IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

PRESIDENT AND FELLOWS OF HARVARD COLLEGE Plaintiff, v. MICRON TECHNOLOGY, INC. Defendant.	)	Civil Action No. 1:16-cv-11249-WGY **LEAVE TO FILE GRANTED JANUARY 30, 2017** **JURY TRIAL DEMANDED**

AMENDED COMPLAINT

Plaintiff, President and Fellows of Harvard College ("Harvard"), by and through its counsel, Pepper Hamilton LLP, for its Amended Complaint against Defendant Micron Technology, Inc. ("Micron"), alleges as follows:

THE PARTIES

1. Plaintiff Harvard is an educational institution and charitable corporation organized under the laws of the Commonwealth of Massachusetts with its principal place of business at Massachusetts Hall, Cambridge, MA 02138.

2. Upon information and belief, Defendant Micron Technology, Inc. is a Delaware corporation with its principal place of business at 8000 S. Federal Way, Boise, ID 83707.

JURISDICTION AND VENUE

3. This is an action for patent infringement arising under the Patent Laws of the United States, 35 U.S.C. § 1 *et. seq*. This Court has jurisdiction over the subject matter of this action pursuant to 28 U.S.C. §§ 1331 and 1338(a).

4. This Court has personal jurisdiction over Micron at least based upon Micron's contacts with the forum and the nature of the infringing activity alleged herein. Upon information and belief, Micron regularly does or solicits business, engages in other persistent courses of conduct, and/or derives substantial revenue from products and/or services provided to individuals in the Commonwealth of Massachusetts. Upon information and belief Micron has committed acts of patent infringement within the Commonwealth of Massachusetts by, *inter alia*, selling, offering for sale, importing products manufactured by processes, and/or using materials that infringe one or more claims of the patents asserted herein. Further, the exercise of personal jurisdiction comports with Due Process under the United States Constitution.

5. Venue is proper in this district pursuant to 28 U.S.C. §§ 1391(b) and 1400.

BACKGROUND

6. Established in 1636, Harvard is the nation's oldest institution of higher learning and is recognized as one of the world's leading academic institutions. The range of research activities at Harvard is broad and deep. Harvard scholars conduct research in almost every field of knowledge and constantly seek to expand human knowledge through analysis, innovation, and insight. Research at Harvard is supported by more than $800 million of sponsored research funds each year. Researchers include faculty members, visiting scholars, post-doctoral fellows, and graduate and undergraduate students. These researchers collaborate with colleagues across Harvard, at Harvard-affiliated institutions, at other research institutions, and with private corporations throughout the world.

7. Harvard has a long history of benefiting the public through its research programs. Harvard recognizes that the public benefits from new products and processes resulting from discoveries and inventions made by individuals connected with Harvard in the course of their scholarly and research activities. Harvard protects and manages the intellectual property that

results from the efforts of its researchers, to the benefit of, among others, the researchers, Harvard, and the public.

Professor Gordon's Research Team and the Patented Technology

8. Professor Roy G. Gordon has worked for and performed research in Harvard's Department of Chemistry for over 50 years. Professor Gordon has served as Chairman of the Department of Chemistry and is the Thomas D. Cabot Professor of Chemistry. The Department of Chemistry at Harvard, through its faculty, students, postdoctoral fellows, and other research scholars, work in first-class facilities on individual investigator-led research projects and in collaboration with others in a broad spectrum of chemistry topics.

9. Professor Gordon's research has spanned a wide range of subjects including applied mathematics, quantum mechanics, spectroscopy, intermolecular forces, solid state, and materials science. His theoretical work has led to a better understanding of bonding in molecules and solids, and to predictions of new solid phases and phase transitions. Currently, the chemical kinetics of crystal growth from vapor systems is being studied both theoretically and experimentally in his laboratory. His discoveries of new materials and vapor deposition processes are widely used commercially for making thin films in solar cells, energy-conserving window coatings, display devices, and semiconductor electronics.

10. Professor Gordon, along with Drs. Jill Becker, Dennis Hausmann, and Seigi Suh are named inventors on U.S. Patent Nos. 6,969,539 and 8,334,016 (collectively, "the Asserted Patents"). Harvard is the assignee of each of the Asserted Patents and owns all right, title, and interest in the Asserted Patents.

11. The inventions claimed by the Asserted Patents include novel processes and materials for deposition of thin films that contain metal oxides, silicates, metal phosphates, or

silicon dioxide. Such films are essential to key components of numerous products such as computers and cell phones.

12. Some of the claimed inventions include atomic layer deposition ("ALD"). ALD is a process by which thin films for microelectronics are produced. ALD requires a number of process steps, one of which is the use of a chemical precursor with appropriate reactive properties, *e.g.*, to form a dielectric layer. Additionally, the chemical precursor used for the ALD process must allow for appropriate deposition rates when creating the thin film, and should not leave behind elements that are deleterious to the properties of the film. These problems have been found with the use of precursors such as metal chlorides and silicon alkoxides.

13. Additional problems can occur with the use of ALD for the fabrication of modern semiconductors, which require thin dielectric film layers. For example, problems can occur in forming dielectric materials in deep-trench structures with high aspect ratios, such as those found in dynamic random access memory ("DRAM") devices. Not only must the capacitance values remain at a certain level despite the required film thickness, but the precursor must also be delivered deep into the trenches without causing a premature reaction that precludes uniform coverage within the entire deep-trench structure.

14. The ALD processes and materials claimed by the Asserted Patents solve some of the problems associated with the production of semiconductors at smaller sizes. The inventions claimed by the Asserted Patents provide a viable solution for the semiconductor industry, including a solution to forming dielectric materials in deep-trench structures, such as those found in DRAM devices.

Micron's Infringing Actions and Products

15. Micron advertises that it is a leader in advanced semiconductor systems with a broad portfolio of high-performance memory technologies, including DRAM, as well as other types of memory, such as NAND Flash. Micron is one of the three largest manufacturers of DRAM in the world.[1]

16. Upon information and belief, Micron markets its products through its internal sales force, independent sales representatives, and distributors to original equipment manufacturers and retailers around the world, including throughout the United States and within the Commonwealth of Massachusetts.

17. Micron obtains the products it sells from wholly-owned manufacturing facilities, including manufacturing facilities in the United States. Micron continually offers new generations of products with improved performance characteristics, including higher data transfer rates, reduced package sizes, lower power consumption, improved read/write reliability, and increased memory density. Micron has and continues to manufacture DRAM associated with the problems that can occur with the use of ALD. For example, in 2015, the majority of Micron's DRAM production was manufactured with 25nm line-width process technologies. Micron expects that by the second half of 2016, the majority of its DRAM production will be manufactured on its 20nm line-width process technology.[2]

18. Upon information and belief, Micron's manufacturing facilities in the United States manufacture certain products in an infringing manner, using ALD processes and materials

[1] *See* TECHNOLOGY ROADMAP of DRAM for Three Major manufacturers: Samsung, SK-Hynix and Micron (Oct. 2014), *available at* http://www.techinsights.com/uploadedFiles/Public_Website/Content_-_Primary/Marketing/2015/TechServices/TechInsights-DRAMRoadmap2014.ppt.

[2] 2015 Annual Report on Form 10-K of Micron Technology, Inc., *available at* http://investors.micron.com/sec.cfm?view=all.

claimed by the Asserted Patents. For example, upon information and belief, Micron's manufacturing facilities in the United States manufacture DRAM devices using the ALD processes and materials claimed by the Asserted Patents.

19. Upon information and belief, Micron manufactures DRAM devices using an ALD process that uses a metal alkylamide precursor. Upon information and belief, Micron uses a metal alkylamide precursor in its ALD process during the manufacture of its DRAM devices to avoid the problems associated with manufacturing modern DRAM.

