11** of or including zinc stannate (e.g., ZnSnO, Zn_2SnO_4, or other suitable stoichiometry) or other suitable material, which may be amorphous or substantially amorphous as deposited; another dielectric layer **13** of or including zinc oxide, doped with at least one dopant (e.g., Sn), which is crystalline or substantially crystalline as deposited; another infrared (IR) reflecting layer of or including silver **19** located over and directly contacting layer **13**; another contact layer **21** of or including Ni and/or Cr (e.g., NiCr, $NiCrO_x$, $NiCrN_x$, NiCrON, NiCrM, $NiCrMoO_x$, etc.), Ti, or other suitable material, over and directly contacting the IR reflecting layer **19**; another dielectric layer **23** of or including zinc stannate (e.g., ZnSnO, Zn_2SnO_4, or other suitable stoichiometry) or other suitable material such as tin oxide, which may be amorphous or substantially amorphous as deposited; and amorphous or substantially amorphous dielectric layer **25** of or including silicon nitride (e.g., Si_3N_4, or other suitable stoichiometry) which may optionally be doped with Al and/or O. The layers shown in FIG. **1**(*a*) may be deposited by sputter-deposition or in any other suitable manner.

As explained herein, it has been found that the presence of as-deposited crystalline or substantially crystalline layer **3** and/or **13** of or including zinc oxide, doped with at least one dopant (e.g., Sn), immediately under and directly contacting an infrared (IR) reflecting layer of or including silver **7** and/or **19** in a low-E coating **30** has the effect of significantly improving the coating's thermal stability (i.e., lowering the ΔE* value). In certain example embodiments, the crystalline or substantially crystalline layer **3** and/or **13** of or including zinc oxide is doped with from about 1-30% Sn, more preferably from about 1-20% Sn, more preferably from about 5-15% Sn, with an example being about 10% Sn (in terms of wt. %).

In certain example embodiments, the dielectric zinc stannate (e.g., ZnSnO, Zn_2SnO_4, or the like) based layers **11** and

23 may be deposited in an amorphous or substantially amorphous state (it/they may become crystalline or substantially crystalline upon heat treatment). It has been found that having similar amounts of Zn and Sn in the layer, or more Sn than Zn in the layer, helps ensure that the layer is deposited in an amorphous or substantially amorphous state. For example, the metal content of amorphous zinc stannate based layers **11** and **23** may include from about 30-70% Zn and from about 30-70% Sn, more preferably from about 40-60% Zn and from about 40-60% Sn, with examples being about 52% Zn and about 48% Sn, or about 50% Zn and 50% Sn (weight %, in addition to the oxygen in the layer) in certain example embodiments of this invention. Thus, for example, the amorphous or substantially amorphous zinc stannate based layers **11** and/or **23** may be sputter-deposited using a metal target comprising about 52% Zn and about 48% Sn, or about 50% Zn and about 50% Sn, in certain example embodiments of this invention. Optionally, the zinc stannate based layers **11** and **23** may be doped with other metals such as Al or the like. Depositing layers **11** and **23** in an amorphous, or substantially amorphous, state, while depositing layers **3** and **13** in a crystalline, or substantially crystalline, state, has been found to advantageously allow for improved thermal stability to be realized in combination with good optical characteristics such as acceptable transmission, color, and reflection. It is noted that zinc stannate layers **11** and/or **23** may be replaced with respective layer(s) of other material(s) such as tin oxide, zinc oxide, zinc oxide doped with from 1-20% Sn (as discussed elsewhere herein regarding layers **11**, **13**), or the like.

Dielectric layer **25**, which may be an overcoat, may be of or include silicon nitride (e.g., Si_3N_4, or other suitable stoichiometry) in certain embodiments of this invention, in order to improve the heat treatability and/or durability of the coated article. The silicon nitride may optionally be doped with Al and/or O in certain example embodiments, and also may be replaced with other material such as silicon oxide or zirconium oxide in certain example embodiments.

Infrared (IR) reflecting layers **7** and **19** are preferably substantially or entirely metallic and/or conductive, and may comprise or consist essentially of silver (Ag), gold, or any other suitable IR reflecting material. IR reflecting layers **7** and **19** help allow the coating to have low-E and/or good solar control characteristics. The IR reflecting layers may, however, be slightly oxidized in certain embodiments of this invention.

Other layer(s) below or above the illustrated coating in FIG. **1** may also be provided. Thus, while the layer system or coating is "on" or "supported by" substrate **1** (directly or indirectly), other layer(s) may be provided therebetween. Thus, for example, the coating of FIG. **1**(*a*) may be considered "on" and "supported by" the substrate **1** even if other layer(s) are provided between layer **3** and substrate **1**. Moreover, certain layers of the illustrated coating may be removed in certain embodiments, while other layer(s) may be added between the various layers or the various layer(s) may be split with other layer(s) added between the split sections in other embodiments of this invention without departing from the overall spirit of certain embodiments of this invention.

While various thicknesses and materials may be used in layers in different embodiments of this invention, example thicknesses and materials for the respective layers on the glass substrate **1** in the FIG. **1**(*a*) embodiment are as follows, from the glass substrate outwardly:

TABLE 1

Example Materials/Thicknesses; FIG. 1(a) Embodiment

Layer Glass	Preferred Range (Å)	More Preferred (Å)	Example (Å)
Sn-doped ZnO (layer 3)	20-900 (or 100-900) Å	350-550 Å	470 Å
Ag (layer 7)	60-260 Å	110-170 Å	151 Å
$NiCrO_x$ (layer 9)	10-100 Å	20-45 Å	41 Å
ZnSnO (layer 11)	200-1200 Å	500-900 Å	736 Å
Sn-doped ZnO (layer 13)	60-900 Å	120-400 Å	177 Å
Ag (layer 19)	80-280 Å	150-250 Å	232 Å
$NiCrO_x$ (layer 21)	10-100 Å	20-45 Å	41 Å
ZnSnO (layer 23)	10-750 Å	70-200 Å	108 Å
Si_3N_4 (layer 25)	10-750 Å	100-240 Å	191 Å

The FIG. **1**(*b*) embodiment is the same as the FIG. **1**(*a*) embodiment discussed above and elsewhere herein, except that the low-E coating **30** in the FIG. **1**(*b*) embodiment also includes a substantially transparent dielectric layer **2** of or including silicon zirconium oxide, zirconium oxide, silicon oxide, and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, $SiAlO_2$, and/or $SiZrO_xN_y$) under and directly contacting the doped zinc oxide based layer **3**. It has been found that this additional layer **2** provides for further improved thermal stability of the coated article, and thus an even lower the ΔE* value (e.g., a lower glass side reflective ΔE* value) upon heat treatment (HT) such as thermal tempering. The dielectric layer **2** of or including silicon zirconium oxide, zirconium oxide, silicon oxide, and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, $SiAlO_2$, and/or $SiZrO_xN_y$) may be provided directly under and contacting the lowermost doped zinc oxide based layer **3** in certain example embodiments of this invention, as shown in FIG. **1**(*b*). In certain example embodiments of this invention, dielectric layer **2** of or including silicon zirconium oxide, zirconium oxide, silicon oxide, and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, $SiAlO_2$, and/or $SiZrO_xN_y$) may be from about 20-600 Å thick, more preferably from about 40-400 Å thick, and most preferably from about 50-300 Å thick. The thicknesses above for the FIG. **1**(*a*) embodiment may also apply to FIGS. **1**(*b*)-**1**(*h*).

When layer **2** (or **2'**, or **2"**) is of or includes $SiZrO_x$ and/or $SiZrO_xN_y$, it has been found that providing more Si than Zr in that layer is advantageous from an optical point of view with a low refractive index (n) and improved antireflection and other optical characteristics. For example, in certain example embodiments, when layer **2** (or **2'**, or **2"**) is of or includes $SiZrO_x$ and/or $SiZrO_xN_y$, metal content of the layer may comprise from 51-99% Si, more preferably from 70-97% Si, and most preferably from 80-90% Si, and from 1-49% Zr, more preferably from 3-30% Zr, and most preferably from 10-20% Zr (atomic %). In example embodiments, transparent dielectric layer **2** of or including $SiZrO_x$ and/or $SiZrO_xN_y$ may have a refractive index (n), measured at 550 nm, of from about 1.48 to 1.68, more preferably from about 1.50 to 1.65, and most preferably from about 1.50 to 1.62.

The FIG. **1**(*c*) embodiment is the same as the FIG. **1**(*b*) embodiment discussed above and elsewhere herein, except that the low-E coating **30** in the FIG. **1**(*c*) embodiment also includes a substantially transparent dielectric layer **2'** of or including silicon nitride (e.g., Si_3N_4, optionally doped with 1-10% Al or the like, and optionally including from 0-10% oxygen, or other suitable stoichiometry) and/or silicon zir-

conium oxynitride, located between and contacting the glass substrate **1** and the dielectric layer **2**. Layer **2'** may also be of or including aluminum nitride (e.g., AlN).

