IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT DELAWARE

RAMOT AT TEL AVIV UNIVERSITY LTD.,	)	
Plaintiff,	)	
v.	)	C.A. No. _______________
	)	**JURY TRIAL DEMANDED**
ACACIA COMMUNICATIONS, INC.,	)	
Defendant.	)	

COMPLAINT FOR PATENT INFRINGEMENT

1. Plaintiff Ramot at Tel Aviv University, Ltd. ("Ramot") files this complaint for Patent Infringement against Acacia Communications, Inc. ("Acacia"), requests a trial by jury, and alleges as follows upon actual knowledge with respect to itself and its own acts and upon information and belief as to all other matters.

NATURE OF ACTION

2. This is an action for patent infringement. Ramot alleges that Acacia infringes U.S. Patent Nos. 10,270,535 ("the '535 patent") and 10,033,465 ("the '465 patent") (collectively, the "Asserted Patents"), copies of which are attached hereto as Exhibits A and B.

3. Ramot alleges that Acacia directly and indirectly infringes the Asserted Patents by making, using, offering for sale, selling and importing optical networking transceiver modules and components thereof, providing advanced electro-optical modulation techniques—including, without limitation, certain of Acacia's various coherent optical modules and associated circuitry and software. Ramot further alleges that Acacia induces and contributes to the infringement of others. Ramot seeks damages and other relief for Acacia's infringement of the Asserted Patents.

PARTIES

4. Ramot is a limited liability company organized under the laws of Israel with its principal place of business at Tel Aviv University, Senate Building at Gate no. 4, George Wise Street, Tel Aviv, Israel.

5. Ramot is the Business Engagement Center of Tel Aviv University ("TAU") and acts as the University's liaison to industry. Ramot connects cutting-edge promising innovations at the University with the global commercial marketplace through collaboration with industry partners around the world as well as the formation of new companies. TAU was founded in 1956 and is the largest academic and research institution in the State of Israel. It is the most multidisciplinary with many young scientists that graduated from some of the leading research institutions around the world, which resulted in accomplishing the third highest position among the EU scientific community for the young scientist category. Ramot provides the resources, as well as the business and legal frameworks for inventions made by TAU's faculty, students, and researchers, protecting the discoveries with IP and working jointly with industry and the venture community to bring scientific innovations to the global markets.

6. Ramot manages a portfolio of more than 5000 patents and patent applications worldwide. This number represents hundreds of distinct technology families of which more than 30 percent are already commercialized to multi-national companies as well as newly founded companies. Ramot is the owner of more than 600 granted patents of which more than 400 are United States patents.

7. Ramot is the assignee and owner of the Asserted Patents. The Asserted Patents are based on and claim the inventions of Dr. Yossef Ehrlichman, Dr. Amrani Ofer, and Professor Shlomo Ruschin. Each of the inventors was affiliated with TAU's School of Electrical

Engineering during the relevant time period of the inventions, and assigned his rights to the Asserted Patents to Ramot.

8. On information and belief, Defendant Acacia is a Delaware corporation duly organized and existing under the laws of the state of Delaware with its principal place of business at Three Mill and Main Place, Suite 400, Maynard, Massachusetts 01754. On information and belief, Acacia may be served with process through its registered agent Corporation Trust Company, 1209 Orange St., Wilmington, DE 19801

JURISDICTION AND VENUE

9. This is an action arising under the patent laws of the United States, 35 U.S.C. § 271, *et seq*. Accordingly, this Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a).

10. This Court has general and specific jurisdiction over Acacia at least because Acacia is at home in the State of Delaware, where it is incorporated.

11. Venue is proper in this District under 28 U.S.C. §§ 1391 and 1400(b) at least because Acacia resides in this judicial District. As set forth above, Acacia is incorporated in the State of Delaware.

FACTUAL ALLEGATIONS

Ramot Patents

12. Ramot is the Business Engagement Center at Tel Aviv University, Israel's foremost research and teaching university. Ramot's mission is to foster, initiate, lead and manage the transfer of new technologies from the laboratory to the marketplace. Ramot helps commercialize promising scientific discoveries by providing the resources, business, Intellectual Property, and legal framework for researchers—creating successful business connections

between Tel Aviv University's scientists and researchers, and technology companies ranging from startups to Fortune 500 companies.

13. Since 1999, Ramot has helped found more than 130 technology startup companies. Within the area of electronics and electro-optics, Ramot is currently affiliated with over 70 accomplished researchers who are developing dozens of distinct cutting-edge technologies. Ramot owns hundreds of granted patents worldwide that span various fields of technology.

14. Co-Inventor Dr. Yossef Ehrlichman, received the B.Sc.(EE) and MBA degrees from the Technion, Haifa, Israel, in 1999 and 2002, respectively. He received the M.Sc.(EE) and Ph.D. degrees from Tel Aviv University, Tel Aviv, Israel, in 2007 and 2015, respectively. During his Ph.D., he worked on photonic integrated mixed signal circuits, such as photonic digital-to-analog and analog-to-digital converters. He co-invented a direct digital drive method which allows the integration of digital CMOS circuits with photonic integrated modulators. Between 2013-2015 he worked as a Radiometry Engineer at SemiConductor Devices (SCD), Israel, developing advanced cooled-IR detectors. Between 2015-2017 he held a position of a Postdoctoral Research Associate at the University of Colorado Boulder investigating silicon photonics devices and circuits for RF photonics applications. Between 2017-2018 he held a position of Postdoctoral Researcher at University of California San Diego, continuing his research on silicon photonic devices and circuits for RF photonics applications. Since 2018 he is a Senior Member of the Technical Staff at Axalume, San Diego, CA, developing silicon-photonics hybrid lasers, and electronics-photonics circuits for data centers. Dr. Ehrlichman is a senior member of the IEEE.

15. Co-Inventor Dr. Ofer Amrani is faculty at Tel Aviv University's School of Electrical Engineering, Tel Aviv, Israel. He received the Ph.D. degree in Electrical Engineering with honors from Tel Aviv University in November 2000. In 1999 he co-founded CUTE-systems and served as its CTO. In October 2001 he joined Tel Aviv University in the department of Electrical Engineering-Systems. In 2006 he was a visiting scientist at the Dept. of Electrical Engineering, Technion-Israel Institute of Technology. Since 2007 he has been with Tel Aviv University as a senior lecturer. His main research interests include various aspects of digital communications; as well as optical components and new transistor architectures for interfacing between electronic and optical signals. Dr. Amrani currently heads the Tel-Aviv University nano-satellite laboratory and led the development, construction, and recent successful launch of the University's first orbiting research satellite. Since 1994 he has been consulting to various industrial companies.

16. Co-Inventor and Professor Shlomo Ruschin received the B.Sc. degree in Physics and Mathematics from the Hebrew University in Jerusalem in 1969. He continued his graduate studies at the Technion-Israel Institute of Technology in Haifa where he specialized in the fields of Lasers and Quantum Optics. He received the M.Sc. degree in 1973 and the D.Sc. in 1977. During the period 1978-79 he completed Postdoctoral studies at Cornell University where he was involved in the research of laser diagnostics of molecules and bistability effects. In 1980, Dr. Ruschin joined the Department of Physical Electronics at the Faculty of Engineering of Tel Aviv University, where he presently is Professor Emeritus of Electrical Engineering. During the years 2013-2018 he was Incumbent of the Chana and Heinrich Manderman Chair in Optoelectronics. His fields of research include Laser Physics and electro-optics, and he presently leads the Photonic Devices group at the University. The group is dedicated to various aspects of theory

and practice of wave guided devices for optical communication and sensing. Other topics of his research interest are the shaping of coherent beams, and near-field optics. He published more than 165 articles in reviewed periodicals in subjects related to quantum optics, electro-optics, and lasers. In 2001, Shlomo Ruschin co-founded ColorChip Inc., a company marketing integrated optics components and high-speed optical transceivers for data centers. During 1995-1999, Prof. Ruschin acted as Head of the Department of Electrical Engineering-Physical Electronics at Tel Aviv University.