20. Upon information and belief, Micron's products that are manufactured using the ALD processes and materials claimed by the Asserted Patents are sold individually, as well as incorporated into computing, consumer, enterprise, networking, mobile, and automotive products, throughout the United States, including within the Commonwealth of Massachusetts. For example, Micron's DDR4 DRAM is sold individually, and incorporated in other products, throughout the United States, including within the Commonwealth of Massachusetts.

21. Micron operates a public website, micron.com, which is accessible in the Commonwealth of Massachusetts. Through micron.com, Micron advertises its products, such as its DRAM memory. Micron's website provides, among other information, technical and purchasing information regarding its products. Micron's website includes a page dedicated to "How to Buy" Micron's products, including DRAM memory.

22. Micron's semiconductor memory products are offered under, at least, the brand name Crucial. The brand name Crucial is a registered trademark of Micron. Through its public website, micron.com, Micron leads potential customers to crucial.com. Crucial.com is a public website, which is accessible in the Commonwealth of Massachusetts. Through crucial.com, customers throughout the United States, including within the Commonwealth of Massachusetts,

can buy Micron products, such as DRAM products. For example, through crucial.com a customer in the Commonwealth of Massachusetts can order Micron DRAM memory such as Crucial 4GB DDR4-2133 UDIMM.

23. Upon information and belief, Micron has infringed and continues to infringe the Asserted Patents by manufacturing products using the ALD processes and materials claimed by the Asserted Patents. Additionally, Micron has infringed and continues to infringe the Asserted Patents by, directly or through its agents, using, offering for sale, and selling infringing products throughout the United States, including within the Commonwealth of Massachusetts.

24. Micron has been aware of its infringing activities at least as of the filing of the original Complaint filed by Harvard in this matter.

COUNT I
(INFRINGEMENT OF U.S. PATENT NO. 6,969,539)

25. Harvard hereby re-alleges and incorporates by reference the foregoing paragraphs of the Amended Complaint as if fully set forth herein.

26. On November 29, 2005, the United States Patent and Trademark Office ("USPTO") duly and legally issued U.S. Patent No. 6,969,539, entitled "Vapor Deposition of Metal Oxides, Silicates and Phosphates, and Silicon Dioxide," to inventors Roy G. Gordon, Jill Becker, Dennis Hausmann, and Seigi Suh (the "'539 Patent"). A true and correct copy of the '539 Patent is attached as Exhibit A to this Amended Complaint.

27. Upon information and belief, in violation of 35 U.S.C. § 271, Micron and its subsidiaries have directly infringed and continue to directly infringe, either literally or under the doctrine of equivalents, one or more claims of the '539 Patent, by, without limitation, making products using the process claimed by one or more claims of the '539 Patent. Additionally, Micron and its subsidiaries have infringed and continue to infringe the '539 Patent, either

literally or under the doctrine of equivalents, in violation of 35 U.S.C. § 271, by, without limitation, using, offering for sale and/or selling, those products throughout the United States, including within the Commonwealth of Massachusetts.

28. Upon information and belief, at least certain Micron DRAM memory products are made using a process that includes all of the limitations of one or more of the claims of the ’539 Patent. Upon information and belief, Micron makes these memory products in the United States. Micron directly or indirectly, uses, sells, and/or offers for sale these memory products throughout the United States, including within the Commonwealth of Massachusetts.

29. Micron further violates 35 U.S.C. § 271(g), to the extent Micron makes DRAM memory products using a process that includes all of the limitations of one or more of the claims of the ’539 Patent abroad and imports them into the United States.

A. Direct Infringement of the ’539 Patent

30. Upon information and belief, certain Micron processors such as DRAM memory products are made using the process claimed by one or more claims of the ’539 Patent. The analysis below demonstrates how an exemplary Micron DRAM product is made using a process claimed by one or more claims of the ’539 Patent. The claim and products analyzed below are exemplary and are not intended to limit Harvard’s allegations. The analysis is based on information available to Harvard before discovery in this action. Harvard reserves the right to assert any additional claims of the ’539 Patent against any infringing acts by Micron.

1. Claim 24

31. Claim 24 recites:

A process for forming a metal oxide, comprising:

exposing a heated surface alternately to the vapor of one or more metal amides having an amido group selected from the group consisting

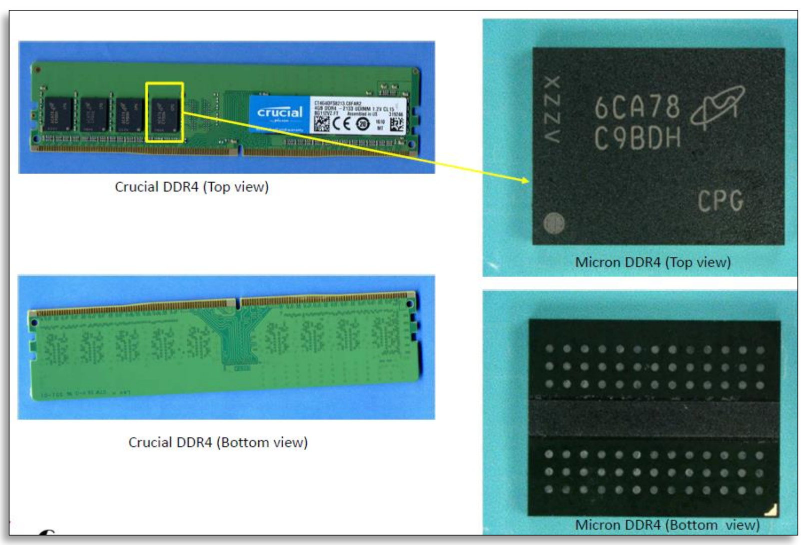
> of dialkylamido, disilylamido and (alkyl)(silyl) amido moieties, and then to the vapors of water or an alcohol.

32. Upon information and belief, at least Micron's DRAM memory is made using a process that practices each element of exemplary claim 24 of the '539 Patent.

a. *A process for forming a metal oxide, comprising:*

33. Micron makes, sells, offers for sale, or imports DRAM memory chips such as the one pictured below. [3]

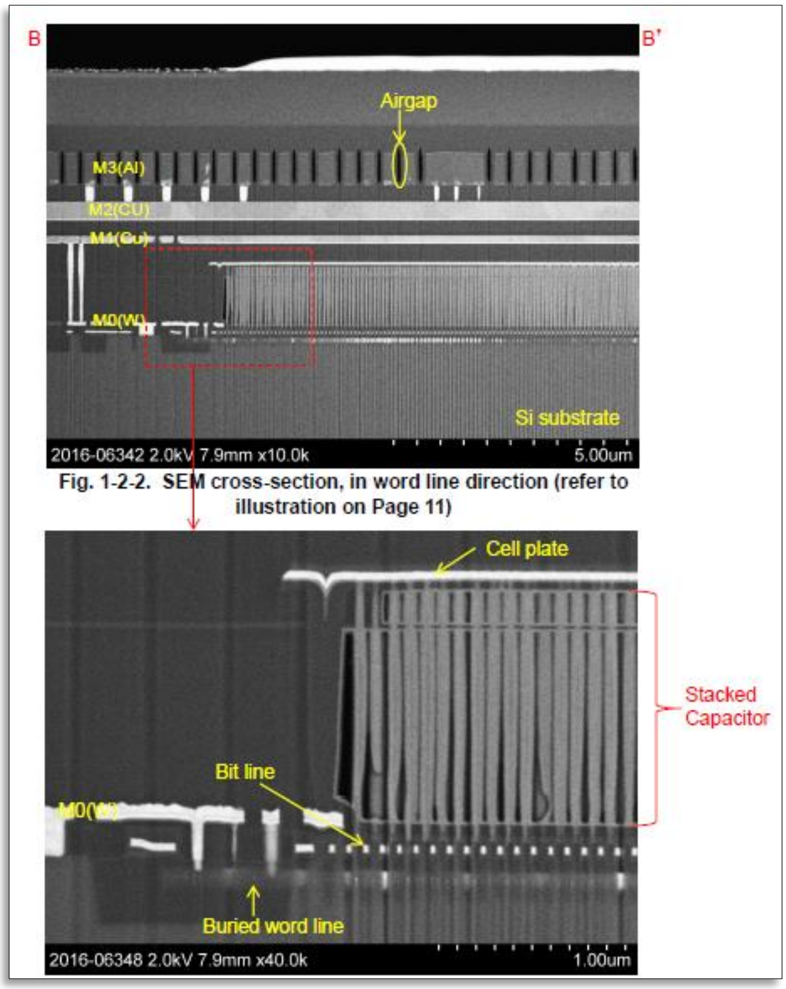
For example, Micron mass produces DDR4 DRAM memory chips, such as the one obtained by Harvard and shown below.