The FIG. **1**(*d*) embodiment is the same as the FIG. **1**(*b*) embodiment discussed above and elsewhere herein, except that the low-E coating **30** in the FIG. **1**(*d*) embodiment also includes a metallic or substantially metallic absorber layer **42** sandwiched between and contacting silicon nitride based layers **41** and **43** (e.g., Si_3N_4, optionally doped with 1-10% Al or the like, and optionally including from 0-10% oxygen). Dielectric layer(s) **41** and/or **43** may also be of or include aluminum nitride (e.g., AlN) in certain example embodiments. The absorber layer **42** may be of or including NiCr, NbZr, Nb, Zr, or nitrides thereof, or other suitable material, in example embodiments of this invention. The absorber layer **42** preferably contains from 0-10% oxygen (atomic %), more preferably from 0-5% oxygen. In certain example embodiments, it has been found that providing an absorber layer (e.g., NiCr, $NiCrN_x$, NbZr, and/or $NbZrN_x$) **42** between the glass substrate and the dielectric layer **2** of or including silicon zirconium oxide, zirconium oxide, silicon oxide, and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, $SiAlO_2$, and/or $SiZrO_xN_y$) advantageously reduces glass side visible reflection (R_gY) of the coated article in a desirable manner, and allows the visible transmission to be tuned in a desirable manner. See, for example, FIG. **39** and Example 22. In certain example embodiments, the absorber layer **42** may be from about 10-150 Å thick, more preferably from about 30-80 Å thick. In certain example embodiments, the silicon nitride based layers **41** and **43** may be from about 50-300 Å thick, more preferably from about 70-140 Å thick. For instance, in Example 22 and FIG. **39**, the absorber layer **42** is a nitride of NiCr, and is about 1.48 nm thick. In other example embodiments, the stack made up of the absorber layer **42**, between nitride based dielectric layers **41** and **43**, may be located at other position(s) within the stack.

Referring to FIGS. **1**(*a*)-**1**(*d*), another transparent dielectric layer (not shown) of or including ZrO_2, $SiZrO_x$ and/or $SiZrO_xN_y$ may be provided either between layers **11** and **13**. In certain example embodiments, zinc stannate inclusive layer **11** may be omitted, or may be replaced with such another transparent dielectric layer of or including ZrO_2, $SiZrO_x$ and/or $SiZrO_xN_y$. It is also possible for doped zinc oxide layer **13** to be split with such another layer transparent dielectric layer of or including ZrO_2, $SiZrO_x$ and/or $SiZrO_xN_y$. For example, in certain example embodiments, when such an additional layer is of or includes $SiZrO_x$ and/or $SiZrO_xN_y$, metal content of the layer may comprise from 51-99% Si, more preferably from 70-97% Si, and most preferably from 80-90% Si, and from 1-49% Zr, more preferably from 3-30% Zr, and most preferably from 10-20% Zr (atomic %), and may contain from 0-20% nitrogen, more preferably from 0-10% nitrogen, and most preferably from 0-5% nitrogen (atomic %). For instance, at least one dielectric layer (e.g., **2** and/or **2"**) of or including silicon oxide, zirconium oxide, silicon zirconium oxide and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, and/or $SiZrO_xN_y$) may be provided: (i) in the bottom dielectric portion of the coating under all silver based IR reflecting layer(s) (e.g., see FIGS. **1**(*b*)-**1**(*i*)), and/or (ii) in a middle dielectric portion of the coating between a pair of silver based IR reflecting layers (e.g., see FIGS. **1**(*e*)-**1**(*i*)).

As explained above and shown in the figures, the coated article may include a dielectric layer(s) **2**, **2"** (e.g., ZrO_2 or $SiZrO_x$) as shown in FIGS. **1**(*b*)-(*i*), which may possibly be located under and directly contacting the first crystalline or substantially crystalline layer **3** comprising zinc oxide doped with from about 1-30% Sn, and/or below a zinc oxide inclusive layer **3"**. The dielectric layer(s) **2** (and **2"**) may be of or include silicon oxide optionally doped with Al, zirconium oxide (e.g., ZrO_2), silicon zirconium oxide and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, and/or $SiZrO_xN_y$). The dielectric layer **2** (or **2"**) may be in direct contact with the glass substrate **1** (e.g., see FIGS. **1**(*b*), **1**(*e*), **1**(*g*), **1**(*h*)). The dielectric layer(s) **2**, **2"** may each have a physical thickness of from about 30-600 Å, more preferably from about 40-400 Å, more preferably from about 50-300 Å, and most preferably from about 50-200 Å. The dielectric layer(s) **2**, **2"** is/are preferably an oxide based dielectric layer, and preferably contains little or no nitrogen. For example, the dielectric layer(s) **2**, **2"** may each comprise from 0-20% nitrogen, more preferably from 0-10% nitrogen, and most preferably from 0-5% nitrogen (atomic %).

The FIG. **1**(*i*) embodiment is based on the embodiments of FIGS. **1**(*a*)-(*b*), **1**(*e*), and **1**(*h*) discussed herein, and layer and performance descriptions regarding those embodiments also apply to FIG. **1**(*i*). However, the FIG. **1**(*i*) embodiment also includes an absorber film made up of layers **57** and **59**, where the absorber film is provided in the central portion of the layer stack and over dielectric layers **11**, **2"** and **3"** as described herein. Layer **3"** may be zinc stannate, zinc oxide, zinc aluminum oxide, or dope zinc oxide as discussed above in different embodiments of this invention. Layer **2"** is discussed above, and may be of or include silicon oxide optionally doped with Al, zirconium oxide (e.g., ZrO_2), silicon zirconium oxide and/or silicon zirconium oxynitride (e.g., $SiZrO_x$, ZrO_2, SiO_2, and/or $SiZrO_xN_y$).

In the FIG. **1**(*i*) embodiment, the absorber film may be a multi-layer absorber film including a first layer **57** of or including silver (Ag), and a second layer **59** of or including NiCr which may be partially or fully oxided ($NiCrO_x$), and possibly slightly nitrided. Such a multi-layer absorber film **57**, **59** may thus, in certain example embodiments, be made up of a layer sequence of Ag/$NiCrO_x$. This layer sequence may be repeated in certain example instances. For example, the absorber film may be made up of a layer sequence of Ag/$NiCrO_x$/Ag/$NiCrO_x$, or Ag/$NiCrO_x$/Ag/$NiCrO_x$/Ag/$NiCrO_x$, in certain example embodiments of this invention, which each of the layers in the sequence contributing to the light absorption. Elements from one layer may diffuse into an adjacent layer due to HT or other factors. The NiCr based layer **59** of the absorber may be initially deposited in metallic form, or as a suboxide, in certain example embodiments. The silver based layer **57** may be a continuous layer, and/or may optionally be doped, in certain example embodiments. Examples 30-33 relate to the FIG. **1**(*i*) embodiment (see FIGS. **47**-**50**).

The silver based layer **57** of the absorber film is preferably sufficiently thin so that its primary function is to absorb visible light and provide desirable coloration (as opposed to being much thicker and primarily function as an IR reflection layer). The NiCr or $NiCrO_x$ **59** is provided over and contacting the silver **57** of the absorber film in order to protect the silver, and also to contribute to absorption. In certain example embodiments, the silver based layer **57** of the absorber film may be no more than about 30 Å thick, more preferably no greater than about 20 Å thick, and most preferably no greater than about 15 Å thick, and possibly no greater than about 12 Å thick, in certain example embodiments of this invention. In certain example embodiments, the NiCr based layer **59** of the absorber film may be from about 5-200 Å thick, more preferably from about 10-110 Å thick, and most preferably from about 40-90 Å thick. In

certain example embodiments, the ratio of Ag/$NiCrO_x$ in the absorber film may be 1:Z (where 0.1<Z<20, more preferably where 2<Z<15, and most preferably where 3<Z<12), with an example being about 1:5.

With respect to the silver based layer **57** of the absorber film being sufficiently thin so that its primary function is to absorb visible light and provide desirable coloration (as opposed to being much thicker and primarily function as an IR reflection layer), the ratio of the physical thickness of the IR reflecting layer **7** (e.g., silver) to the physical thickness of the silver based layer **57** is preferably at least 5:1, more preferably at least about 8:1, even more preferably at least about 10:1, and even more preferably at least about 15:1. Likewise, the ratio of the physical thickness of the IR reflecting layer **19** (e.g., silver) to the physical thickness of the silver based layer **57** is preferably at least 5:1, more preferably at least about 8:1, even more preferably at least about 10:1, and even more preferably at least about 15:1.

While a single layer of NiCr (or other suitable material) may also be used as an absorber film in low-E coatings in certain example embodiments of this invention (e.g., see absorber film **42** in FIGS. **1**(*d*) and **1**(*f*)), it has surprisingly been found that using silver **57** in an absorber film (single layer, or multi-layer, absorber film) of FIG. **1**(*i*) provides for several unexpected advantages compared to a single layer of NiCr as the absorber. First, it has been found that a single layer of NiCr as the absorber tends to cause yellowish coloration in certain low-E coating coated articles, which may not be desirable in certain instances. In contrast, it has been surprisingly found that using silver **57** in an absorber films tends to avoid such yellowish coloration and/or instead provide for more desirable neutral coloration of the resulting coated article. Thus, the use of silver **57** in an absorber film has been found to provide for improved optical characteristics. Second, the use of a single layer of NiCr **42** as the absorber tends to also involve providing silicon nitride based layers on both sides of the NiCr so as to directly sandwich and contact the NiCr therebetween. For example, see FIGS. **1**(*d*) and **1**(*f*). It has been found that the provision of silicon nitride in certain locations in a coating stack may lead to compromised thermal stability upon HT. In contrast, it has been surprisingly found that when using silver in an absorber film as shown in FIG. **1**(*i*) for example, a pair of immediately adjacent silicon nitride layers are not needed, so that thermal stability upon HT may be improved. Thus, the use of silver **57** in an absorber film has been found to provide for improved thermal stability including lower ΔE* values and therefor improved matchability between HT and non-HT versions of the same coating. The use of silver in an absorber film may also provide for improved manufacturability in certain situations.