17. United States Patent No. 10,270,535 ("the '535 Patent"), entitled "Linearized Optical Digital-to-Analog Modulator," was duly and lawfully issued April 23, 2019. Ramot is the owner of all right, title, and interest in the '535 Patent. A true and correct copy of the '535 Patent is attached hereto as Exhibit A.

18. The '535 Patent describes problems and shortcomings in the field of optical modulators for converting high speed digital data into modulated optical signals, and claims novel and inventive technological improvements and solutions to such problems and shortcomings. For example, the '535 patent discloses and claims methods for performing advanced modulation techniques that meet the need for "high-performance and large bandwidth" signal conversion for multi-GHz communication systems. In one aspect of the invention, the disclosed and claimed features enable actuating a plurality of electrodes using multiple actuating voltage levels so as to modulate the optical signal according to a QAM (Quadrature Amplitude Modulation) modulation scheme. In another aspect of the invention, the disclosed and claimed features enable using a digital mapping of symbols to pre-equalize or compensate for known signal degradations—such as the non-linear response of modulator components.

19. United States Patent No. 10,033,465 ("the '465 Patent"), entitled "Linearized Optical Digital-to-Analog Modulator," was duly and lawfully issued July 24, 2018. Ramot is the owner of all right, title, and interest in the '465 Patent. A true and correct copy of the '465 Patent is attached hereto as Exhibit B.

20. The '465 Patent also describes problems and shortcomings in the field of optical modulators for converting high speed digital data into modulated optical signals and claims novel and inventive technological improvements and solutions to such problems and shortcomings. For example, the '465 patent explains that Mach-Zehnder Interferometer modulators used in fiber-optic communications applications exhibited serious problems at higher speeds due to the "inherent non-linear response of the modulator." The '465 patent discloses and claims solutions to this problem that "offer improved linearity of response without sacrificing efficiency or dynamic range." In one aspect of the invention, the disclosed and claimed features enable digital mapping of data bits to voltage values, suitable for driving modulator electrodes or for being coupled indirectly to the modulator (such as through a driver circuit or digital to analog converter), so as to select the actuation pattern that best models a desired optical signal output for a given digital input. In this and other disclosed aspects of the invention, the mapping function, in combination with the disclosed and claimed advanced modulation techniques, enables multi-GHz optical communication with improved speed, clarity, and/or linearity.

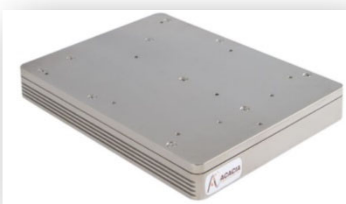
ACACIA'S USE OF THE PATENTED TECHNOLOGY

Acacia Optical Transceiver Modules and DSP Chips

21. On information and belief, Acacia makes, uses, sells, and/or offers to sell in the United States, and/or imports into the United States various coherent optical transceiver modules—as well as major components of such modules such as Digital Signal Processing

("DSP") application specific integrated circuits ("ASICs") and Silicon Photonic integrated circuits ("ICs") suitable for use by others in building infringing optical transceiver modules. For example, Acacia makes, uses, and sells embedded and pluggable coherent optical transceiver modules (and components thereof), for use in cloud datacenter interconnect, high-speed metro, long-haul, and submarine optical networks, as well as in several optical access network applications. *See, e.g.*, Applications, *available at* https://acacia-inc.com/applications/.

22. Acacia's coherent optical transceiver modules include embedded modules such as the AC1200 and AC400 products, as well as 100G, 200G, and 400G pluggable modules in a variety of standard form factors such as CFP-DCO, CFP2-DCO, CFP2-ACO, OSFP, and QSFP-DD. *See, e.g.*, Products, *available at* https://acacia-inc.com/products/.



23. Acacia also sells multiple generations of its DSP ASICs and Silicon Photonic ICs as standalone products. *See, e.g.*, Products, *available at* https://acacia-inc.com/products/. Acacia's customers can buy embedded or pluggable modules as a complete solution, or can "buy the DSP directly from Acacia and integrate them directly on their linecards using an Acacia-provided reference design." *See, e.g.*, DSP ASIC Products, *available at* https://acacia-inc.com/product/dsp-asic-products/. Acacia's customers can also buy the Silicon Photonic ICs used in Acacia's modules as a separate component, to be "Coupled with Acacia's DSP ASIC" in their own linecard designs. *See, e.g.*, *available at* https://acacia-inc.com/product/silicon-photonic-integrated-circuits-pic/.

24. Acacia's coherent optical transceiver modules (and components thereof) operate at speeds of 100Gbps or higher per optical wavelength. *See, e.g.*, Product Portfolio: Powering High Speed Communications at 100G and Beyond, *available at* https://acacia-inc.com/acacia-resources/brochure-acacia-product-portfolio/. Acacia's announced products include modules that transmit as much as 1.2Tbps on a single wavelength. *See, e.g.*, Blog: "Introducing the AC1200-SC^2 Coherent 1.2T Single-Chip, Single-Channel Module," *available at* https://acacia-inc.com/blog/introducing-the-ac1200-sc2-coherent-1-2t-single-chip-single-channel-module/.

25. Each of Acacia's currently offered coherent optical transceiver modules employ advanced modulation techniques such as Quadrature Amplitude Modulation (QAM) with modulation constellations ranging from 4 (QPSK) to as many as 64 (64QAM) points. *See, e.g.*, Product Portfolio at 3 (AC200 CFP2-DCO Product Family: "With support for 100 Gbps using QPSK modulation and 200 Gbps using either 8QAM or 16QAM, the module offers enhanced flexibility in a pluggable coherent solution"); Whitepaper, "Network Optimization in the 600G Era," *available at* https://acacia-inc.com/acacia-resources/white-paper-network-optimization-in-the-600g-era/ ("The AC1200 uses a dual-core modem design to drive two tunable 600G C-band or L-band wavelengths from one DSP device for a total transmission capacity of 1.2Tb per module up to 64QAM"); QSFP DD Product Family, *available at* https://acacia-inc.com/product/qsfp-dd-product-family/ (400ZR QSFP-DD Pluggable Coherent Optical Module: "reaches up to 120km using 16QAM transmission"); Press Release, Acacia

Communications Announces the Industry's First Coherent Flex-rate 400G 5×7 Transceiver Module, *available at* http://ir.acacia-inc.com/news-releases/news-release-details/acacia-communications-announces-industrys-first-coherent-flex ("The new AC-400 is the first Flex-Rate 400G Coherent 5×7 Transceiver Module supporting the most advanced modulation modes including 8QAM, 16QAM and QPSK"); Press Release, Acacia Communications Industry-First Coherent AC100-CFP Now Generally Available and Shipping in Volumes, *available at* http://ir.acacia-inc.com/news-releases/news-release-details/acacia-communications-industry-first-coherent-ac100-cfp-now ("enabling single wavelength coherent 100G PM-QPSK in a CFP form factor"); Press Release, Acacia Communications Introduces CFP2-ACO Module Based on Its Silicon PIC, *available at* http://ir.acacia-inc.com/news-releases/news-release-details/acacia-communications-introduces-cfp2-aco-module-based-its ("Acacia's CFP2-ACO is capable of supporting both 100G DP-QPSK and 200G DP-16QAM modulation"); *see also* H. Zhang, *et al.*, Real-time transmission of 16 Tb/s over 1020km using 200Gb/s CFP2-DCO, Optics Express, Vol. 26, No. 16, Mar. 19, 2018 at Fig. 2:

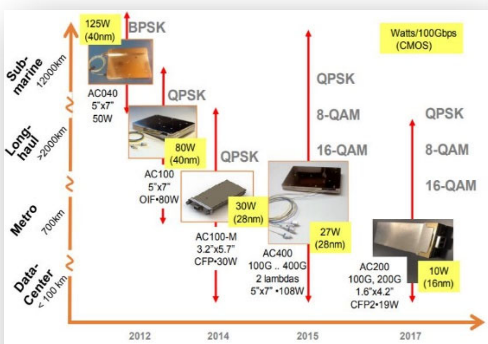


Fig. 2. Evolution in power and density per 100Gbps for coherent transceiver modules.