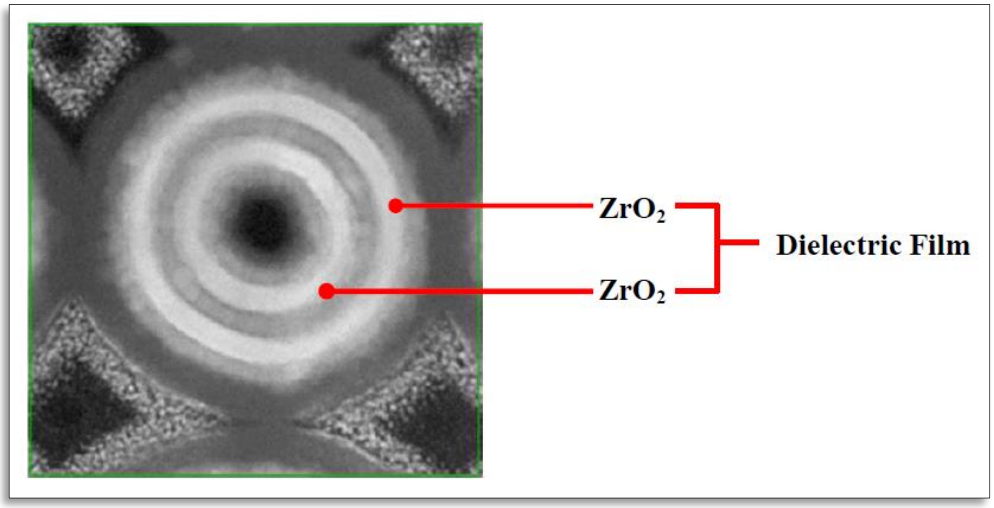
Crucial DDR4 (Top view)
Micron DDR4 (Top view)
Crucial DDR4 (Bottom view)
Micron DDR4 (Bottom view)

[3] *See* Micron, DRAM, https://www.micron.com/products/dram; Micron, DDR4, https://www.micron.com/products/dram/ddr4-sdram.

34. Micron performs a process for forming a metal oxide as part of its manufacturing of certain Micron DRAM memory chips. DRAM memory chips are microelectronic devices that include insulators in the form of metal oxide dielectric film layers. For example, the capacitors in Micron's DDR4 DRAM memory chips include insulators in the form of metal oxide dielectric film layers. Capacitors in Micron's DDR4 DRAM memory chips are shown in the teardown image below.



35. An analysis of a Micron DDR4 DRAM memory chip obtained by Harvard shows a capacitor dielectric that includes a zirconium oxide (ZrO_2) (*i.e.*, metal oxide) layer.[4] A teardown image showing a top down view of a single capacitor from that Micron DDR4 DRAM memory chip is shown below.



High-Angle Annular Dark-Field (HAADF) image of Micron DDR4 DRAM capacitor

This teardown image shows the Micron DDR4 DRAM capacitor's layers, appearing as a series of rings in the image. Energy dispersive x-ray spectroscopy (EDX) line analysis reveals that the layers in the Micron DDR4 DRAM capacitor include ZrO_2 dielectric layers, as indicated.

36. Micron uses an ALD process in the manufacture of its DRAM capacitor metal oxide dielectric films.[5]

[4] *See* TECHNOLOGY ROADMAP of DRAM for Three Major manufacturers: Samsung, SK-Hynix and Micron (Oct. 2014), *available at* http://www.techinsights.com/uploadedFiles/Public_Website/Content_-_Primary/Marketing/2015/TechServices/TechInsights-DRAMRoadmap2014.ppt; *see also* Carl Wintgens, *The 50-nm DRAM battle rages on: An overview of Micron's technology*, EETimes (Mar. 23, 2009), http://www.eetimes.com/document.asp?doc_id=1170601 (identifying that Micron uses zirconium oxide dielectric).

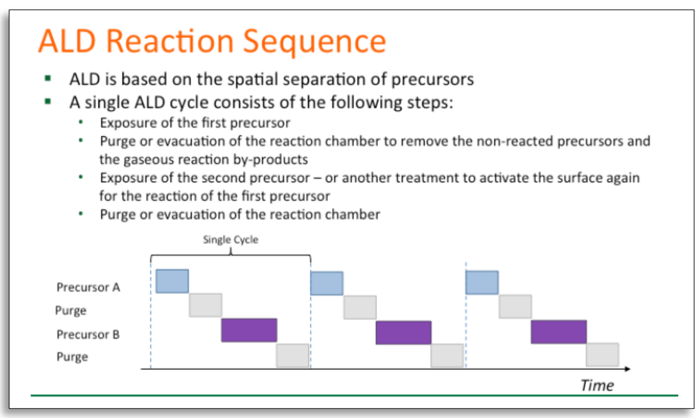
[5] *See* M. Leskelä, Industrial Applications of Atomic Layer Deposition (ALD), 10th MIICS Conference, Mikkeli, March 18, 2010, *available at* http://www.miics.net/archive/getfile.php?file=162; *see also* Micron unveils new DRAM blueprint, EETimes (June 16, 2004), http://www.eetimes.com/document.asp?doc_id=1150471.

b. *exposing a heated surface alternately to the vapor of one or more metal amides having an amido group selected from the group consisting of dialkylamido, disilylamido and (alkyl)(silyl) amido moieties, and then to the vapors of water or an alcohol.*

37. Upon information and belief, Micron performs a process wherein a heated surface is exposed alternately to the vapor of one or more metal amides having an amido group selected from the group consisting of dialkylamido, disilylamido and (alkyl)(silyl) amido moieties, and then to the vapors of water or an alcohol.

38. Micron uses an ALD process in the manufacture of its DRAM capacitor metal oxide dielectric films.[6] ALD is used for DRAM capacitor dielectric films such as that contained in Micron's DRAM memory chips because of the required film thickness and high aspect ratios of the capacitor structures.[7]

39. Micron performs the step of exposing a heated surface alternately to vapor, which is part of ALD, as described by the presentation slide shown below.[8]

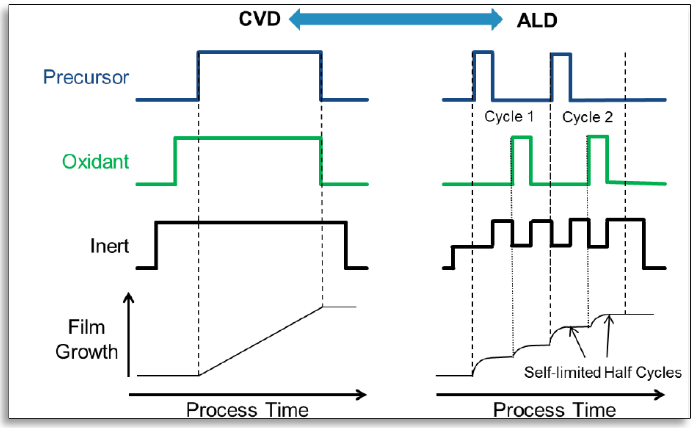


[6] *See* M. Leskelä, Industrial Applications of Atomic Layer Deposition (ALD), 10th MIICS Conference, Mikkeli, March 18, 2010, *available at* http://www.miics.net/archive/getfile.php?file=162; *see also* Micron unveils new DRAM blueprint, EETimes (June 16, 2004), http://www.eetimes.com/document.asp?doc_id=1150471.