While the absorber film **57**, **59** in FIG. **1**(*i*) is provided in the central portion of the layer stack between the IR reflecting layers **7** and **19**, it is also possible to provide such an absorber film **57**, **59** instead in the lower portion of the layer stack below the bottom IR reflecting layer **7**, or in another suitable location. For example, the FIG. **1**(*i*) embodiment may be modified by moving directly adjacent and contacting layers **57** and **59** to a position between layers **2** and **3**, so that layers **2** and **57** contact each other, and layers **59** and **3** contact each other. As another example, the FIG. **1**(*i*) embodiment may be modified by moving the sequence of three layers **3"/57/59** from the central portion of the stack to a position between layers **2** and **3** in FIG. **1**(*i*), so that layers **2** and **3"** contact each other, and layers **59** and **3** contact each other. However, it has been surprisingly found that by providing the absorber film **57**, **59** in the central portion of the layer stack as shown in FIG. **1**(*i*), optical characteristics such as SHGC and glass side reflectance may be improved.

FIG. **1**(*i*) illustrates layer **59** of the absorber film as of or including $NiCrO_x$ (partially or fully oxided). However, layer **59** of the absorber film may be of or include other metal based materials (e.g., NiCr, Ni, Cr, $NiCrO_x$, $NiCrN_x$, NiCrON, NiCrM, $NiCrMoO_x$, Ti, or other suitable material).

It is noted that zinc stannate layers **11** and/or **23** may be replaced with respective layer(s) of other material(s) such as tin oxide, zinc oxide, zinc oxide doped with from 1-20% Sn (as discussed elsewhere herein regarding layers **11**, **13**), or the like.

While various thicknesses and materials may be used in layers in different embodiments of this invention, example thicknesses and materials for the respective layers on the glass substrate **1** in the FIG. **1**(*i*) embodiment are as follows, from the glass substrate outwardly:

TABLE 1'

Example Materials/Thicknesses; FIG. 1(i) Embodiment

Layer Glass	Preferred Range (Å)	More Preferred (Å)	Example (Å)
ZrO_x/$SiZrO_x$ (layer 2)	30-600 Å	40-400 Å	50-200 Å
Sn-doped ZnO (layer 3)	20-900 (or 100-900) Å	100-550 Å	223 Å
Ag (layer 7)	60-260 Å	100-170 Å	151 Å
$NiCrO_x$ (layer 9)	10-100 Å	20-45 Å	41 Å
ZnSnO (layer 11)	100-1200 Å	150-500 Å	280 Å
ZrO_x/$SiZrO_x$ (layer 2")	30-600 Å	40-400 Å	50-200 Å
Sn-doped ZnO (layer 3")	20-900 Å	50-150 Å	100 Å
Ag (layer 57)	3-30 Å	4-20 Å	5-15 Å
$NiCrO_x$ (layer 59)	5-200 Å	10-110 Å	40-90 Å
Sn-doped ZnO (layer 13)	60-900 Å	120-400 Å	331 Å
Ag (layer 19)	80-280 Å	120-250 Å	156 Å
$NiCrO_x$ (layer 21)	10-100 Å	20-45 Å	41 Å
ZnSnO (layer 23)	10-750 Å	70-200 Å	103 Å
Si_3N_4 (layer 25)	10-750 Å	100-240 Å	214 Å

In certain embodiments of this invention, layer systems herein (e.g., see FIGS. **1**(*a*)-(*i*)) provided on clear monolithic glass substrates (e.g., 6 mm thick glass substrates for example reference purposes) have color as follows before heat treatment, as viewed from the glass side of the coated article (R_G %) (Ill. C, 2 degree Observer):

TABLE 2

Reflection/Color (R_G) Before and/or After Heat Treatment

	General	Preferred
R_gY (%)	5-35%, or 5-20%	8-18%
a_g*	−5.0 to +4.0	−3.5 to +2.0
b_g*	−16.0 to 0.0	−14.0 to −5.0

Comparative Examples 1 and 2

FIG. **19** is a cross sectional view of a first Comparative Example (CE) coated article, and FIG. **23** is an XRD Lin (Cps) vs. 2-Theta-Scale graph illustrating, for the first Comparative Example (CE), the relative large 166% change in Ag (111) peak height due to heat treatment.

A difference between the first Comparative Example coating (see FIG. **19**), and Examples 1-24, 27-28, and 30-33 below, is that the lowermost dielectric stack of the coating

in the first Comparative Example is made up of a Zn_2SnO_4 layer, and a zinc oxide based layer that is doped with aluminum. The metal content of the zinc stannate layer (Zn_2SnO_4 is a form of zinc stannate) is about 50% Zn and about 50% Sn (wt. %); and thus the zinc stannate layer is sputter-deposited in amorphous form. The overall thickness of the lowermost dielectric stack in the first CE was about 400-500 angstroms, with the zinc stannate layer making up the majority of that thickness. FIG. **23** illustrates, for the first Comparative Example (CE), the relative large 166% change in Ag (111) peak height due to heat treatment at about 650 degrees C. which is indicative of a significant change in structure of the silver layers during the heat treatment, and which is consistent with the ΔE* values over 4.0 realized by the Comparative Example. Thus, the first CE was undesirable because of the significant changes in the Ag (111) peak, and the high of ΔE* values over 4.0, due to heat treatment. In contrast with the first Comparative Example, Examples 1-24, 27-28, and 30-33 below had a crystalline or substantially crystalline layer **3**, **13** with a metal content of either 90(Zn)/10(Sn) or 85(Zn)/15(Sn) directly under and contacting silver **7**, **19**, and realized significantly improved/lower ΔE* values.

A second Comparative Example (CE 2) is shown in FIGS. **34-35**. FIG. **34** is chart illustrating sputter-deposition conditions for the sputter-deposition of the low-E coating of Comparative Example 2 (CE 2) on a 6 mm thick glass substrate. The layer stack of CE 2 is the same as that shown in FIG. **1**(*b*) of the instant application, except that the lowermost dielectric layer in CE 2 is made of silicon nitride (doped with about 8% aluminum) instead of the $SiZrO_x$ shown in FIG. **1**(*b*). Thus, the bottom dielectric stack in CE 2 is made up of only this silicon nitride based layer and a zinc oxide layer **3** doped with about 10% Sn. The thicknesses of the layers of the coating of CE 2 are in the far right column of FIG. **34**. For example, the bottom silicon nitride based layer, doped with Al (sputtered from an SiAl target in an atmosphere of Ar and N_2 gas), is 10.5 nm thick in CE 2, the zinc oxide layer **3** doped with about 10% Sn directly under the bottom silver is 32.6 nm thick in CE 2, and so forth.

It can be seen in FIG. **35** that CE 2 suffers from relatively high glass side reflective ΔE* values (ΔE* R_g) and film side reflective ΔE* values (ΔE* R_f) over 4.0, due to heat treatments of 12, 16, and 24 minutes. For example, FIG. **35** shows that CE has a relatively high glass side reflective ΔE* value (ΔE* R_g) of 4.9 and a relatively high film side reflective ΔE* value (ΔE* R_f) of 5.5 due to heat treatment for 12 minutes. FIG. **35** is a chart illustrating optical characteristics of Comparative Example 2 (CE 2): as coated (annealed) before heat treatment in the left-most data column, after 12 minutes of heat treatment at 650 degrees C. (HT), after 16 minutes of HT at 650 degrees C. (HTX), and after 24 minutes of heat treatment at 650 degrees C. (HTXXX) in the far right data column. These relatively high ΔE* values of CE 2 are undesirable.

Accordingly, Comparative Example 2 (CE 2) in FIGS. **34-35** demonstrates that undesirably high ΔE* values are realized, even when a crystalline or substantially crystalline zinc oxide layer **3** doped with about 10% Sn is provided directly below the bottom silver layer **7**, when the only layer between that layer **3** and the glass substrate **1** is a silicon nitride based layer. The difference between the CE 2 coating, and Examples 1-24, 27-28, and 30-33 below, is that Examples 1-24, 27-28, and 30-33 below were surprisingly and unexpectedly able to realize much improved (lower) ΔE* values using the crystalline or substantially crystalline zinc oxide layer **3** doped with about 10% or 15% Sn, by not having a silicon nitride based layer located directly below and contacting the crystalline or substantially crystalline zinc oxide layer **3** doped with about 10% or 15% Sn.

Examples 11-14, 19-21, and 26-33 below also demonstrate that replacing the bottom silicon nitride based layer of CE 2 with a $SiZrO_x$ or ZrO_2 layer **2** dramatically improves/lowers ΔE* values in an unexpected manner.