26. With the exception of Acacia's CFP2-ACO modules, each of Acacia's currently offered coherent optical transceiver modules employ one or more instances of one of Acacia's various generations of DSP ASIC, integrated into the module. *See, e.g.*, OSFP Product Family,

available at https://acacia-inc.com/product/osfp-product-family/ ("The 400G OSFP product family is based on our Greylock 7nm DSP"); QSFP-DD Product Family, *available at* https://acacia-inc.com/product/qsfp-dd-product-family/ ("based on our 7nm DSP technology"); AC1200 Product Family, *available at* https://acacia-inc.com/product/ac1200/ ("based on our Pico digital signal processor (DSP) ASIC"); CFP2-DCO Product Family, *available at* https://acacia-inc.com/product/cfp2-dco/, ("incorporates Acacia's Meru DSP ASIC"); AC400 Flex Product Family, *available at* https://acacia-inc.com/product/ac400-flex/ ("based on our Denali DSP"); *see also* Whitepaper, "Network Optimization in the 600G Era," *available at* https://acacia-inc.com/acacia-resources/white-paper-network-optimization-in-the-600g-era/ at Figure 7:

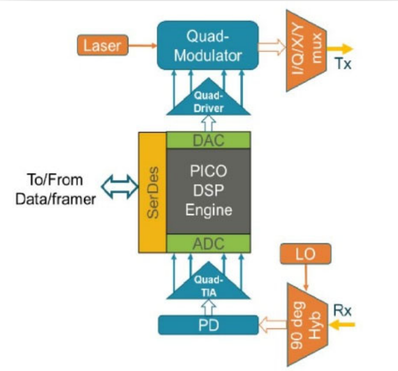
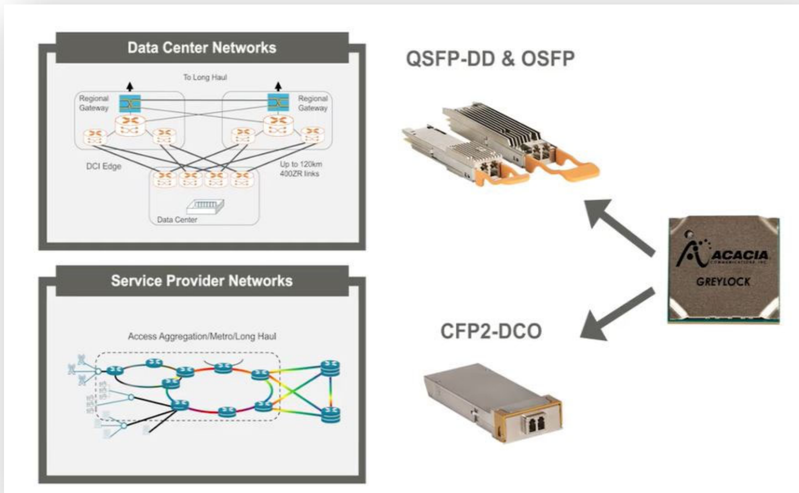


Figure 7. AC1200 simple block diagram. Shared local oscillator (LO) and Tx laser.

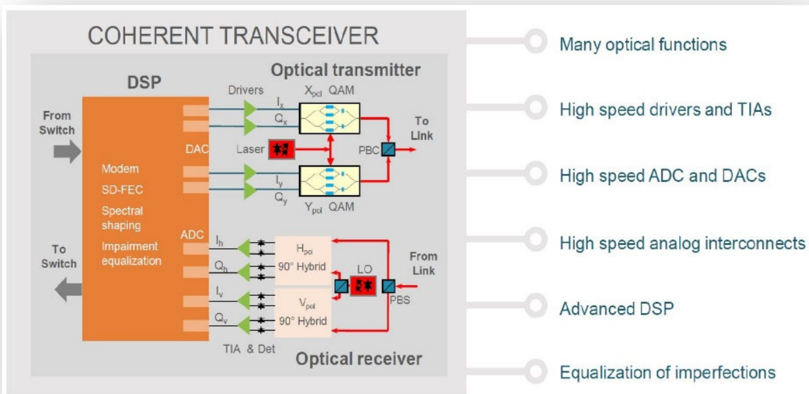
27. For example, Acacia's recently announced line of 400Gbps pluggable modules in OSFP, QSFP-DD, and CFP2-DCO form factors use Acacia's latest generation of DSP ASIC and Silicon Photonic ICs to address an important application for high-speed coherent optical links in data center interconnect and at the access edge of service provider networks. *See, e.g.*, Blog, 400G Pluggables Usher in an Architectural Change to High-Bandwidth DCI, *available at* https://acacia-inc.com/blog/400g-pluggables-usher-in-an-architectural-change-to-high-

bandwidth-dci/ ("Acacia's new 400G pluggable modules are based on its Greylock 7nm DSP"); Video, The New Era of 400G Coherent Pluggable Solutions, *available at* https://acacia-inc.com/acacia-resources/the-new-era-of-400g-coherent-pluggable-solutions/:



28. The digital mapping technologies of the Asserted Patents, as practiced by Acacia's DSP ASICs, are an enabling technology for these 400Gbps coherent transmission applications. *See, e.g.*, Presentation, Coherent Solutions Evolving Toward Edge and Access Applications, Optinet 2020, Aug. 27, 2020 at 8, *available at* https://acacia-inc.com/wp-content/uploads/2020/08/Optinet-2020_Coherent-Solutions-Evolving-Towards-Edge-and-Access-Applications_Acacia.pdf (listing "Electrical compensations" for "impairments" from, *inter alia*, "Components" among motivators for use of 400 Gbps coherent in Edge/Access applications); Whitepaper, 400ZR: Accessible 400G for Edge DCIs and Beyond, at 5, *available at* https://acacia-inc.com/wp-content/uploads/2019/07/400ZR-Market-Backgrounder_June2019-FINAL1.pdf ("However, advances in CMOS, integrated optics, coherent digital signal processor (DSP) designs, as well as DSP coding and equalization algorithms, have significantly reduced the power and size of coherent interfaces for edge DCI applications while maintaining a high

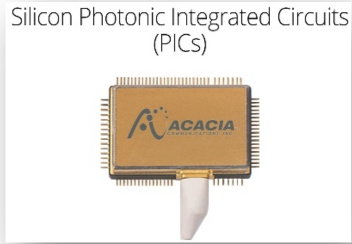
level of performance"); Presentation, Coherent Optical Solutions for Data Center Interconnect, Optinet 2019, June 13, 2019, at 8, *available at* https://acacia-inc.com/wp-content/uploads/2019/06/Optinet-China-2019_Acacia_Fenghai-Liu_UpLoad_v1.pdf ("Efficient EQ for non-perfect optics"), 6 ("Spectral shaping" and "Impairment equalization" in "Advanced DSP" for "Equalization of imperfections"):