[7] *See* Clark, Robert D., Emerging Applications for High K Materials in VLSI Technology, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

[8] *See* Atomic Layer Deposition Overview, Ultratech/CambridgeNanotech http://www.cambridgenanotechald.com/ald-tutorial.shtml#.

This is further illustrated by the process schematic, shown below, which shows a basic gas-flow sequence to the chamber for Chemical Vapor Deposition and for ALD. [9]



Accordingly, Micron's ALD process used in the manufacture of its DRAM capacitor metal oxide dielectric films includes exposing a heated surface alternately to the vapors of one or more chemical precursors.

40. To produce the ZrO_2 (*i.e.*, metal oxide) layers in Micron's DRAM memory chips using ALD, Micron is required to use a precursor with appropriate reactive properties.

41. Micron maintains the details of its ALD process for the manufacture of its DRAM chips as confidential business information. However, upon information and belief, Micron uses tetrakis (ethylmethylamino) zirconium during the ALD process used to manufacture its DDR4 DRAM. Tetrakis (ethylmethylamino) zirconium is a precursor from one of the classes of precursors claimed in Claim 24 and taught by the '539 Patent as having the appropriate reactive properties for the successful mass production of metal oxide dielectric layers in semiconductor devices, such as DRAM, using ALD.

[9] Clark, Robert D., *Emerging Applications for High K Materials in VLSI Technology*, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

42. Tetrakis (ethylmethylamino) zirconium is a precursor that, when used in an ALD process, will produce a ZrO_2 dielectric layer such as the one identified in the analysis conducted on a sample Micron DDR4 DRAM chip. Tetrakis (ethylmethylamino) zirconium has been identified as being one of the most common precursors relied upon for use in the mass production of DRAM products containing a ZrO_2 dielectric layer deposited by an ALD process.[10]

43. Micron represents a significant part of the semiconductor manufacturing industry that mass produces DRAM products, including its DDR4 DRAM.[11] Micron is one of the three largest DRAM manufacturers in the world, out of a total of six manufacturers with a significant market share.[12] Together, the three largest DRAM manufactures (including Micron) represent a combined market share of approximately 93% of the worldwide DRAM market.[13]

44. Tetrakis (ethylmethylamino) zirconium is a metal alkylamide. When producing ZrO_2 layers using ALD, the semiconductor manufacturing industry, which includes Micron, has primarily used alkylamides.[14] In its own publicly available publications, Micron has suggested using an alkylamide, and even more specifically, tetrakis (ethylmethylamino) zirconium, to successfully create a ZrO_2 layer.[15] Micron also suggests using tetrakis (dimethylamino) zirconium, tetrakis (diethylamino) zirconium and tetrakis (ethylmethylamino) zirconium, all of

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[10] *See* Wada, Senji, et.al., "Development of ALD Precursors for Semiconductor Devices", Atomic Layer Deposition Applications 4, ECS Transactions, Volume 16, Issue 4, pages 103-111 (2008).

[11] *See* TECHNOLOGY ROADMAP of DRAM for Three Major manufacturers: Samsung, SK-Hynix and Micron (Oct. 2014), *available at* http://www.techinsights.com/uploadedFiles/Public_Website/Content_-_Primary/Marketing/2015/TechServices/TechInsights-DRAMRoadmap2014.ppt.

[12] *Id.*

[13] *Id.*

[14] *Atomic Layer Deposition for Semiconductors*, Hwang, Cheol Seong et. al., at 95. http://www.springer.com/us/book/9781461480532.

[15] U.S. Patent No. 8,394,725

which are alkyalmides.[16] Alkylamides are one of the classes of precursors claimed in Claim 24 and taught by the '539 Patent as having the appropriate reactive properties for successfully manufacturing semiconductor devices, such as DRAM, using ALD.

45. Further, "ALD of metal oxides involves the reaction of a metal oxide precursor with an oxygen source. Water is the most commonly used oxygen precursor[.]"[17] In its own publications, Micron has suggested using water as the oxygen source in its ALD process.[18] Thus, upon information and belief, Micron's process includes exposing the heated surface to water vapor.

COUNT II
(INFRINGEMENT OF U.S. PATENT NO. 8,334,016)

46. Harvard hereby re-alleges and incorporates by reference the foregoing paragraphs of the Amended Complaint as if fully set forth herein.

47. On December 18, 2012, the USPTO duly and legally issued U.S. Patent No. 8,334,016, entitled "Vapor Deposition of Metal Oxides, Silicates and Phosphates, and Silicon Dioxide," to inventors Roy G. Gordon, Jill Becker, Dennis Hausmann, and Seigi Suh ("the '016 Patent"), as a continuation of U.S. Patent No. 7,507,848, which is a continuation of the '539 Patent. A true and correct copy of the '016 Patent is attached as Exhibit B to this Amended Complaint.

48. Upon information and belief, in violation of 35 U.S.C. § 271, Micron and its subsidiaries have directly infringed and continue to directly infringe, either literally or under the doctrine of equivalents, one or more claims of the '016 Patent, including at least claims 1, 2, 7,

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[16] *Id.*

[17] Clavel, G.; Marichy, C.; and Pinna, N., ALD of Nanostructured Materials, Chapter 4.2 - Sol-Gel and ALD: An Overview. (2012), Wiley-VCH, page 63.

[18] U.S. Patent No. 8,945,350

and 8, by, without limitation, making products using the process claimed by one or more claims of the ’016 Patent. Micron and its subsidiaries have infringed and continue to infringe the ’016 Patent, either literally or under the doctrine of equivalents, by, without limitation, using, offering for sale and/or selling, those products throughout the United States, including within the Commonwealth of Massachusetts.

49. Upon information and belief, at least Micron DDR4 DRAM memory products are made using a process that includes all of the limitations of one or more of the claims of the ’016 Patent, including at least claims 1, 2, 7, and 8. Upon further information and belief, Micron makes these memory products in the United States. Micron, directly or indirectly, uses, sells, and/or offers for sale these memory products throughout the United States, including within the Commonwealth of Massachusetts.

50. Micron further violates 35 U.S.C. § 271(g) to the extent it makes DRAM memory products using a process that includes all of the limitations of one or more of the claims of the ’016 Patent abroad and imports them into the United States.

A. Direct Infringement of the ’016 Patent

51. Upon information and belief, certain Micron processors are made using the process claimed by one or more claims of the ’016 Patent, including at least claims 1, 2, 7, and 8. The analysis below demonstrates how an exemplary Micron DRAM product is made using a process claimed by one or more claims of the ’016 Patent. The claims and products analyzed below are exemplary and are not intended to limit Harvard’s allegations. The analysis is based on information available to Harvard before discovery in this action. Harvard reserves the right to assert any additional claims of the ’016 Patent against any infringing acts by Micron.