Examples 1-33

Surprisingly and unexpectedly, it was found that when the lowermost dielectric stack **5**, **6** of the Comparative Example (CE) (made up mostly by the zinc stannate layer which is amorphous as deposited) in FIG. **19** was replaced with a crystalline or substantially crystalline Sn-doped zinc oxide layer **3** of similar thickness (the rest of the stack remained substantially the same) contacting the silver based layer, with no silicon nitride based layer directly under and contacting the crystalline or substantially crystalline layer **3**, the result was a much more thermally stable product with significant lower ΔE* values and a much smaller change in Ag (111) peak height due to heat treatment at about 650 degrees C. The metal content of the crystalline or substantially crystalline Sn-doped zinc oxide layer **3** in Examples 1-24, 27-28, and 30-33 was approximately 90% Zn and 10% Sn (wt. %) (see also 85% Zn, and 15% Sn metal content for "85" regarding layer **13** in Example 19), which helped allow the Sn-doped zinc oxide layers **3**, **13** in Examples 1-24, 27-28, 30-33 to be sputter-deposited in crystalline or substantially crystalline form (as opposed to the amorphous form in the CE). For instance, FIG. **20** illustrates the layer stack of Example 10, FIG. **21** illustrates the sputter-deposition conditions and layer thicknesses of Example 10, and FIG. **22** illustrates the much smaller 66% change in Ag (111) peak height due to heat treatment at about 650 degrees C. for Example 10 which is consistent with the much lower ΔE* values realized by Examples 1-24, 27-28 and 30-33. FIG. **16** also illustrates the relatively small refractive index (n) shift, upon heat treatment, for Example 8.

The Example coated articles (each annealed and heat treated), Examples 1-29, were made in accordance with certain example embodiments of this invention. Indicated example coatings **30** were sputter-deposited via the sputtering conditions (e.g., gas flows, voltage, and power), sputtering targets, and to the layer thicknesses (nm) shown in FIGS. **2**, **3**, **6**, **7**, **9**, **11**, **13**, **15**, **21**, **24-26**, **28**, **30**, **32**, and **36-50**. For example, FIG. **2** shows the sputtering conditions, sputtering targets used for sputter-depositing, and the layer thicknesses for the coating of Example 1, FIG. **3** shows the sputtering conditions, sputtering targets used for sputter-depositing, and the layer thicknesses for the coating of Example 2, FIG. **6** shows the sputtering conditions, sputtering targets used for sputter-depositing, and the layer thicknesses for the coating of Example 3, FIG. **7** shows the sputtering conditions, sputtering targets used for sputter-depositing, and the layer thicknesses for the coating of Example 4, and so forth. Meanwhile, data for the indicated Examples, including visible transmission (TY or T_{vis}), glass side visible reflectance (R_gY or RGY), film side visible reflectance (R_fY or RFY), a* and b* color values, L* values, and sheet resistance (SR or R_s) are shown in FIGS. **4**, **5**, **8**, **10**, **12**, **14**, **18**, **27**, **29**, **31**, **33**, and **36-50**. As explained above, ΔE* values are calculated using the L*, a*, and b* values, taken before and after heat treatment, for a given example. For instance, a glass side reflective ΔE* value (ΔE*G or ΔE* R_g) is calculated using the glass side reflec-

tive L*, a*, and b* values, taken before and after heat treatment, for a given example. As another example, a film side reflective ΔE* value (ΔE^*_F or ΔE* R_f) is calculated using the glass side reflective L*, a*, and b* values, taken before and after heat treatment, for a given example. As another example, a transmissive ΔE* value (ΔE^*_T) is calculated using the glass side reflective L*, a*, and b* values, taken before and after heat treatment, for a given example.

For examples having approximately 3 mm thick glass substrates, in FIGS. **4**, **5**, **8**, **10**, **12**, **14**, and **18**, "HT" refers to heat treatment at 650 degrees for about 8 minutes, "HTX" refers to heat treatment at 650 degrees for about 12 minutes, and "HTXXX" refers to heat treatment at 650 degrees for about 20 minutes. And for examples having approximately 6 mm thick glass substrates, in FIGS. **4**, **5**, **8**, **10**, **12**, **14**, **18**, **27**, **29**, **31**, **33**, and **36-50** "HT" refers to heat treatment at 650 degrees for about 12 minutes, "HTX" refers to heat treatment at 650 degrees for about 16 minutes, and "HTXXX" refers to heat treatment at 650 degrees for about 24 minutes. The heat treatment temperatures and times are for reference purposes only (e.g., to simulate examples of different tempering and/or heat bending processes).

FIGS. **4** and **5**, for instance, illustrate the ΔE* values for Examples 1 and 2, respectively. The data for Example 1 is explained below in detail, for purposes of example and explanation, and that discussion also applies to the data for Examples 2-33.

As shown in FIG. **4**, Example 1 as coated (prior to heat treatment) had a visible transmission (TY or T_{vis}) of 74.7%, a transmissive L* value of 89.3, a transmissive a* color value of −4.7, a transmissive b* color value of 5.8, a glass side reflectance (R_gY) of 9.6%, a glass side reflective L* value of 37.1, a glass side reflective a* color value of −1.1, a glass side reflective b* color value of −10.1, a film side reflectance (R_fY) of 9.9%, a film side reflective L* value of 37.7, a film side reflective a* color value of −1.5, a film side reflective b* color value of −5.7, and a sheet resistance (SR) of 2.09 ohms/square. FIG. **2** shows the thicknesses of the layers in Example 1. In particular, FIG. **2** shows that the layer thicknesses for Example 1 were are follows: glass/crystalline Sn-doped ZnO (47.0 nm)/Ag(15.1 nm)/$NiCrO_x$ (4.1 nm)/amorphous zinc stannate (73.6 nm)/crystalline Sn-doped ZnO (17.7 nm)/Ag(23.2 nm)/$NiCrO_x$ (4.1 nm)/amorphous zinc stannate (10.8 nm)/silicon nitride doped with aluminum (19.1 nm).

The coated article of Example 1, which had a 6 mm thick glass substrate **1**, was then heat treated. As shown in FIG. **4**, Example 1 following heat treatment at 650 degrees C. for about 12 minutes had a visible transmission (TY or T_{vis}) of 77.0%, a transmissive L* value of 90.3, a transmissive a* color value of −3.5, a transmissive b* color value of 4.9, a glass side reflectance (R_gY) of 9.8%, a glass side reflective L* value of 37.5, a glass side reflective a* color value of −0.7, a glass side reflective b* color value of −10.5, a film side reflectance (R_fY) of 10.2%, a film side reflective L* value of 38.1, a film side reflective a* color value of −1.4, a film side reflective b* color value of −8.0, a sheet resistance (SR) of 1.75, a transmissive ΔE* value of 1.8, a glass side reflective ΔE* value 0.7, and a film side reflective ΔE* value of 2.4.

It will be appreciated that these ΔE* values for Example 1 (and also those for Examples 2-33) are much improved (significantly lower) than those of the prior art discussed in the background and compared to the values over 4.0 for the Comparative Examples (CEs) discussed above. Thus, the data from the examples demonstrates, for example, that when the lowermost dielectric stacks of the Comparative Examples was replaced with at least a crystalline or substantially crystalline Sn-doped zinc oxide layer of similar thickness (the rest of the stack remained substantially the same), with no silicon nitride based layer directly under and contacting the crystalline or substantially crystalline Sn-doped zinc oxide layer **3**, the result was a much more thermally stable product with significant lower ΔE* values and a much smaller change in Ag (111) peak height due to heat treatment.

Other examples show these same unexpected results, compared to the Comparative Example. In general, the Examples demonstrate that the crystalline or substantially crystalline Sn-doped zinc oxide layer, and/or the layer(s) **2**, **2"** of or including $SiZrO_x$, ZrO_x, SiO_2, significantly improved ΔE* values. For example, Examples 1-10 had layer stacks generally shown by FIG. **1**(*a*) where the only dielectric layer beneath the bottom silver was the crystalline or substantially crystalline Sn-doped zinc oxide layer **3** with a metal content of approximately 90% Zn and 10% Sn (wt. %). In Examples 11-14, 19-24, 27-28 metal content of the crystalline or substantially crystalline Sn-doped zinc oxide layer **3** was approximately 90% Zn and 10% Sn (wt. %), directly over a $SiZrO_x$ layer **2** where metal content of the layer **2** was about 85% Si and 15% Zr (atomic %). In Examples 30-33 the crystalline or substantially crystalline Sn-doped zinc oxide layer **3** was approximately 90% Zn and 10% Sn (wt. %), and provided directly over a ZrO_2 layer **2** as shown in FIG. **1**(*i*). In Examples 15-16 metal content of the crystalline or substantially crystalline Sn-doped zinc oxide layer **3** was approximately 90% Zn and 10% Sn (wt. %), directly over a ZrO_2 layer **2**; and in Examples 17-18 metal content of the crystalline or substantially crystalline Sn-doped zinc oxide layer **3** was approximately 90% Zn and 10% Sn (wt. %), directly over a SiO_2 layer **2** doped with about 8% Al (atomic %). These examples surprisingly and unexpectedly realized much improved ΔE* values compared to the Comparative Examples.