29. Acacia participates in, and advertises that its modules are interoperable with, a number of industry working group standards and implementation agreements. For example, Acacia participated in, and advertises that its 400G pluggable modules are interoperable with, the OIF 400ZR Implementation Agreement. *See, e.g.*, QSFP-DD Product Family ("Acacia's 400Gbps 400ZR QSFP-DD coherent optical module is designed to adhere to the Optical Internetworking Forum (OIF) 400ZR Implementation Agreement"); CFP2-DCO Product Family ("Acacia's 400Gbps CFP2-DCO coherent optical module is designed with adherence to OpenROADM, OpenZR+, OIF 400ZR, as well as CableLabs specifications"); *see also* Optical Interface Forum, Implementation Agreement 400ZR, OIF-400ZR-01.0, March 10, 2020 at 99, *available at* https://www.oiforum.com/wp-content/uploads/OIF-400ZR-01.0_reduced2.pdf.

30. Acacia's CFP2-ACO module is designed to be used with an external DSP ASIC on a linecard. *See, e.g.*, CFP2-ACO Product Family, *available at* https://acacia-inc.com/product/cfp2-aco/. It can be used in this configuration with Acacia's own standalone DSP ASICs. In that configuration, the combination of CFP2-ACO module and DSP ASIC would infringe the Asserted Patents, for the same reasons discussed herein that Acacia's integrated CFP2-DCO modules (with an Acacia Meru DSP ASIC built into the module) infringe.

31. Each of Acacia's currently offered coherent optical transceiver modules employ Silicon Photonics optical modulator ICs developed by Acacia. *See, e.g.*, OSFP Product Family, *available at* https://acacia-inc.com/product/osfp-product-family/ ("our silicon photonic integrated circuit (PIC)"); QSFP-DD Product Family, *available at* https://acacia-inc.com/product/qsfp-dd-product-family/ ("our silicon photonic integrated circuit (PIC)"); AC1200 Product Family, *available at* https://acacia-inc.com/product/ac1200/ ("Key Acacia technologies include:" "Highly integrated silicon photonics circuit that supports high baud rates while reducing interconnect costs"); CFP2-DCO Product Family, *available at* https://acacia-inc.com/product/cfp2-dco/, ("Acacia's silicon PIC"); AC400 Flex Product Family, *available at* https://acacia-inc.com/product/ac400-flex/ ("Leveraging our dual-core Denali DSP and in-house silicon PIC technology"); CFP2-ACO Product Family, *available at* https://acacia-inc.com/product/cfp2-aco/ ("Acacia's CFP2-ACO is our fourth Acacia product family to utilize its integrated coherent silicon PIC"); CFP-DCO Product Family, *available at* https://acacia-inc.com/product/cfp-dco/ ("The integration of power saving DSP technology and silicon photonic integrated circuit (PIC) technologies has allowed Acacia to optimize the balance of power and performance"); *see also* Silicon Photonic Integrated Circuits (PICs), *available at* https://acacia-inc.com/product/silicon-photonic-integrated-circuits-pic/:



32. Acacia's Silicon Photonic Integrated Circuits employ multiple Mach-Zehnder optical modulators. *See, e.g.*, L. Chen, *et al.*, Silicon Photonics for 100G-and-beyond Coherent Transmissions, OFC 2016 at 1 ("The chip includes 4 carrier- depletion Mach-Zehnder modulators"), Figs 1(a)-(d):

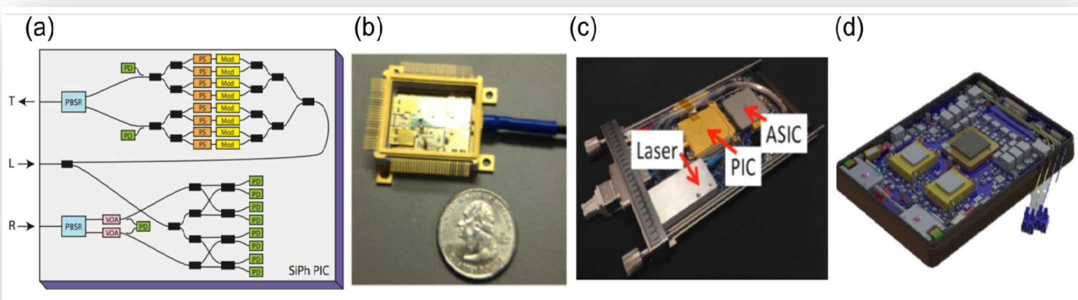
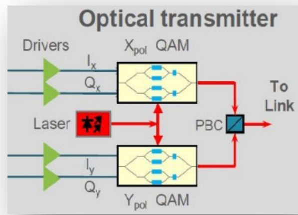


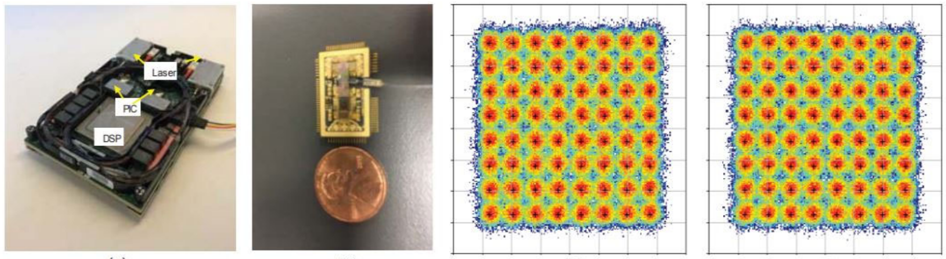
Fig. 1. Silicon coherent PIC and modules. (a) Block diagram of a silicon single chip transceiver excluding laser. (b) Gold box with the silicon PIC packaged with drivers, transimpedance amplifiers, fiber array, and other components. (c) Acacia's coherent CFP with the silicon PIC and ASIC. (d) Acacia's dual-carrier with one ASIC and two silicon PICs.

See also C. Doerr, *et al.*, Single-Chip Silicon Photonics 100-Gb/s Coherent Transceiver, OFC Postdeadline 2014 ("On the transmitter side, there are two in-phase (I) / quadrature (Q) traveling wave Mach-Zehnder modulators (MZMs)"); H. Zhang, *et al.*, Real-time transmission of 16 Tb/s over 1020km using 200Gb/s CFP2-DCO, Optics Express, Vol. 26, No. 16, Mar. 19, 2018 at 2, *available at* https://acacia-inc.com/wp-content/uploads/2018/03/Optics-Express-26-6-6943.pdf ("The CFP2-DCO module . . . integrates a tuneable narrow-linewidth laser, a single-chip silicon photonic integrated circuit for quad-parallel Mach-Zehnder modulators"); Presentation, Coherent

Optical Solutions for Data Center Interconnect, Optinet 2019, June 13, 2019 at 6, *available at* https://acacia-inc.com/wp-content/uploads/2019/06/Optinet-China-2019_Acacia_Fenghai-Liu_UpLoad_v1.pdf (image detail below):