1. Claim 1

52. Claim 1 recites:

A process for making an insulator in a microelectronic device, the process comprising:

introducing a first reactant component into a deposition chamber;

introducing a second reactant component into the deposition chamber; and

alternately repeating introducing the first reactant component and the second reactant component into the deposition chamber;

wherein deposition of the first reactant component and the second reactant component are self-limiting;

wherein said first reactant component comprises a metal alkylamide;

wherein said second reactant component interacts with the deposited first reactant component to form the insulator; and

wherein said insulator comprises oxygen and the metal from the metal alkylamide.

53. Upon information and belief, at least, Micron's DRAM memory chips are made using a process that practices each element of claim 1 of the '016 Patent.

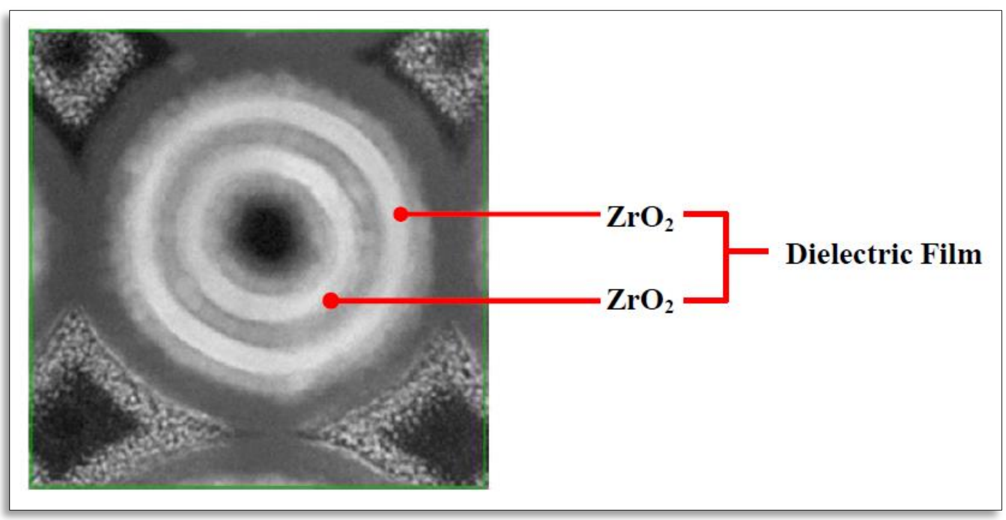
a. *A process for making an insulator in a microelectronic device, the process comprising:*

54. Micron performs a process for making an insulator in a microelectronic device. Micron performs a process for making an insulator as part of its manufacturing of Micron DRAM memory chips. DRAM memory chips, such as the one pictured below, are microelectronic devices that include insulators.[19]

[19] *See* Micron, DRAM, https://www.micron.com/products/dram; Micron, DDR4, https://www.micron.com/products/dram/ddr4-sdram.

55. DRAM memory chips are microelectronic devices that include insulators in the form of metal oxide dielectric film layers. For example, the capacitors in Micron's DDR4 DRAM memory chips include insulators in the form of metal oxide dielectric film layers.

56. The teardown image below shows a top down view of a single capacitor from a Micron DDR4 DRAM memory chip.



High-Angle Annular Dark-Field (HAADF) image of Micron DDR4 DRAM capacitor

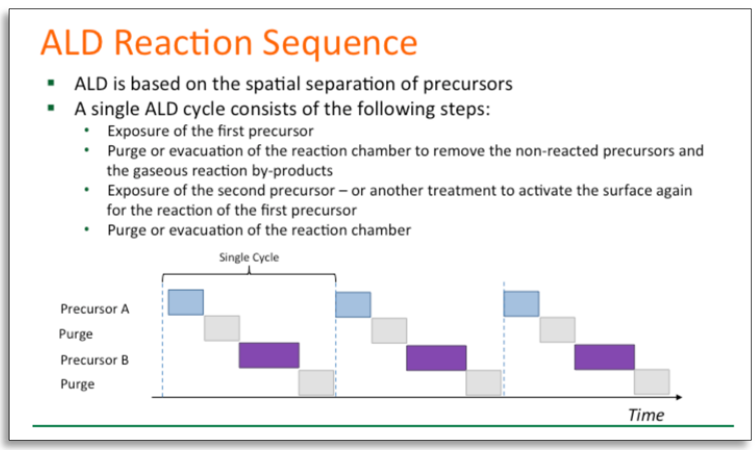
This teardown image shows the Micron DDR4 DRAM capacitor's layers, appearing as a series of rings in the image. Energy dispersive x-ray spectroscopy (EDX) line analysis reveals that the layers in the Micron DDR4 DRAM capacitor include ZrO_2 dielectric layers, as indicated, which are insulators.

b. *introducing a first reactant component into a deposition chamber;*

57. Micron introduces a first reactant component into a deposition chamber.

58. Micron uses an ALD process in the manufacture of its DRAM capacitor metal oxide dielectric film insulators.[20] ALD is typically used for DRAM capacitor dielectric films such as that contained in Micron's DRAM memory chips because of the required film thickness and high aspect ratios of the capacitor structures.[21]

59. The step of introducing a first reactant component into a deposition chamber is part of ALD, as described by the presentation slide shown below.[22]



This is further illustrated by the process schematic, below, which shows a basic gas flow sequence to the chamber for Chemical Vapor Deposition and for ALD.[23]

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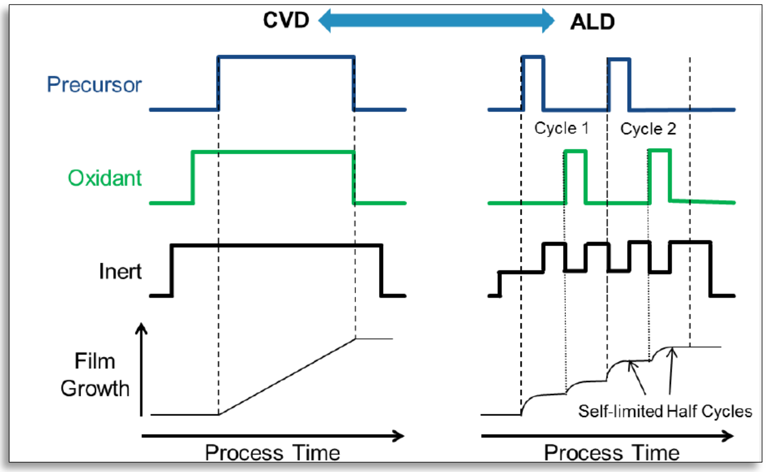
[20] *See* M. Leskelä, Industrial Applications of Atomic Layer Deposition (ALD), 10th MIICS Conference, Mikkeli, March 18, 2010, *available at* http://www.miics.net/archive/getfile.php?file=162; *see also* Micron unveils new DRAM blueprint, EETimes (June 16, 2004), http://www.eetimes.com/document.asp?doc_id=1150471.

[21] *See* Clark, Robert D., Emerging Applications for High K Materials in VLSI Technology, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

[22] *See* Atomic Layer Deposition Overview, Ultratech/CambridgeNanotech http://www.cambridgenanotechald.com/ald-tutorial.shtml#.



c. *introducing a second reactant component into the deposition chamber; and*

60. Micron introduces a second reactant component into a deposition chamber. Micron uses an ALD process in the manufacture of its DRAM capacitor metal oxide dielectric films.[24] ALD is typically used for DRAM capacitor dielectric films such as that contained in Micron's DRAM memory chips because of the required film thickness and high aspect ratios of the capacitor structures.[25] The step of introducing a second reactant component into a deposition chamber is part of ALD.[26]

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[23] Clark, Robert D., *Emerging Applications for High K Materials in VLSI Technology*, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

[24] *See* M. Leskelä, Industrial Applications of Atomic Layer Deposition (ALD), 10th MIICS Conference, Mikkeli, March 18, 2010, *available at* http://www.miics.net/archive/getfile.php?file=162; *see also* Micron unveils new DRAM blueprint, EETimes (June 16, 2004), http://www.eetimes.com/document.asp?doc_id=1150471.