The layer stacks of Examples 1-10 are generally illustrated by FIG. **1**(*a*). The layer stacks of Examples 11-14, 19 and 27 are generally illustrated by FIG. **1**(*b*), with layer **2** being of $SiZrO_x$. The layer stacks of Examples 15-16 are generally illustrated by FIG. **1**(*b*), with layer **2** being of ZrO_2. The layer stacks of Examples 17-18 are generally illustrated by FIG. **1**(*b*), with layer **2** being of SiO_2. The layer stacks of Examples 20-21 and 28 are generally illustrated by FIG. **1**(*e*), with layers **2** and **2"** being of $SiZrO_x$. The layer stacks of Examples 23-24 are generally illustrated by FIG. **1**(*f*), with layers **2** and **2"** being of $SiZrO_x$. The layer stack of Example 25 is generally illustrated by FIG. **1**(*g*), with layers **2** and **2"** being of $SiZrO_x$. The layer stack of Example 22 is generally illustrated by FIG. **1**(*d*), with layer **2** being of $SiZrO_x$. The layer stack of Example 26 is generally illustrated by FIG. **1**(*h*), with layers **2** and **2"** being of $SiZrO_x$, oxide layer **3'** having a meal content 90% Zn and 10% Sn, and oxide layers **3**, **13** being zinc oxide doped with about 4-8% Al. The layer stack of Example 29 is generally illustrated by FIG. **1**(*h*), except that layer **2"** is not present in Example 29, and with layer **2** being of $SiZrO_x$, oxide layer **3'** having a metal content 90% Zn and 10% Sn, and oxide layers **3**, **13** being zinc oxide doped with about 4-8% Al. The layer stacks of Examples 30-33 are generally illustrated by FIG. **1**(*i*), with layers **2** and **2"** being of ZrO_2. These examples surprisingly and unexpectedly realized much improved ΔE* values compared to the Comparative Examples. These examples demonstrate that the crystalline or substantially crystalline Sn-doped zinc oxide layer(s)

(e.g., layer **3** and/or **13**), and/or the dielectric layer(s) **2**, **2"** of or including $SiZrO_x$, ZrO_x, SiO_2, significantly improved/lowered ΔE* values.

For instance, comparing Examples 23-24 ($SiZrO_x$ layer **2"** added to the center dielectric portion of the coating as shown in FIG. **1**(*f*)) to Example 22 (no such layer **2"** in the center dielectric portion as shown in FIG. **1**(*d*)) demonstrates and evidences that the addition of the $SiZrO_x$ layer **2"** in Examples 23-24 unexpectedly improved/lowered at least glass side reflective ΔE* values. Thus, it will be appreciated that the addition of the $SiZrO_x$ layer **2"** provides for unexpected results.

Furthermore, comparing Example 28 ($SiZrO_x$ layer **2"** added to the center dielectric portion of the coating as shown in FIG. **1**(*e*)) to Example 27 (no such layer **2"** in the center dielectric portion as shown in FIG. **1**(*b*)) further demonstrates and evidences that the addition of the $SiZrO_x$ layer **2"** in Example 28 unexpectedly improved/lowered glass side reflective ΔE* values. Thus, it will again be appreciated that the addition of the $SiZrO_x$ or ZrO_2 layer **2"** provides for unexpected results with respect to improving thermal stability.

Examples 30-33 are generally illustrated by FIG. **1**(*i*) including absorber film **57**, **59**, with layers **2** and **2"** being of ZrO_2 in these examples. These examples surprisingly and unexpectedly realized much improved ΔE* values compared to the Comparative Examples. Examples 30-33 demonstrate that the crystalline or substantially crystalline Sn-doped zinc oxide layer(s) (e.g., layer **3** and/or **13**), and the dielectric layer(s) **2**, **2"** of or including ZrO_2, significantly improved/lowered ΔE* values in an unexpected manner. Examples 30-33 further demonstrate that providing the absorber film including silver inclusive layer **57** and $NiCrO_x$ inclusive layer **59** allows the visible transmission to be tuned to a desirable value without sacrificing thermal stability or desired color of the resulting coated article. For example, Examples 30-33 with the Ag/$NiCrO_x$ absorber film (**57**, **59**) as shown in FIG. **1**(*i*) have surprisingly more neutral glass side reflective b* values (Rg b*) values compared to Examples 23-24 where the single NiCr layer absorber was utilized.

Certain terms are prevalently used in the glass coating art, particularly when defining the properties and solar management characteristics of coated glass. Such terms are used herein in accordance with their well known meaning. For example, as used herein:

Intensity of reflected visible wavelength light, i.e. "reflectance" is defined by its percentage and is reported as R_xY or R_x (i.e. the Y value cited below in ASTM E-308-85), wherein "X" is either "G" for glass side or "F" for film side. "Glass side" (e.g. "G" or "g") means, as viewed from the side of the glass substrate opposite that on which the coating resides, while "film side" (i.e. "F" or "f") means, as viewed from the side of the glass substrate on which the coating resides.

Color characteristics are measured and reported herein using the CIE LAB a*, b* coordinates and scale (i.e. the CIE a*b* diagram, Ill. CIE-C, 2 degree observer). Other similar coordinates may be equivalently used such as by the subscript "h" to signify the conventional use of the Hunter Lab Scale, or Ill. CIE-C, 10^0 observer, or the CIE LUV u*v* coordinates. These scales are defined herein according to ASTM D-2244-93 "Standard Test Method for Calculation of Color Differences From Instrumentally Measured Color Coordinates" Sep. 15, 1993 as augmented by ASTM E-308-85, Annual Book of ASTM Standards, Vol. 06.01 "Standard Method for Computing the Colors of Objects by 10 Using the CIE System" and/or as reported in IES LIGHTING HANDBOOK 1981 Reference Volume.

Visible transmittance can be measured using known, conventional techniques. For example, by using a spectrophotometer, such as a Perkin Elmer Lambda 900 or Hitachi U4001, a spectral curve of transmission is obtained. Visible transmission is then calculated using the aforesaid ASTM 308/2244-93 methodology. A lesser number of wavelength points may be employed than prescribed, if desired. Another technique for measuring visible transmittance is to employ a spectrometer such as a commercially available Spectrogard spectrophotometer manufactured by Pacific Scientific Corporation. This device measures and reports visible transmittance directly. As reported and measured herein, visible transmittance (i.e. the Y value in the CIE tristimulus system, ASTM E-308-85), as well as the a*, b*, and L* values, and glass/film side reflectance values, herein use the Ill. C., 2 degree observer standard.

Another term employed herein is "sheet resistance". Sheet resistance (R_s) is a well known term in the art and is used herein in accordance with its well known meaning. It is here reported in ohms per square units. Generally speaking, this term refers to the resistance in ohms for any square of a layer system on a glass substrate to an electric current passed through the layer system. Sheet resistance is an indication of how well the layer or layer system is reflecting infrared energy, and is thus often used along with emittance as a measure of this characteristic. "Sheet resistance" may for example be conveniently measured by using a 4-point probe ohmmeter, such as a dispensable 4-point resistivity probe with a Magnetron Instruments Corp. head, Model M-800 produced by Signatone Corp. of Santa Clara, Calif.

The terms "heat treatment" and "heat treating" as used herein mean heating the article to a temperature sufficient to achieve thermal tempering, heat bending, and/or heat strengthening of the glass inclusive coated article. This definition includes, for example, heating a coated article in an oven or furnace at a temperature of least about 580 degrees C., more preferably at least about 600 degrees C., including 650 degrees C., for a sufficient period to allow tempering, bending, and/or heat strengthening. In certain instances, the heat treatment may be for at least about 8 minutes or more as discussed herein.

In an example embodiment of this invention, there is provided a coated article including a coating on a glass substrate, wherein the coating comprises: a first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), provided on the glass substrate; a first infrared (IR) reflecting layer comprising silver located on the glass substrate and directly over and contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn; wherein no silicon nitride based layer is located directly under and contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn; at least one dielectric layer comprising at least one of: (a) an oxide of silicon and zirconium, (b) an oxide of zirconium, and (c) an oxide of silicon; wherein the at least one dielectric layer comprising at least one of (a), (b), and (c) is located: (1) between at least the glass substrate and the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), and/or (2) between at least the first IR reflecting layer comprising silver and a second IR reflecting layer comprising silver of the coating; an absorber film including a layer comprising silver, wherein a ratio of a physical thickness of the first IR reflecting layer comprising silver to a physical

thickness of the layer comprising silver of the absorber film is at least 5:1 (more preferably at least 8:1, even more preferably at least 10:1, and most preferably at least 15:1); and wherein the coated article is configured to have, measured monolithically, at least two of: (i) a transmissive ΔE* value of no greater than 3.0 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

The coated article of the immediately preceding paragraph may be configured to have, measured monolithically, all three of: (i) a transmissive ΔE* value of no greater than 3.0 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

In the coated article of any of the preceding two paragraphs, the least one dielectric layer comprising at least one of (a) an oxide of silicon and zirconium, (b) an oxide of zirconium, and (c) an oxide of silicon, may be located at least between at least the glass substrate and the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %).

In the coated article of any of the preceding three paragraphs, the least one dielectric layer comprising at least one of (a) an oxide of silicon and zirconium, (b) an oxide of zirconium, and (c) an oxide of silicon, may be located at least between at least the first IR reflecting layer comprising silver and the second IR reflecting layer comprising silver of the coating.

In the coated article of any of the preceding four paragraphs, the at least one dielectric layer comprising at least one of (a), (b), and (c) may include both a first layer comprising at least one of: (a) an oxide of silicon and zirconium, (b) an oxide of zirconium, and (c) an oxide of silicon, and a second layer comprising at least one of: (a) an oxide of silicon and zirconium, (b) an oxide of zirconium, and (c) an oxide of silicon; wherein the first layer may be located between at least the glass substrate and the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %); and wherein the second layer may be located between at least the first IR reflecting layer comprising silver and the second IR reflecting layer comprising silver of the coating.