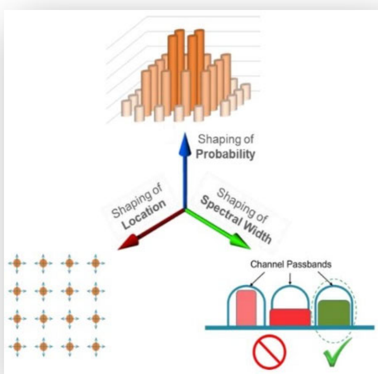
33. Acacia's coherent optical transceiver modules (and DSP ASIC components thereof) achieve optical networking transport speeds of 100 Gbps and above by employing the digital signal mapping techniques of the Asserted Patents. Mapping of the digital symbols prior to transmission to pre-equalize or compensate for modulator non-linearity and other such signal degradations is necessary at the high per-lane speeds and extended reaches at which Acacia's products operate. Accordingly, Acacia's various generations of DSP ASIC perform multiple digital mappings according to the claims of the Asserted Patents, in order to implement these digital pre-compensation functions. *See, e.g.*, H. Zhang, *et al.*, "Real-time Transmission of Single-Carrier 400 Gb/s and 600 Gb/s 64QAM over 200km-Span Link," ECOC 2019 at 1 ("High-baud rate 64QAM is intrinsically more susceptible to noise as well as linear and nonlinear distortions from analog electrical and optical components. Transmitter pre-distortion effectively improves the performance of high-baud rate 64QAM."), 2 ("digital pre-distortion"); 2 ("The ASIC includes . . . a DSP engine which performs pulse shaping and pre-equalization on the transmitter side"), Fig. 1.:



(a) (b) (c) (d)

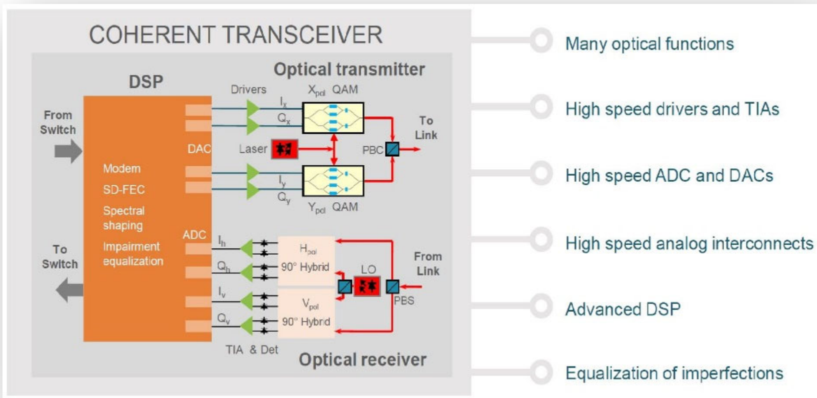
Fig. 1. (a) Coherent transciver and (b) silicon-photonics integrated citcuits, (c, d) Received 64 QAM constellation in X- and Y- polarizations at 69 GBd

34. For example, Acacia advertises that its AC1200 module and Pico DSP ASIC perform "3D Shaping" on transmit modulation constellation points. *See, e.g.*, AC1200 Product Family, *available at* https://acacia-inc.com/product/ac1200/ ("A primary capability of the AC1200 family is 3D-Shaping which enables fine-tune adjusting of the line-side modulation characteristics helping network operators optimize capacity and reach for their particular network or link"); Blog, Get in Shape with the AC1200, *available at* https://acacia-inc.com/blog/get-in-shape-with-the-ac1200/; Whitepaper, Optimize Network Utilization with 3D Shaping, *available at* https://acacia-inc.com/wp-content/uploads/2018/05/Optimize-Network-Utilization-with-Acacia-3D-Shaping.pdf ("3D Shaping enables fine-tune adjusting of the line-side coherent modulation characteristics"):



These digital shaping adjustments utilize the claimed digital mapping of the Asserted Patents.

35. Acacia's publications and product marketing material emphasize the capability of its DSP ASICs to perform digital pre-equalization or compensation of signals to be transmitted—to correct for non-linearity and other known signal degradations. *See, e.g.*, H. Zhang, *et al.*, "Real-time Transmission of Single-Carrier 400 Gb/s and 600 Gb/s 64QAM over 200km-Span Link," ECOC 2019 at 1 ("susceptible to noise as well as linear and nonlinear distortions from analog electrical and optical components. Transmitter pre-distortion effectively improves the performance"); Whitepaper, "Network Optimization in the 600G Era," *available at* https://acacia-inc.com/acacia-resources/white-paper-network-optimization-in-the-600g-era/ (discussing use of features such as "nonlinear equalization" to "provide additional system margin improvement"); H. Zhang, *et al.*, Real-time transmission of 16 Tb/s over 1020km using 200Gb/s CFP2-DCO, Optics Express, Vol. 26, No. 16, Mar. 19, 2018 at 3, *available at* https://acacia-inc.com/wp-content/uploads/2018/03/Optics-Express-26-6-6943.pdf ("The ASIC includes . . . a DSP engine which performs pulse shaping and pre-equalization on the transmitter side"); Presentation, Coherent Optical Solutions for Data Center Interconnect, Optinet 2019, June 13, 2019, at 6, *available at* https://acacia-inc.com/wp-content/uploads/2019/06/Optinet-China-2019_Acacia_Fenghai-Liu_UpLoad_v1.pdf (highlighting digital "Impairment equalization" in Acacia's DCP ASIC for "Equalization of imperfections" in the signal path):



36. Acacia has specifically highlighted the benefits it receives from use of the inventions of the Asserted Patents for signal compensation, marketing its use of DSP technology to provide a "better algorithm to mitigate or compensate the penalty from those [photonic and RF] components." *See, e.g.*, Video, Acacia Talks Coherent: Hongbin Zhang and Digital Signal Processing, *available at* https://acacia-inc.com/acacia-resources/acacia-talks-coherent-hongbin-zhang-and-digital-signal-processing/ (last accessed Feb. 22, 2021). A screenshot from this marketing video on Acacia's commercial website highlights "3D Shaping" and "Non-linear compensation" as key benefits of its DSP technology:

By **Acacia** | Posted on November 12, 2020

In this episode of Acacia Experts Talk Coherent, Principal DSP Designer Hongbin Zhang, Ph.D. explains digital signal processing (DSP) design challenges and solutions, key applications in optical networks, and key benefits of smaller CMOS node sizes.

These features are made possible through Acacia's infringement of the Asserted Patents.

37. As described above, and detailed with respect to patent claims below, Acacia's infringing coherent optical transceiver modules (and DSP ASIC and Silicon Photonic IC components thereof) (the "Accused Products") support advanced mapping and modulation techniques according to the Asserted Patents—including without limitation digital mapping to provide digital pre-equalization, pre-distortion, shaping, and non-linearity compensation, and modulation by varied quadrature modulation formats (*e.g.*, QPSK, 8QAM, 16QAM, 32QAM, 64QAM, etc.).

38. The Accused Products include, but are not limited to: 100, 200, and 400 Gbps pluggable CFP-DCO and CFP2-DCO pluggable modules; 1.2T (AC1200) and 400G (AC400) embedded modules; 400 Gbps OSFP and QSFP-DD pluggable modules that operate relative to 400ZR or OpenZR+ industry implementation agreements; and 100G QSFP-DD pluggable modules; as well as any similarly capable products under development by Acacia. The Accused

Products also include Acacia's CFP2-ACO modules to the extent they are used with an Acacia DSP ASIC on a linecard. Acacia is also accused of directly infringing via its own reference and test designs, and indirectly infringing by inducing or contributing to its customer's designs—that implement one of Acacia's Denali, Meru, Pico, or Greylock DSP ASICs coupled together with one of Acacia's Silicon Photonic ICs.