[25] *See* Clark, Robert D., Emerging Applications for High K Materials in VLSI Technology, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

[26] *See* Atomic Layer Deposition Overview, Ultratech/CambridgeNanotech http://www.cambridgenanotechald.com/ald-tutorial.shtml#; *see also* Clark, Robert D., *Emerging Applications for High K Materials in VLSI Technology*, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

d. *alternately repeating introducing the first reactant component and the second reactant component into the deposition chamber;*

61. Upon information and belief, Micron alternately repeats introducing the first reactant component and the second reactant component into the deposition chamber. Micron uses an ALD process in the manufacture of its DRAM capacitor metal oxide dielectric film insulators.[27] ALD is typically used for DRAM capacitor dielectric films such as that contained in Micron's DRAM memory chips because of the required film thickness and high aspect ratios of the capacitor structures.[28] Alternately repeating introducing the first reactant component and the second reactant component into the deposition chamber is part of ALD.[29]

e. *wherein deposition of the first reactant component and the second reactant component are self-limiting;*

62. Micron performs the process wherein deposition of the first reactant component and the second reactant component are self-limiting. Micron uses an ALD process in the manufacture of its DRAM capacitor metal oxide dielectric film insulators.[30] ALD is typically used for DRAM capacitor dielectric films such as that contained in Micron's DRAM memory chips because of the required film thickness and high aspect ratios of the capacitor structures.[31]

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[27] *See* M. Leskelä, Industrial Applications of Atomic Layer Deposition (ALD), 10th MIICS Conference, Mikkeli, March 18, 2010, *available at* http://www.miics.net/archive/getfile.php?file=162; *see also* Micron unveils new DRAM blueprint, EETimes (June 16, 2004), http://www.eetimes.com/document.asp?doc_id=1150471.

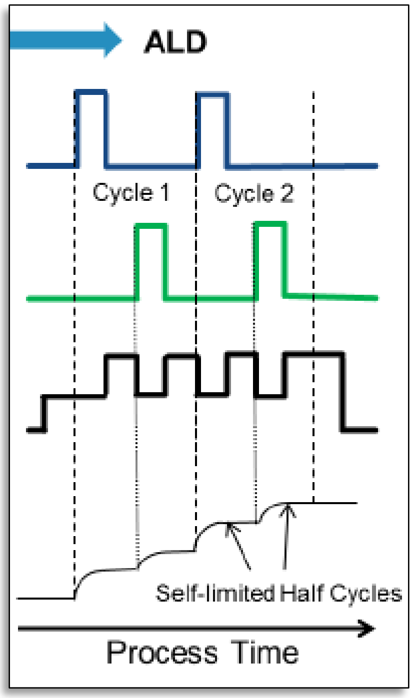
[28] *See* Clark, Robert D., Emerging Applications for High K Materials in VLSI Technology, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

[29] *See* Atomic Layer Deposition Overview, Ultratech/CambridgeNanotech http://www.cambridgenanotechald.com/ald-tutorial.shtml#; *see also* Clark, Robert D., *Emerging Applications for High K Materials in VLSI Technology*, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

[30] *See* M. Leskelä, Industrial Applications of Atomic Layer Deposition (ALD), 10th MIICS Conference, Mikkeli, March 18, 2010, *available at* http://www.miics.net/archive/getfile.php?file=162; *see also* Micron unveils new DRAM blueprint, EETimes (June 16, 2004), http://www.eetimes.com/document.asp?doc_id=1150471.

[31] *See* Clark, Robert D., Emerging Applications for High K Materials in VLSI Technology, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

The process wherein deposition of the first reactant component and the second reactant component are self-limiting is part of ALD, as illustrated below.[32]



f. *wherein said first reactant component comprises a metal alkylamide;*

63. Micron performs the process wherein the first reactant component comprises a metal alkylamide.

64. An analysis of a Micron DDR4 DRAM memory chip obtained by Harvard shows a capacitor dielectric that includes a zirconium oxide (ZrO_2) (*i.e.*, metal oxide) layer.[33] A teardown image showing a top down view of a single capacitor from that Micron DDR4 DRAM memory chip is shown below.

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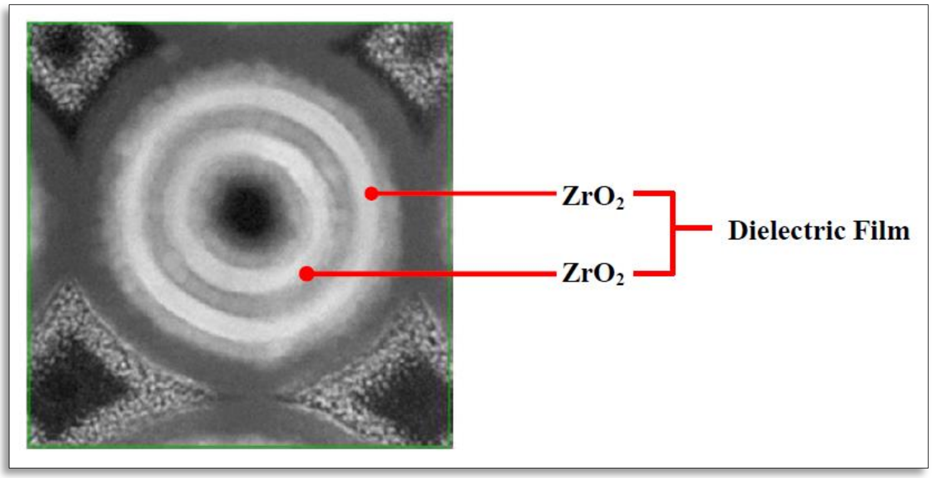
[32] Clark, Robert D., Emerging Applications for High K Materials in VLSI Technology, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

[33] *See* TECHNOLOGY ROADMAP of DRAM for Three Major manufacturers: Samsung, SK-Hynix and Micron (Oct. 2014), *available at* http://www.techinsights.com/uploadedFiles/Public_Website/Content_-_Primary/Marketing/2015/TechServices/TechInsights-DRAMRoadmap2014.ppt; *see also* Carl Wintgens, *The 50-nm DRAM battle rages on: An overview of Micron's technology*, EETimes (Mar. 23, 2009), http://www.eetimes.com/document.asp?doc_id=1170601 (identifying that Micron uses zirconium oxide dielectric).



High-Angle Annular Dark-Field (HAADF) image of Micron DDR4 DRAM capacitor

This teardown image shows the Micron DDR4 DRAM capacitor's layers, appearing as a series of rings in the image. Energy dispersive x-ray spectroscopy (EDX) line analysis reveals that the layers in the Micron DDR4 DRAM capacitor include ZrO_2 dielectric layers, as indicated.

65. Micron uses an ALD process in the manufacture of its DRAM capacitor metal oxide dielectric films.[34] ALD is typically used for DRAM capacitor dielectric films such as that contained in Micron's DRAM memory chips because of the required film thickness and high aspect ratios of the capacitor structures.[35]

66. To produce the ZrO_2 (*i.e.*, metal oxide insulator) layers in Micron's DRAM memory chips using ALD, Micron is required to use a precursor with appropriate reactive properties.