In the coated article of any of the preceding five paragraphs, the at least one dielectric layer comprising at least one of (a), (b), and (c) may comprise or consist essentially of an oxide of silicon and zirconium (e.g., $SiZrO_x$). the dielectric layer comprising the oxide of silicon and zirconium may have a metal content of from 51-99% Si and from 1-49% Zr, more preferably from 70-97% Si and from 3-30% Zr (atomic %).

In the coated article of any of the preceding six paragraphs, the at least one dielectric layer comprising at least one of (a), (b), and (c) may comprise an oxide of zirconium.

In the coated article of any of the preceding seven paragraphs, the first crystalline or substantially crystalline layer comprising zinc oxide may be doped with from about 1-20% Sn, more preferably from about 5-15% Sn (wt. %).

In the coated article of any of the preceding eight paragraphs, the first crystalline or substantially crystalline layer comprising zinc oxide doped with Sn may be crystalline or substantially crystalline as sputter-deposited.

The coated article according to any of the preceding nine paragraphs may be configured to have, measured monolithically, all of: (i) a transmissive ΔE* value of no greater than 2.5 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 2.5 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

The coated article according to any of the preceding ten paragraphs may be configured to have, measured monolithically, at least two of: (i) a transmissive ΔE* value of no greater than 2.3 due to a reference heat treatment for 16 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 2.0 due to the reference heat treatment for 16 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 16 minutes at a temperature of about 650 degrees C.

The coated article according to any of the preceding eleven paragraphs may be configured so that the coating may have a sheet resistance (R_s) of no greater than 20 ohms/square, more preferably no greater than 10 ohms/square, and most preferably no greater than 2.5 ohms/square.

The coated article according to any of the preceding twelve paragraphs may have, measured monolithically, a visible transmission of at least 35%, more preferably of at least 50%, and more preferably of at least 68%.

In the coated article of any of the preceding thirteen paragraphs, the coating as deposited may further comprise a first amorphous or substantially amorphous layer comprising zinc stannate located on the glass substrate over at least the first IR reflecting layer comprising silver. The first amorphous or substantially amorphous layer comprising zinc stannate may have a metal content of from about 40-60% Zn and from about 40-60% Sn (wt. %).

In the coated article of any of the preceding fourteen paragraphs, the coating may further comprise a contact layer located over and directly contacting the first IR reflecting layer comprising silver. The contact layer may comprise Ni and/or Cr, and may or may not be oxided and/or nitrided.

In the coated article of any of the preceding fifteen paragraphs, the coating may further comprise: the second IR reflecting layer comprising silver located on the glass substrate over at least the first IR reflecting layer comprising silver, a second crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), located under and directly contacting the second IR reflecting layer comprising silver; and wherein no silicon nitride based layer need be located between the glass substrate and the second IR reflecting layer comprising silver.

In the coated article of any of the preceding sixteen paragraphs, the coating may further comprise an amorphous or substantially amorphous layer, as deposited, comprising zinc stannate located on the glass substrate over at least the second IR reflecting layer comprising silver. The amorphous or substantially amorphous layer comprising zinc stannate, which is amorphous or substantially amorphous as deposited, may have a metal content of from about 40-60% Zn and

from about 40-60% Sn (wt. %). In certain example embodiments, the coating may further comprise a layer comprising silicon nitride located over at least the amorphous or substantially amorphous layer comprising zinc stannate.

The coated article of any of the preceding seventeen paragraphs may be thermally tempered.

The coated article of any of the preceding eighteen paragraphs may further comprise a metallic or substantially metallic absorber layer located between the glass substrate and the first IR reflecting layer. The absorber layer may be sandwiched between and contacting first and second layers comprising silicon nitride. The absorber layer may comprise Ni and Cr (e.g., NiCr, NiCrMo), or any other suitable material such as NbZr. The dielectric layer comprising at least one of (a), (b), and (c) may be located between at least the absorber layer and the first crystalline or substantially crystalline layer comprising zinc oxide.

In the coated article of any of the preceding nineteen paragraphs, the at least one dielectric layer comprising at least one of (a), (b), and (c) may comprise from 0-20% nitrogen, more preferably from 0-10% nitrogen, and most preferably from 0-5% nitrogen (atomic %).

In the coated article of any of the preceding twenty paragraphs, the absorber film may further comprises a layer comprising an oxide of Ni and/or Cr located over and directly contacting the layer comprising silver of the absorber film.

In the coated article of any of the preceding twenty-one paragraphs, the absorber film may be located over the first IR reflecting layer, so that the first IR reflecting layer is located between at least the absorber film and the glass substrate.

In the coated article of any of the preceding twenty-two paragraphs, the ratio of the physical thickness of the first IR reflecting layer comprising silver to the physical thickness of the layer comprising silver of the absorber film may be at least 8:1, more preferably at least 10:1, and even more preferably at least 15:1.

In the coated article of any of the preceding twenty-three paragraphs, the layer comprising silver of the absorber film may be less than 30 Å thick, more preferably less than 20 Å thick, and even more preferably less than 15 Å thick.

In an example embodiment of this invention, there is provided a coated article including a coating on a glass substrate, wherein the coating comprises: a first crystalline or substantially crystalline layer (e.g., at least 50% crystalline, more preferably at least 60% crystalline) comprising zinc oxide doped with from about 1-30% Sn (wt. %), provided on the glass substrate; a first infrared (IR) reflecting layer comprising silver located on the glass substrate and directly over and contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn; an absorber film including a layer comprising silver, wherein a ratio of a physical thickness of the first IR reflecting layer comprising silver to a physical thickness of the layer comprising silver of the absorber film is at least 5:1 (more preferably at least 8:1, more preferably at least 10:1, and even more preferably at least 15:1); wherein no silicon nitride based layer (which includes no silicon oxynitride based layer) is located directly under and contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn between the glass substrate and the first IR reflecting layer comprising silver; and wherein the coated article is configured to have, measured monolithically, one, two, or all three of: (i) a transmissive ΔE* value of no greater than 3.0 due to a reference heat treatment for 8 minutes at a temperature of about 650 degrees C. (e.g., on a reference 3 mm thick glass substrate), (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C. (e.g., on a reference 3 mm thick glass substrate), and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C. (e.g., on a reference 3 mm thick glass substrate).

In the coated article of the immediately preceding paragraph, the first crystalline or substantially crystalline layer comprising zinc oxide may be doped with from about 1-20% Sn (wt. %), more preferably with from about 5-15% Sn (wt. %), and most preferably with about 10% Sn (wt. %).

In the coated article of any of the preceding two paragraphs, the first crystalline or substantially crystalline layer comprising zinc oxide doped with Sn may be crystalline or substantially crystalline as sputter-deposited.

In the coated article of any of the preceding three paragraphs, the coated article may be configured to have, measured monolithically, at least two of: (i) a transmissive ΔE* value of no greater than 3.0 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C.

In the coated article of any of the preceding four paragraphs, the coated article may be configured to have, measured monolithically, all of: (i) a transmissive ΔE* value of no greater than 3.0 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C.

In the coated article of any of the preceding five paragraphs, the coated article may be configured to have, measured monolithically, at least two of: (i) a transmissive ΔE* value of no greater than 2.5 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 2.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

In the coated article of any of the preceding six paragraphs, the coated article may be configured to have, measured monolithically, all of: (i) a transmissive ΔE* value of no greater than 2.5 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 2.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

In the coated article of any of the preceding seven paragraphs, the coated article may be configured to have, measured monolithically, at least one of: (i) a transmissive ΔE* value of no greater than 2.3 due to a reference heat treatment for 16 minutes at a temperature of about 650

degrees C., (ii) a glass side reflective ΔE* value of no greater than 1.0 due to the reference heat treatment for 16 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 2.0 due to the reference heat treatment for 16 minutes at a temperature of about 650 degrees C.

In the coated article of any of the preceding eight paragraphs, the coating may have a sheet resistance (R_s) of no greater than 20 ohms/square, more preferably no greater than 10 ohms/square, and most preferably no greater than 2.2 ohms/square, before and/or after heat treatment.

In the coated article of any of the preceding nine paragraphs, the coated article may have a visible transmission of at least 30%, more preferably of at least 40%, more preferably of at least 50% (e.g., from about 40-65%) (e.g., measured monolithically).

In the coated article of any of the preceding ten paragraphs, the first crystalline or substantially crystalline layer comprising zinc oxide doped with Sn may be located between and directly contacting the glass substrate and the first IR reflecting layer comprising silver.

In the coated article of any of the preceding eleven paragraphs, the coating may further comprise a first amorphous or substantially amorphous layer comprising zinc stannate located on the glass substrate over at least the first IR reflecting layer comprising silver. The first amorphous or substantially amorphous layer comprising zinc stannate may have a metal content of from about 40-60% Zn and from about 40-60% Sn (wt. %).

In the coated article of any of the preceding twelve paragraphs, the coating may further comprise a contact layer located over and directly contacting the first IR reflecting layer comprising silver. The contact layer may comprise for instance one or more of Ni, Cr, Ni and/or Cr, NiCr, Ti, NiCrMo, and/or oxides and/or nitrides thereof.