39. Acacia makes, uses, offers to sell, sells (including directly to end users and as an original equipment manufacturer to resellers), and/or imports into the United States the Accused Products. Acacia further uses and offers its Accused Products at industry trade shows and demonstrations to existing or potential customers. *See, e.g.*, Blog: "Introducing the AC1200-SC^2 Coherent 1.2T Single-Chip, Single-Channel Module," *available at* https://acacia-inc.com/blog/introducing-the-ac1200-sc2-coherent-1-2t-single-chip-single-channel-module/; Blog, Aloha PTC '19 – Acacia Prepares to Hang-10 at the annual Pacific Telecommunications Council event, *available at* https://acacia-inc.com/blog/aloha-ptc-19-acacia-prepares-to-hang-10-at-the-annual-pacific-telecommunications-council-event/.

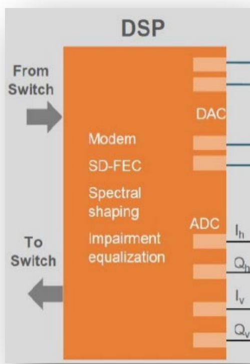
COUNT I
(INFRINGEMENT OF U.S. PATENT NO. 10,270,535)

40. Ramot incorporates by reference the allegations set forth in the proceeding paragraphs of this Complaint as though fully set forth herein.

41. Acacia makes, uses, sells, and/or offers to sell in the United States, and/or imports into the United States products that directly infringe the '535 Patent, including the above identified Acacia Accused Products that use advanced QAM modulation techniques (QPSK, 8-QAM, 16-QAM, 64QAM, etc.), as well as digital mapping of data for, *inter alia*, equalization, pre-distortion, shaping, or compensation of the transmitted signal ('535 Accused Products).

Acacia's '535 Accused Products that use advanced quadrature modulation techniques infringe at least claim 2 of the '535 Patent.

42. As an example, the '535 Accused Products implement modulating and transmitting an optical signal over an optical fiber in response to inputting N bits of digital data. Acacia's coherent optical transceiver modules manipulate digital data in the form of multi-bit words or symbols, which is converted, modulated, and transmitted as optical signals. For example, and without limitation, on information and belief Acacia's DSP ASICs take in, and operate internally, on parallel digital data words. *See, e.g.*, Presentation, Coherent Optical Solutions for Data Center Interconnect, Optinet 2019, June 13, 2019, at 6:



see also Whitepaper, "Network Optimization in the 600G Era," at Figure 7:

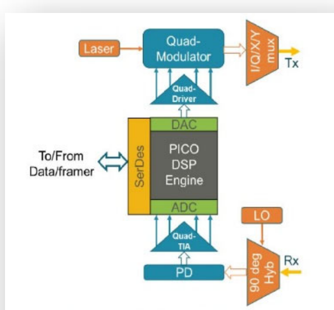


Figure 7. AC1200 simple block diagram. Shared local oscillator (LO) and Tx laser.

Acacia's various transceiver modules and DSP ASICs accept parallel digital data from a host interface and then operate internally on multi-bit symbols. *See, e.g.*, OIF-400ZR-01.0 at 5 ("1x400GAUI-8"):

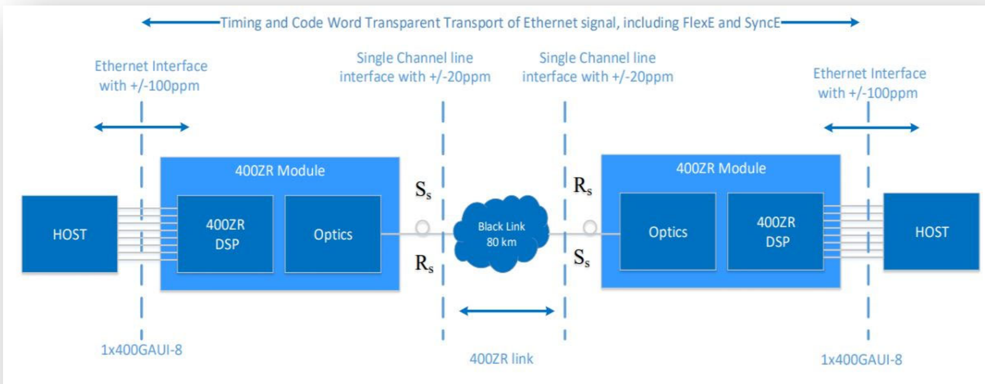


Figure 1: 400ZR reference diagram

See also id. at 18, 48 ("Each 128-bit code word is mapped to 16 DP-16QAM symbols (S)"), Fig. 6.

43. As described above, Acacia's Accused Products modulate symbols into various QAM constellations with points ranging from 4 (QPSK) to 64 (64QAM). *See, e.g.*, *id.* at 48 ("DP-16QAM symbols"); H. Zhang, *et al.*, Real-time transmission of 16 Tb/s over 1020km using 200Gb/s CFP2-DCO, Optics Express, Vol. 26, No. 16, Mar. 19, 2018 at Fig. 2:

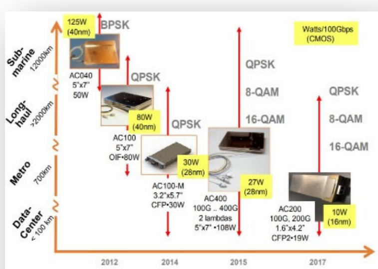


Fig. 2. Evolution in power and density per 100Gbps for coherent transceiver modules.

H. Zhang, *et al.*, "Real-time Transmission of Single-Carrier 400 Gb/s and 600 Gb/s 64QAM over

200km-Span Link," ECOC 2019 at Fig. 1(c) and (d):

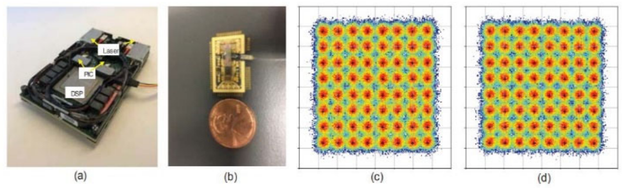
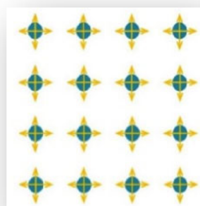


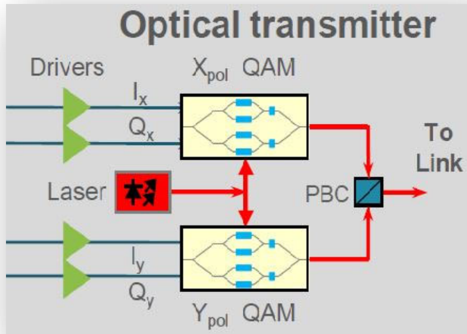
Fig. 1. (a) Coherent transciver and (b) silicon-photonics integrated citucits, (c, d) Received 64 QAM constellation in X- and Y- polarizations at 69 GBd

See also Blog, Get in Shape with the AC1200, at 2 ("Shaping of the constellation points' location to increase reach"):



44. As described above, Acacia's coherent optical transceiver modules (and Silicon Photonic IC components thereof) each transmit optical signals. *See, e.g.*, Products Overview ("Our optical interconnect solutions include sophisticated modules engineered to perform a majority of the DSP and optical functions required to process network traffic at transmission speeds of 100 Gbps to greater than 1 Tbps").