67. Micron maintains the details of its ALD process for the manufacture of its DRAM chips as confidential business information. However, upon information and belief, Micron uses

[34] *See* M. Leskelä, Industrial Applications of Atomic Layer Deposition (ALD), 10th MIICS Conference, Mikkeli, March 18, 2010, *available at* http://www.miics.net/archive/getfile.php?file=162; *see also* Micron unveils new DRAM blueprint, EETimes (June 16, 2004), http://www.eetimes.com/document.asp?doc_id=1150471.

[35] *See* Clark, Robert D., Emerging Applications for High K Materials in VLSI Technology, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

tetrakis (ethylmethylamino) zirconium during the ALD process used to manufacture its DDR4 DRAM. Tetrakis (ethylmethylamino) zirconium is a metal alkylamide as claimed in Claim 1 and taught by the ’016 Patent as having the appropriate reactive properties for the successful mass production of metal oxide dielectric layers in semiconductor devices, such as DRAM, using ALD.

68. Tetrakis (ethylmethylamino) zirconium is a precursor that, when used in an ALD process, will produce a ZrO_2 dielectric layer such as the one identified in the analysis conducted on a sample Micron DDR4 DRAM chip. Tetrakis (ethylmethylamino) zirconium has been identified as being one of the most common precursors relied upon for use in the mass production of DRAM products containing a ZrO_2 dielectric layer deposited by an ALD process.[36] Micron represents a significant part of the semiconductor manufacturing industry that mass produces DRAM products, including its DDR4 DRAM, and in its own publicly available publications, Micron has suggested using a metal alkylamide, and even more specifically, tetrakis (ethylmethylamino) zirconium, to successfully create a ZrO_2 layer.[37]

69. Thus, upon information and belief, the first reactant is tetrakis (ethyl-methylamino) zirconium, which is a metal alkylamide.

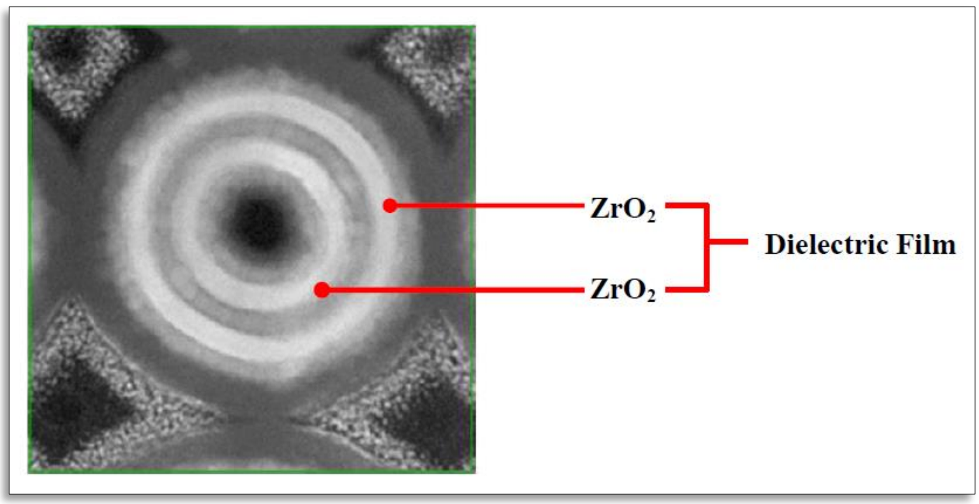
g. *wherein said second reactant component interacts with the deposited first reactant component to form the insulator; and*

70. Micron performs a process wherein the second reactant component interacts with the deposited first reactant component to form the insulator. Micron uses an ALD process in the

[36] *See* Wada, Senji, et.al., “Development of ALD Precursors for Semiconductor Devices”, Atomic Layer Deposition Applications 4, ECS Transactions, Volume 16, Issue 4, pages 103-111 (2008); *see also Atomic Layer Deposition for Semiconductors*, Hwang, Cheol Seong et. al., at 95. http://www.springer.com/us/book/9781461480532.

[37] *See* TECHNOLOGY ROADMAP of DRAM for Three Major manufacturers: Samsung, SK-Hynix and Micron (Oct. 2014), *available at* http://www.techinsights.com/uploadedFiles/Public_Website/Content_-_Primary/Marketing/2015/TechServices/TechInsights-DRAMRoadmap2014.ppt; U.S. Patent No. 8,394,725.

manufacture of its DRAM capacitor metal oxide dielectric film insulators.[38] ALD is typically used for DRAM capacitor dielectric films such as that contained in Micron's DRAM memory chips because of the required film thickness and high aspect ratios of the capacitor structures.[39] The teardown images of Micron's DRAM memory chip show a capacitor dielectric insulator that is formed by the ALD process with the second component interacting with the first reactant.[40] For example, the teardown image below shows a top down view of a single capacitor from that Micron DDR4 DRAM memory chip.



High-Angle Annular Dark-Field (HAADF) image of Micron DDR4 DRAM capacitor

This teardown image shows the Micron DDR4 DRAM capacitor's layers, appearing as a series of rings in the image. Energy dispersive x-ray spectroscopy (EDX) line analysis reveals that the

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[38] *See* M. Leskelä, Industrial Applications of Atomic Layer Deposition (ALD), 10th MIICS Conference, Mikkeli, March 18, 2010, *available at* http://www.miics.net/archive/getfile.php?file=162; *see also* Micron unveils new DRAM blueprint, EETimes (June 16, 2004), http://www.eetimes.com/document.asp?doc_id=1150471.

[39] *See* Clark, Robert D., Emerging Applications for High K Materials in VLSI Technology, Materials 2014, 7(4), 2913-2944, *available at* http://www.mdpi.com/1996-1944/7/4/2913.

[40] *See* TECHNOLOGY ROADMAP of DRAM for Three Major manufacturers: Samsung, SK-Hynix and Micron, Oct 2014, *available at* http://www.techinsights.com/uploadedFiles/Public_Website/Content_-_Primary/Marketing/2015/TechServices/TechInsights-DRAMRoadmap2014.ppt; *see also* Carl Wintgens, *The 50-nm DRAM battle rages on: An overview of Micron's technology*, EETimes (Mar. 23, 2009), http://www.eetimes.com/document.asp?doc_id=1170601 (identifying that Micron uses zirconium oxide dielectric).

layers in the Micron DDR4 DRAM capacitor include ZrO_2 dielectric layers, as indicated. The ZrO_2 dielectric layers are insulators formed by a second reactant component interacting with the deposited first reactant component.

h. *wherein said insulator comprises oxygen and the metal from the metal alkylamide.*

71. Micron performs a process wherein the insulator comprises oxygen and the metal from the metal alkylamide. Teardown images of a Micron DRAM chip show a capacitor dielectric insulator that includes a zirconium oxide (ZrO_2), metal oxide layer. Upon information and belief, the zirconium oxide layer includes oxygen and the zirconium metal from the metal alkylamide (tetrakis (ethylmethylamino) zirconium).[41]

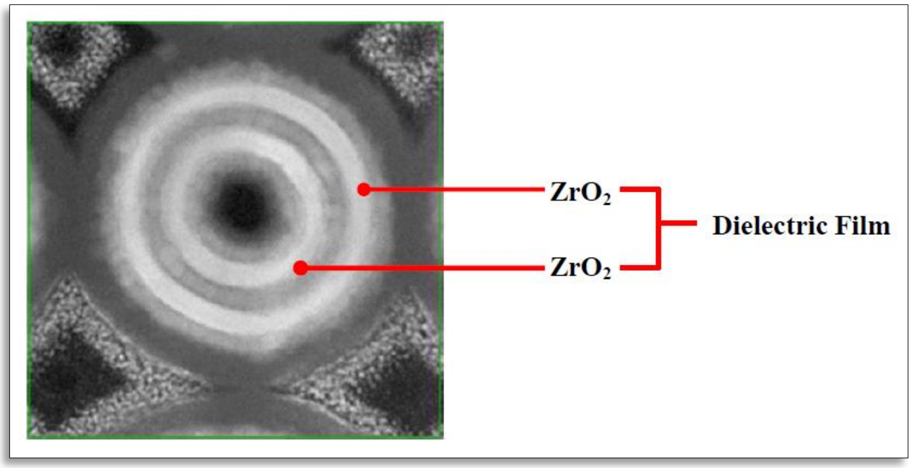
2. Claim 2

72. Upon information and belief, at least Micron's DRAM memory chips are made using a process that practices each element of claim 2 of the '016 Patent.

a. *The process as in claim 1, wherein the insulator insulates a gate or a capacitor.*

73. Micron performs the process of claim 1, wherein the insulator insulates a gate or a capacitor. For example, the teardown image below shows a top down view of a single capacitor from a Micron DDR4 DRAM memory chip.