In the coated article of any of the preceding thirteen paragraphs, the coating may further comprise: a second IR reflecting layer comprising silver located on the glass substrate over at least the first IR reflecting layer comprising silver, a second crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), located under and directly contacting the second IR reflecting layer comprising silver, and wherein the layer comprising silver of the absorber film does not directly contact any of the first and second IR reflecting layers. Optionally, no silicon nitride based layer is located between the glass substrate and the second IR reflecting layer comprising silver. The coating may also further comprise an amorphous or substantially amorphous layer comprising zinc stannate located on the glass substrate over at least the second IR reflecting layer comprising silver, where the amorphous or substantially amorphous layer comprising zinc stannate may have a metal content of from about 40-60% Zn and from about 40-60% Sn (wt. %). The coating may further comprise a layer comprising silicon nitride located over at least the amorphous or substantially amorphous layer comprising zinc stannate. The coating may further comprise a contact layer (e.g., see example contact layer materials above) located over and directly contacting the second IR reflecting layer comprising silver.

In the coated article of any of the preceding fourteen paragraphs, the coated article may be thermally tempered.

In the coated article of any of the preceding fifteen paragraphs, the coated article may be configured to have, measured monolithically, each of: (i) a transmissive ΔE* value of no greater than 3.5 due to a reference heat treatment for 16 minutes at a temperature of about 650 degrees C., and (ii) a glass side reflective ΔE* value of no greater than 1.8 due to the reference heat treatment for 16 minutes at a temperature of about 650 degrees C.

In the coated article of any of the preceding sixteen paragraphs, the coated article may further comprise a layer comprising zirconium oxide located under and directly contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn.

In the coated article of any of the preceding seventeen paragraphs, the coated article may comprise a layer comprising an oxide and/or nitride of silicon and zirconium located under and directly contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn.

In the coated article of any of the preceding eighteen paragraphs, the coated article may comprises a layer comprising an oxide of silicon and zirconium located under and directly contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn.

In the coated article of any of the preceding nineteen paragraphs, the coated article may comprise a layer comprising an oxide of silicon and zirconium located between at least the glass substrate and the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn.

In certain example embodiments, there is provided a coated article including a coating on a glass substrate, wherein the coating comprises: a layer comprising zinc oxide doped with from about 1-30% Sn (more preferably from about 5-15%) (wt. %), provided on the glass substrate; a first infrared (IR) reflecting layer comprising silver located on the glass substrate and directly over and contacting the first layer comprising zinc oxide doped with from about 1-30% Sn; at least one dielectric layer on the glass substrate over at least the first IR reflecting layer comprising silver and the first crystalline or substantially crystalline layer comprising zinc oxide; an absorber film including a layer comprising silver, wherein a ratio of a physical thickness of the first IR reflecting layer comprising silver to a physical thickness of the layer comprising silver of the absorber film is at least 5:1 (more preferably at least 8:1, more preferably at least 10:1, and even more preferably at least 15:1); and wherein no silicon nitride based layer is located directly under and contacting the layer comprising zinc oxide doped with from about 1-30% Sn; and wherein the coated article is configured to have, measured monolithically, at least one of: (i) a transmissive ΔE* value of no greater than 3.0 due to a reference heat treatment for 8 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 8 minutes at a temperature of about 650 degrees C.

In the coated article of any of the preceding paragraphs, the coated article may further comprise a dielectric layer located under and directly contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn. The dielectric layer may comprise one or more of ZrO_2, SiO_2 which may optionally be doped with from 1-10% Al, and/or an oxide of silicon and zirconium. The dielectric layer may be in direct contact with the glass substrate. The dielectric layer may have a physical thickness of from about 40-400 Å, more preferably from about 50-300 Å, and most preferably from about 50-200 Å.

The dielectric layer preferably contains little or no nitrogen. For example, the dielectric layer may comprise from 0-20% nitrogen, more preferably from 0-10% nitrogen, and most preferably from 0-5% nitrogen (atomic %).

In the coated article of any of the preceding paragraphs, the coating may further comprise a second IR reflecting layer comprising silver located on the glass substrate over at least the first IR reflecting layer comprising silver; a second layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), located under and directly contacting the second IR reflecting layer comprising silver; and a layer comprising zinc stannate located between the first IR reflecting layer and the second layer comprising zinc oxide doped with from about 1-30% Sn. There may be provided a layer comprising an oxide of silicon and zirconium located between at least the glass substrate and the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn. The coated article may further include a dielectric layer comprising zirconium oxide (e.g., ZrO_2), and/or an oxide of silicon and zirconium, located between the layer comprising zinc stannate **11** and the second layer **13** comprising zinc oxide doped with from about 1-30% Sn.

In an example embodiment of this invention, there is provided a coated article including a coating on a glass substrate, wherein the coating comprises: a first dielectric layer located on the glass substrate; a first infrared (IR) reflecting layer comprising silver located on the glass substrate and over the first dielectric layer; a second IR reflecting layer comprising silver located on the glass substrate, wherein the first IR reflecting layer comprising silver is located between the glass substrate and the second IR reflecting layer comprising silver; an absorber film including a layer comprising silver that does not directly contact any of the first and second IR reflecting layers; wherein a ratio of a physical thickness of the first IR reflecting layer comprising silver, and/or a physical thickness of the second IR reflecting layer comprising silver, to a physical thickness of the layer comprising silver of the absorber film is at least 5:1.

In the coated article of the immediately preceding paragraph, the coated article may be configured to have, measured monolithically, at least two of: (i) a transmissive ΔE* value of no greater than 3.0 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

In the coated article of any of the preceding two paragraphs, there may be a case where no silicon nitride based layer is located between the glass substrate and the second IR reflecting layer comprising silver.

In the coated article of any of the preceding three paragraphs, the first dielectric layer may comprise zinc oxide doped with from about 1-30% Sn, or may comprise zirconium oxide.

In the coated article of any of the preceding four paragraphs, the coating may further comprise a layer comprising zirconium oxide located between at least the first and second IR reflecting layers, and under the absorber film.

In the coated article of any of the preceding five paragraphs, the coating may further comprise a layer comprising zirconium oxide located between at least the glass substrate and the first IR reflecting layer.

In the coated article of any of the preceding six paragraphs, the absorber film may further comprise a layer comprising an oxide of Ni and/or Cr located over and directly contacting the layer comprising silver of the absorber film. The layer comprising an oxide of Ni and/or Cr may comprises $NiCrO_x$, and a physical thickness ratio of $Ag/NiCrO_x$ in the absorber film may be 1:Z, where $2.0<Z<15.0$, more preferably $3.0<Z<12.0$.

In the coated article of any of the preceding seven paragraphs, the coating may further comprises a second dielectric layer between at least the first IR reflecting layer and the absorber film, and at least a third dielectric layer between at least the second IR reflecting layer and the absorber film.

In the coated article of any of the preceding eight paragraphs, the absorber film may be located between at least the first and second IR reflecting layers, or alternatively may be located below both the first and second IR reflecting layers so that the absorber film is located between at least the glass substrate and the first IR reflecting layer.

In the coated article of any of the preceding nine paragraphs, the ratio of the physical thickness of the first IR reflecting layer comprising silver to the physical thickness of the layer comprising silver of the absorber film may be at least 8:1, more preferably at least 10:1, and most preferably at least 15:1.

In the coated article of any of the preceding ten paragraphs, the layer comprising silver of the absorber film may be less than 60 Å thick, more preferably no greater than 30 Å thick, and most preferably no greater than 20 or 15 Å thick.

In the coated article of any of the preceding eleven paragraphs, the coating may further comprises a dielectric layer comprising zinc oxide doped with from 1-30% Sn located under and directly contacting the second IR reflecting layer.

In the coated article of any of the preceding twelve paragraphs, the absorber film may comprise or consist essentially of the layer comprising silver and a layer comprising an oxide of Ni and/or Cr, and/or may comprise or consist essentially of a layer sequence comprising $Ag/NiCrO_x/Ag$, and/or may comprise or consist essentially of a layer sequence comprising $Ag/NiCrO_x/Ag/NiCrO_x$.

In the coated article of any of the preceding thirteen paragraphs, the coated article, measured monolithically, may have a visible transmission of at least 30%, more preferably at least 40%, and most preferably at least 50%.

In the coated article of any of the preceding fourteen paragraphs, the coated article, measured monolithically, may have a glass side visible reflectance (R_gY) of no greater than 20% (e.g., from 5-20%).

The coated article of any of the preceding fifteen paragraphs may be provided in an IG window unit, coupled to another glass substrate.

Once given the above disclosure many other features, modifications and improvements will become apparent to the skilled artisan. Such other features, modifications and improvements are therefore considered to be a part of this invention, the scope of which is to be determined by the following claims:

What is claimed is:

1. A coated article including a coating on a glass substrate, wherein the coating comprises:

a first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), provided on the glass substrate;

a first infrared (IR) reflecting layer comprising silver located on the glass substrate and directly over and contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn;

wherein no silicon nitride based layer is located directly under and contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn;

at least one dielectric layer comprising an oxide of zirconium directly contacting the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn, the dielectric layer comprising the oxide of zirconium being located between at least the glass substrate and the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn;

an absorber film including a layer comprising silver, wherein a ratio of a physical thickness of the first IR reflecting layer comprising silver to a physical thickness of the layer comprising silver of the absorber film is at least 5:1, and wherein the layer comprising silver of the absorber film does not directly contact the first IR reflecting layer; and

wherein the coated article is configured to have, measured monolithically, at least two of: (i) a transmissive ΔE* value of no greater than 3.0 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

2. The coated article of claim **1**, wherein the absorber film further comprises a layer comprising an oxide of Ni and/or Cr located over and directly contacting the layer comprising silver of the absorber film.