45. As described above, the Silicon Photonic optical modulators of the '535 Accused Products have a plurality of waveguide branches, where each branch has an input of an unmodulated optical signal. For example, and without limitation, Acacia's Silicon Photonic ICs take as an input an unmodulated laser which is used in the IC for driving the various arms (*i.e.*, waveguide branches) of a nested Mach-Zehnder type modulator. *See, e.g.*, Presentation, Coherent Optical Solutions for Data Center Interconnect, Optinet 2019, June 13, 2019, at 6:



See also L. Chen, *et al.*, Silicon Photonics for 100G-and-beyond Coherent Transmissions, OFC 2016 at 1 ("Figure 1(a) is a block diagram of the silicon PIC. The three optical IOs ('T', 'L', and 'R') are for transmitter output, laser input that is split between the transmitter and receiver, and receiver input, respectively. The chip includes 4 carrier- depletion Mach-Zehnder modulators"), Figs 1(a)-(d):

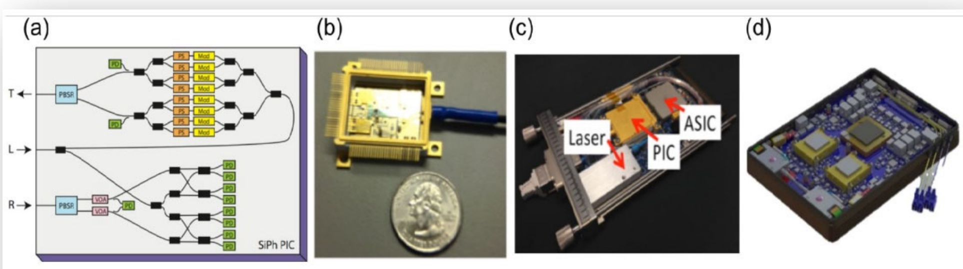
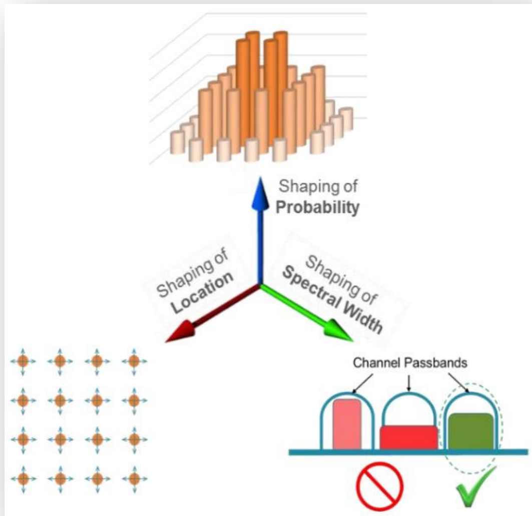


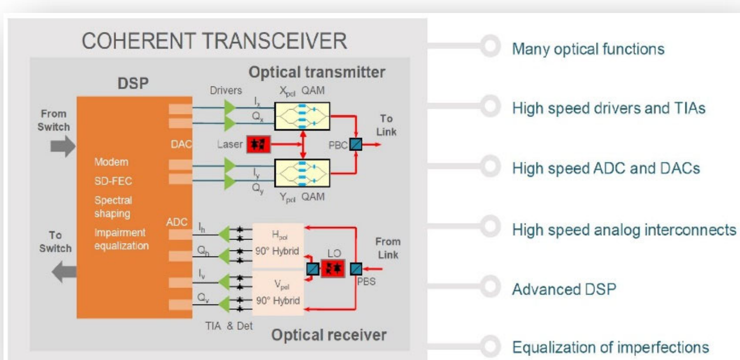
Fig. 1. Silicon coherent PIC and modules. (a) Block diagram of a silicon single chip transceiver excluding laser. (b) Gold box with the silicon PIC packaged with drivers, transimpedance amplifiers, fiber array, and other components. (c) Acacia's coherent CFP with the silicon PIC and ASIC. (d) Acacia's dual-carrier with one ASIC and two silicon PICs.

46. The '535 Accused Products implement converting the N bits of digital data to M drive voltage values, where M>N and N>1. As described above, Acacia's coherent optical transceiver modules (and DSP ASIC components thereof) perform digital signal processing on multi-bit symbols, in order to pre-equalize, pre-distort, shape, or compensate in the digital domain for known impairments. For example, and without limitation, Acacia's DSP ASICs

perform "3D Shaping" that "enables fine-tune adjusting of the line-side coherent modulation characteristics." *See, e.g.*, Whitepaper, Optimize Network Utilization with 3D Shaping:

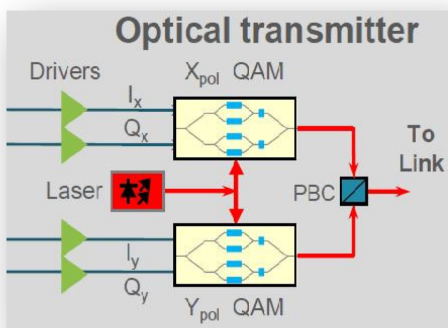


See also Video, Acacia Talks Coherent: Hongbin Zhang and Digital Signal Processing ("mitigate or compensate the penalty from those components" and "Non-linear compensation"); Presentation, Coherent Optical Solutions for Data Center Interconnect, Optinet 2019, June 13, 2019, at 8 ("Efficient EQ for non-perfect optics"), 6 ("Spectral shaping" and "Impairment equalization" in "Advanced DSP" for "Equalization of imperfections"):



On information and belief, the output of the digital conversion functions for the input symbols are vectors of M>N voltage values, suitable for coupling via high-speed digital to analog converters (DACs) and driver cuircuits to the modulator electrodes.

47. The ’535 Accused Products implement coupling the M drive voltage values to the unmodulated optical signal, thereby enabling modulation of the unmodulated optical signal to generate a QAM modulated optical signal. For example, and without limitation, in Acacia’s coherent optical transceiver modules the QAM modulated symbols and corresponding voltage values described above are coupled to the unmodulated optical signal via Drivers and associated circuitry for the branches of the Mach-Zehnder modulator structures. *See, e.g.*, Presentation, Coherent Optical Solutions for Data Center Interconnect, Optinet 2019, June 13, 2019, at 6 (detail below):



See also C. Doerr, *et al.*, Single-Chip Silicon Photonics 100-Gb/s Coherent Transceiver, OFC Postdeadline 2014 (“adjust the MZM phases to produce QPSK”), Fig. 1:

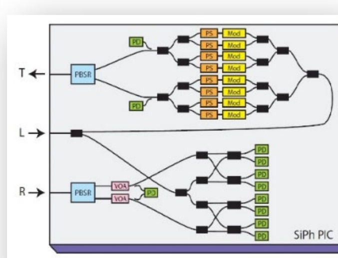


Fig. 1. Block diagram of the SiPh coherent PIC. PS =

48. The ’535 Accused Products implement transmitting the QAM modulated optical signals over an optical fiber. Acacia’s Accused Products have optical fiber ports for transmitting over optical fibers of various lengths, types, and wavelengths. *See, e.g.*, Blog: “Introducing the AC1200-SC^2 Coherent 1.2T Single-Chip, Single-Channel Module (“1.2 Terabit (1.2T) on a single-channel.”):

See also H. Zhang, *et al.*, “Real-time Transmission of Single-Carrier 400 Gb/s and 600 Gb/s 64QAM over 200km-Span Link,” ECOC 2019 at 1 (“We transmit 41 x 600Gb/s polarization multiplexed (PM) 64QAM channels on a 100 GHz grid over 32 nm bandwidth with uniform loading”); H. Zhang, *et al.*, Real-time transmission of 16 Tb/s over 1020km using 200Gb/s CFP2-DCO, Optics Express, Vol. 26, No. 16, Mar. 19, 2018 at 2 (“We demonstrate transmission of 80 x 200Gb/s polarization multiplexed (PM) 8QAM and 16QAM channels on a 50 GHz grid with 2.8dB and 1.2dB Q^2-factor margin, respectively.”).