[41] *See* TECHNOLOGY ROADMAP of DRAM for Three Major manufacturers: Samsung, SK-Hynix and Micron, Oct 2014, *available at* http://www.techinsights.com/uploadedFiles/Public_Website/Content_-_Primary/Marketing/2015/TechServices/TechInsights-DRAMRoadmap2014.ppt; *see also* Carl Wintgens, *The 50-nm DRAM battle rages on: An overview of Micron's technology*, EETimes (Mar. 23, 2009), http://www.eetimes.com/document.asp?doc_id=1170601 (identifying that Micron uses zirconium oxide dielectric).



High-Angle Annular Dark-Field (HAADF) image of Micron DDR4 DRAM capacitor

74. This teardown image shows the Micron DDR4 DRAM capacitor's layers, appearing as a series of rings in the image. Energy dispersive x-ray spectroscopy (EDX) line analysis reveals that the layers in the Micron DDR4 DRAM capacitor include ZrO_2 dielectric layers, as indicated, which insulate the capacitor.

3. Claim 7

75. Upon information and belief, at least Micron's DRAM memory chips are made using a process that practices each element of claim 7 of the '016 Patent.

a. *A process as in claim 2, wherein the metal alkylamide is a zirconium dialkylamide.*

76. Upon information and belief, Micron performs the process of claim 2, wherein the metal alkylamide is a zirconium dialkylamide.

77. Micron maintains the details of its ALD process for the manufacture of its DRAM chips as confidential business information. However, upon information and belief, Micron uses tetrakis (ethylmethylamino) zirconium during the ALD process used to manufacture its DDR4 DRAM. Tetrakis (ethylmethylamino) zirconium is a metal alkylamide as claimed in Claim 1 and taught by the '016 Patent as having the appropriate reactive properties for the successful mass

production of metal oxide dielectric layers in semiconductor devices, such as DRAM, using ALD. Tetrakis (ethylmethylamino) zirconium is a zirconium dialkylamide.

78. Tetrakis (ethylmethylamino) zirconium is a precursor that, when used in an ALD process, will produce a ZrO_2 dielectric layer such as the one identified in the analysis conducted on a sample Micron DDR4 DRAM chip. Tetrakis (ethylmethylamino) zirconium has been identified as being one of the most common precursors relied upon for use in the mass production of DRAM products containing a ZrO_2 dielectric layer deposited by an ALD process.[42] Micron represents a significant part of the semiconductor manufacturing industry that mass produces DRAM products, including its DDR4 DRAM, and in its own publicly available publications, Micron has suggested using a metal alkylamide, and even more specifically, tetrakis (ethylmethylamino) zirconium, to successfully create a ZrO_2 layer.[43]

4. Claim 8

79. Upon information and belief, at least Micron's DRAM memory chips are made using a process that practices each element of claim 8 of the '016 Patent.

a. *A process as in claim 7, wherein the zirconium dialkylamide is tetrakis (ethylmethylamido) zirconium.*

80. Upon information and belief, Micron performs the process of claim 7, wherein the zirconium dialkylamide is tetrakis (ethylmethylamido) zirconium.

81. Micron maintains the details of its ALD process for the manufacture of its DRAM chips as confidential business information. However, upon information and belief, Micron uses tetrakis (ethylmethylamino) zirconium during the ALD process used to manufacture its DDR4

[42] *See* Wada, Senji, et.al., "Development of ALD Precursors for Semiconductor Devices", Atomic Layer Deposition Applications 4, ECS Transactions, Volume 16, Issue 4, pages 103-111 (2008);

[43] *See* TECHNOLOGY ROADMAP of DRAM for Three Major manufacturers: Samsung, SK-Hynix and Micron (Oct. 2014), *available at* http://www.techinsights.com/uploadedFiles/Public_Website/Content_-_Primary/Marketing/2015/TechServices/TechInsights-DRAMRoadmap2014.ppt; U.S. Patent No. 8,394,725.

DRAM. Tetrakis (ethylmethylamino) zirconium is a metal alkylamide as claimed in Claim 1 and taught by the ’016 Patent as having the appropriate reactive properties for the successful mass production of metal oxide dielectric layers in semiconductor devices, such as DRAM, using ALD. Tetrakis (ethylmethylamino) zirconium is a zirconium dialkylamide.

82. Tetrakis (ethylmethylamino) zirconium is a precursor that, when used in an ALD process, will produce a ZrO_2 dielectric layer such as the one identified in the analysis conducted on a sample Micron DDR4 DRAM chip. Tetrakis (ethylmethylamino) zirconium has been identified as being one of the most common precursors relied upon for use in the mass production of DRAM products containing a ZrO_2 dielectric layer deposited by an ALD process.[44] Micron represents a significant part of the semiconductor manufacturing industry that mass produces DRAM products, including its DDR4 DRAM, and in its own publicly available publications, Micron has suggested using a metal alkylamide, and even more specifically, tetrakis (ethylmethylamino) zirconium, to successfully create a ZrO_2 layer.[45]

PRAYER FOR RELIEF

WHEREFORE, Harvard requests that the Court grant the following relief:

A. A finding that Micron has directly infringed the Asserted Patents;

B. An award to Harvard of royalty or lost-profit based damages adequate to compensate it for Micron’s infringement of the ’539 and ’016 patents, such damages to be determined by a jury;

[44] *See* Wada, Senji, et.al., “Development of ALD Precursors for Semiconductor Devices”, Atomic Layer Deposition Applications 4, ECS Transactions, Volume 16, Issue 4, pages 103-111 (2008);

[45] *See* TECHNOLOGY ROADMAP of DRAM for Three Major manufacturers: Samsung, SK-Hynix and Micron (Oct. 2014), *available at* http://www.techinsights.com/uploadedFiles/Public_Website/Content_-_Primary/Marketing/2015/TechServices/TechInsights-DRAMRoadmap2014.ppt; U.S. Patent No. 8,394,725.

C. A permanent injunction against Micron, its officers, agents, employees, and those persons in active concert or participation with it or any of them, and its successors and assigns, from continued acts of infringement of the Asserted Patents, including but not limited being enjoined from making, using, selling, and/or offering for sale within the United States, and/or importing into the United States, any products that infringe the Asserted Patents; and

D. An award to Harvard of such other and further relief as this Court deems just and proper.

DEMAND FOR JURY TRIAL

Plaintiff hereby demands a jury in accordance with Rule 38 of the Federal Rules of Civil Procedure.

Dated: 1/30/2017

Respectfully submitted,

/s/ William Belanger

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CERTIFICATE OF SERVICE

I hereby certify that this document filed through the CM/ECF system will be sent electronically to the registered participants as identified on the Notice of Electronic Filing and paper copies will be sent to those indicated as non-registered participants on January 30, 2017.

/s/ William Belanger
William Belanger