3. The coated article of claim **1**, wherein the absorber film is located over the first IR reflecting layer, so that the first IR reflecting layer is located between at least the absorber film and the glass substrate.

4. The coated article of claim **1**, wherein the ratio of the physical thickness of the first IR reflecting layer comprising silver to the physical thickness of the layer comprising silver of the absorber film is at least 8:1.

5. The coated article of claim **1**, wherein the ratio of the physical thickness of the first IR reflecting layer comprising silver to the physical thickness of the layer comprising silver of the absorber film is at least 10:1.

6. The coated article of claim **1**, wherein the ratio of the physical thickness of the first IR reflecting layer comprising silver to the physical thickness of the layer comprising silver of the absorber film is at least 15:1.

7. The coated article of claim **1**, wherein the layer comprising silver of the absorber film is less than 60 Å thick.

8. The coated article of claim **1**, wherein the layer comprising silver of the absorber film is less than 30 Å thick.

9. The coated article of claim **1**, wherein the layer comprising silver of the absorber film is less than 15 Å thick.

10. The coated article of claim **1**, wherein the coated article is configured to have, measured monolithically, all three of (i) a transmissive ΔE* value of no greater than 3.0 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

11. The coated article of claim **1**, wherein the coating further includes a second IR reflecting layer comprising silver, wherein the second IR reflecting layer is located over the first IR reflecting layer.

12. The coated article of claim **1**, wherein the first crystalline or substantially crystalline layer comprising zinc oxide is doped with from about 1-20% Sn (wt. %).

13. The coated article of claim **1**, wherein the first crystalline or substantially crystalline layer comprising zinc oxide is doped with from about 5-15% Sn (wt. %).

14. The coated article of claim **1**, wherein the first crystalline or substantially crystalline layer comprising zinc oxide doped with Sn is crystalline or substantially crystalline as sputter-deposited.

15. The coated article of claim **1**, wherein the coated article is configured to have, measured monolithically, all of: (i) a transmissive ΔE* value of no greater than 2.5 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 2.5 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

16. The coated article of claim **1**, wherein the coated article is configured to have, measured monolithically, at least two of (i) a transmissive ΔE* value of no greater than 2.3 due to a reference heat treatment for 16 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 2.0 due to the reference heat treatment for 16 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 16 minutes at a temperature of about 650 degrees C.

17. The coated article of claim **1**, wherein said coating has a sheet resistance (R_s) of no greater than 10 ohms/square.

18. The coated article of claim **1**, wherein said coated article, measured monolithically, has a visible transmission of at least 40%.

19. The coated article of claim **1**, wherein the coating as deposited further comprises a first amorphous or substantially amorphous layer comprising zinc stannate located on the glass substrate over at least the first IR reflecting layer comprising silver.

20. The coated article of claim **19**, wherein the first amorphous or substantially amorphous layer comprising zinc stannate has a metal content of from about 40-60% Zn and from about 40-60% Sn (wt. %).

21. The coated article of claim **1**, wherein the coating further comprises a contact layer located over and directly contacting the first IR reflecting layer comprising silver.

22. The coated article of claim **21**, wherein the contact layer comprises Ni and Cr.

23. The coated article of claim **1**, wherein the coating further comprises:

a second IR reflecting layer comprising silver located on the glass substrate over at least the first IR reflecting layer comprising silver,

a second crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), located under and directly contacting the second IR reflecting layer comprising silver;

wherein no silicon nitride based layer is located between the glass substrate and the second IR reflecting layer comprising silver; and

wherein the layer comprising silver of the absorber film does not directly contact any of the first and second IR reflecting layers.

24. The coated article of claim **23**, wherein the absorber film is located between the first and second IR reflecting layers.

25. The coated article of claim **24**, wherein the absorber film is located below both the first and second IR reflecting layers.

26. The coated article of claim **1**, wherein the coated article is thermally tempered.

27. The coated article of claim **1**, wherein the at least one dielectric layer comprising the oxide of zirconium includes two such layers comprising zirconium oxide and is located both: (1) between at least the glass substrate and the first crystalline or substantially crystalline layer comprising zinc oxide doped with from about 1-30% Sn (wt. %), and (2) between at least the first IR reflecting layer comprising silver and the absorber film.

28. The coated article of claim **27**, wherein the at least one dielectric layer comprising the oxide of zirconium comprises from 0-5% nitrogen (atomic %).

29. The coated article of claim **1**, wherein the layer comprising silver of the absorber film is located on and directly contacting a layer comprising zinc oxide.

30. The coated article of claim **29**, wherein the layer comprising zinc oxide is located on and directly contacting a layer comprising zirconium oxide of the at least one dielectric layer comprising the oxide of zirconium.

31. The coated article of claim **1**, wherein the absorber film comprises a layer sequence comprising Ag/$NiCrO_x$/Ag.

32. A coated article including a coating on a glass substrate, wherein the coating comprises:

a first dielectric layer located on the glass substrate;

a first infrared (IR) reflecting layer comprising silver located on the glass substrate and over at least the first dielectric layer;

a second IR reflecting layer comprising silver located on the glass substrate, wherein the first IR reflecting layer comprising silver is located between at least the glass substrate and the second IR reflecting layer comprising silver;

an absorber film including first and second layers comprising silver that do not directly contact any of the first and second IR reflecting layers, and a layer comprising an oxide of Ni and Cr located between and directly contacting the first and second layers comprising silver of the absorber film, and

wherein a ratio of a physical thickness of the first IR reflecting layer comprising silver, and/or a physical thickness of the second IR reflecting layer comprising silver, to a physical thickness of the first layer comprising silver of the absorber film is at least 5:1.

33. The coated article of claim **32**, wherein the coated article is configured to have, measured monolithically, at least two of (i) a transmissive ΔE* value of no greater than 3.0 due to a reference heat treatment for 12 minutes at a temperature of about 650 degrees C., (ii) a glass side reflective ΔE* value of no greater than 3.0 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C., and (iii) a film side reflective ΔE* value of no greater than 3.5 due to the reference heat treatment for 12 minutes at a temperature of about 650 degrees C.

34. The coated article of claim **32**, wherein no silicon nitride based layer is located between the glass substrate and the second IR reflecting layer comprising silver.

35. The coated article of claim **32**, wherein the first dielectric layer comprises zinc oxide doped with from about 1-30% Sn.

36. The coated article of claim **32**, wherein the coating further comprises a layer comprising zirconium oxide located between at least the first and second IR reflecting layers, and under the absorber film.

37. The coated article of claim **32**, wherein the coating further comprises a layer comprising zirconium oxide located between at least the glass substrate and the first IR reflecting layer.

38. The coated article of claim **32**, wherein the layer comprising an oxide of Ni and Cr comprises $NiCrO_x$, and where a physical thickness ratio of Ag/$NiCrO_x$ in the absorber film is 1:Z, where $2.0<Z<15.0$.

39. The coated article of claim **38**, wherein the physical thickness ratio of Ag/$NiCrO_x$ in the absorber film is 1:Z, where $3.0<Z<12.0$.

40. The coated article of claim **32**, wherein the coating further comprises a second dielectric layer between at least the first IR reflecting layer and the absorber film, and at least a third dielectric layer between at least the second IR reflecting layer and the absorber film.

41. The coated article of claim **32**, wherein the absorber film is located between at least the first and second IR reflecting layers.

42. The coated article of claim **32**, wherein the absorber film is located below both the first and second IR reflecting layers, so that the absorber film is located between at least the glass substrate and the first IR reflecting layer.

43. The coated article of claim **32**, wherein the ratio of the physical thickness of the first IR reflecting layer comprising silver to the physical thickness of the layer comprising silver of the absorber film is at least 8:1.

44. The coated article of claim **32**, wherein the ratio of the physical thickness of the first IR reflecting layer comprising silver to the physical thickness of the layer comprising silver of the absorber film is at least 10:1.

45. The coated article of claim **32**, wherein the ratio of the physical thickness of the first IR reflecting layer comprising silver to the physical thickness of the layer comprising silver of the absorber film is at least 15:1.

46. The coated article of claim **45**, wherein the layer comprising silver of the absorber film is less than 30 Å thick.

47. The coated article of claim **32**, wherein the coating further comprises a second dielectric layer comprising zinc oxide doped with from 1-30% Sn located under and directly contacting the second IR reflecting layer.

48. The coated article of claim **32**, wherein the absorber film comprises a layer sequence comprising Ag/$NiCrO_x$/Ag/$NiCrO_x$.

49. The coated article of claim **32**, wherein the coated article, measured monolithically, has a visible transmission of at least 30%.

50. The coated article of claim **32**, wherein the coated article, measured monolithically, has a visible transmission of at least 50%.

51. The coated article of claim **32**, wherein the coated article, measured monolithically, has a glass side visible reflectance (R_gY) of no greater than 20%.

52. An IG window unit comprising the coated article of claim **32** coupled to another glass substrate.

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