49. By making, using, offering for sale, and/or selling products in the United States, and/or importing products into the United States, including but not limited to the ’535 Accused Products, Acacia has injured Ramot and is liable to Ramot for directly infringing one or more claims of the ’535 Patent, including without limitation claim 2 pursuant to 35 U.S.C. § 271(a).

50. Acacia also infringes the ’535 Patent under 35 U.S.C. § 271(b) & (c).

51. Acacia knowingly encourages and intends to induce infringement of the ’535 Patent by making, using, offering for sale, and/or selling products in the United States, and/or

importing them into the United States, including but not limited to the '535 Accused Products, with knowledge and specific intention that such products will be used by its customers. As in the Blog posts, Presentations, Whitepapers, and Videos discussed herein, Acacia instructs its customers on how to use and implement the technology claimed in the '535 patent.

52. Acacia also contributes to the infringement of the '535 Patent. Acacia makes, uses, sells, and/or offers to sell products in the United States, and/or imports them into the United States, including but not limited to the '535 Accused Products, knowing that those products constitute a material part of the claimed invention, that they are especially made or adapted for use in infringing the '535 Patent, and that they are not staple articles or commodities of commerce capable of substantial non-infringing use.

53. On information and belief, Acacia was aware of the '535 Patent and related Ramot patents, had knowledge of the infringing nature of its activities, and nevertheless continues its infringing activities. For example, on June 12, 2019, Ramot sued Acacia customer Cisco for infringement of the Asserted Patents. *See Ramot at Tel Aviv University Ltd. v. Cisco Systems, Inc.*, Case No. 2:19-cv-00225-JRG (E.D. Tex.), D.I. 1.

54. Acacia's infringement of the '535 Patent has been and continues to be deliberate and willful, and, this is therefore an exceptional case warranting an award of enhanced damages and attorneys' fees pursuant to 35 U.S.C. §§ 284-285.

55. As a result of Acacia's infringement of the '535 Patent, Ramot has suffered monetary damages, and seeks recovery in an amount adequate to compensate for Acacia's infringement, but in no event less than a reasonable royalty with interest and costs.

COUNT II
(INFRINGEMENT OF U.S. PATENT NO. 10,033,465)

56. Ramot repeats and incorporates by reference the allegations contained in the preceding paragraphs as if fully set forth herein.

57. Acacia makes, uses, sells, and/or offers to sell in the United States, and/or imports into the United States products that directly infringe the ’465 Patent, including the above identified Acacia Accused Products that use advanced QAM modulation techniques (QPSK, 8-QAM, 16-QAM, 64QAM, etc.), as well as digital mapping of data for, *inter alia*, equalization, pre-distortion, shaping, or compensation of the transmitted signal (’465 Accused Products). Acacia’s ’465 Accused Products that use advanced quadrature modulation techniques infringe one or more claims of the ’465 Patent, including without limitation, claim 13 of the ’465 Patent.

58. As an example, the ’465 Accused Products implement modulating and transmitting an optical signal over an optical fiber in response to inputting N bits of digital data. For example, and without limitation, see the evidence cited and discussed above with respect to paragraphs 42-44.

59. The ’465 Accused Products include Silicon Photonic optical modulators having a plurality of waveguide branches, where each branch has an input of an unmodulated optical signal. For example, and without limitation, see the evidence cited and discussed above with respect to paragraph 45.

60. The ’465 Accused Products implement converting the N bits of digital data to M drive voltage values, where $M \geq N$ and $N > 1$. For example, and without limitation, see the evidence cited and discussed above with respect to paragraph 46.

61. The ’465 Accused Products implement coupling the M drive voltage values to the unmodulated optical signal, thereby enabling modulation of the unmodulated optical signal to

generate a QAM modulated optical signal. For example, and without limitation see the evidence cited above with respect to paragraphs 47.

62. The ’465 Accused Products implement transmitting the QAM modulated optical signals over an optical fiber. For example, and without limitation see the evidence cited above with respect to paragraph 48.

63. By making, using, offering for sale, and/or selling products in the United States, and/or importing them into the United States, including but not limited to the ’465 Accused Products, Acacia has injured Ramot and is liable to Ramot for directly infringing one or more claims of the ’465 Patent, including without limitation claim 13, pursuant to 35 U.S.C. § 271(a).

64. Acacia also infringes the ’465 Patent under 35 U.S.C. § 271(b) & (c).

65. Acacia knowingly encourages and intends to induce infringement of the ’465 Patent by making, using, offering for sale, and/or selling products in the United States, and/or importing them into the United States, including but not limited to the ’465 Accused Products, with knowledge and specific intention that such products will be used by its customers. As in the Blog posts, Presentations, Whitepapers, and Videos discussed herein, Acacia instructs its customers on how to use and implement the technology claimed in the ’465 patent.

66. Acacia also contributes to the infringement of the ’465 Patent. Acacia makes, uses, sells, and/or offers to sell products in the United States, and/or imports them into the United States, including but not limited to the ’465 Accused Products, knowing that those products constitute a material part of the claimed invention, that they are especially made or adapted for use in infringing the ’465 Patent, and that they are not staple articles or commodities of commerce capable of substantial non-infringing use.

67. On information and belief, Acacia was aware of the ’465 Patent and related Ramot patents, had knowledge of the infringing nature of its activities, and nevertheless continues its infringing activities. For example, on June 12, 2019, Ramot sued Acacia customer Cisco for infringement of the Asserted Patents. *See Ramot at Tel Aviv University Ltd. v. Cisco Systems, Inc.*, Case No. 2:19-cv-00225-JRG (E.D. Tex.), D.I. 1.

68. Acacia’s infringement of the ’465 Patent has been and continues to be deliberate and willful, and, this is therefore an exceptional case warranting an award of enhanced damages and attorneys’ fees pursuant to 35 U.S.C. §§ 284-285.

69. As a result of Acacia’s infringement of the ’465 Patent, Ramot has suffered monetary damages, and seeks recovery in an amount adequate to compensate for Acacia’s infringement, but in no event less than a reasonable royalty with interest and costs.

PRAYER FOR RELIEF

WHEREFORE, Plaintiff prays for judgment and seeks relief against Acacia as follows:

(a) For judgment that U.S. Patent Nos. 10,270,535 and 10,033,465 have been and continue to be infringed by Acacia;

(b) For an accounting of all damages sustained by Plaintiff as the result of Acacia’s acts of infringement;

(c) For finding that Acacia’s infringement is willful and enhancing damages pursuant to 35 U.S.C. § 284;

(d) For a mandatory future royalty payable on each and every future sale by Acacia of a product that is found to infringe one or more of the Asserted Patents and on all future products which are not colorably different from products found to infringe;

(e) For an award of attorneys' fees pursuant to 35 U.S.C. § 285 or otherwise permitted by law;

(f) For all costs of suit; and

(g) For such other and further relief as the Court may deem just and proper.

ASHBY & GEDDES

/s/ Andrew C. Mayo

John G. Day (#2403)
Andrew C. Mayo (#5207)
500 Delaware Avenue, 8th Floor
P.O. Box 1150
Wilmington, DE 19899
(302) 654-1888
jday@ashbygeddes.com
amayo@ashbygeddes.com

Attorneys for Plaintiff

Of Counsel:

Denise M. De Mory
Corey Johanningmeier
BUNSOW DE MORY LLP
701 El Camino Real
Redwood City, CA 94063
(650) 351-7248

Dated: February 26, 2021