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.: The Revolution Has Just Begun Q&A with John Bowers

One of the foremost names in the world of integrated photonics is John Bowers, Ph.D., who is credited with leading a team that successfully demonstrated an electrically pumped hybrid silicon laser a decade ago. That advance has paved the way for the commercial production of high-bandwidth silicon photonic devices. Today, Bowers is leading UC Santa Barbara's Institute for Energy Efficiency's involvement in the AIM initiative and is a central figure in this exciting field. Photonics Spectra spoke with Bowers about AIM, his breakthrough work and the impact of integrated photonics on medicine, communications and defense.

Q: Could you provide us with a snapshot of where you see the state of integrated photonics at the moment?

A: Integrated photonics is transforming telecommunications and data communications. Infinera, Acacia and others are introducing new telecommunication products with much higher capacity and performance that have been enabled by integration. Intel, Luxtera, Lumentum, Finisar and others are increasing capacity and lowering cost by integration. Virtually all 100-Gbps transceivers are highly integrated, and the next generation at 400 Gbps are only possible with integration. This started with integration on InP but high volumes are now being shipped by many silicon photonics suppliers, including Intel, Luxtera, Acacia and others.

John E. Bowers holds the Fred Kavli Chair in Nanotechnology, and is the Director of the Institute for Energy Efficiency. He is a member of the National Academy of Engineering, National Academy of Inventors, a fellow of the IEEE, OSA and the American Physical Society, and a recipient of the IEEE Photonics Award, OSA Tyndall Award, OSA Holonyak Prize, and the IEEE LEOS William Streifer Award. Courtesy of UCSB.

Q: Please elaborate on how you feel integrated photonic circuits are likely to impact such fields as transportation, medicine and defense in the years ahead?

A: Optical lidars are being deployed on autonomous vehicles today, but they are too bulky and expensive to be practical. Integration is critical to reduce the size, improve the performance and achieve a price point for widespread application. Optical clocks and integrated optical gyroscopes will transform precision navigation and timing. Similarly, in medicine, OCT has demonstrated tremendous potential, but the best performance uses coherent receivers, and integration is important. The same is true for defense; fiber optical links have advantages over microwave links, particularly at millimeter wave frequencies, but the cost has been prohibitive. Now, low-cost integrated millimeter wave generators on silicon are smaller and cheaper than the alternative.

Q: Your work in ’06/’07 successfully bonding III-V material to a silicon waveguide has been cited as one of the seminal breakthroughs in integrated photonics. A decade later, can you share your reflections on this work and some of the primary challenges you overcame?

A: Fiber optics enabled the internet revolution, but telecom transceivers were still expensive and produced in relatively low volumes. We enabled a transformation to high-volume manufacturing using low-cost, large-area silicon substrates and high-quality silicon processing combined with high gain III-V materials. We married the best of both worlds through Alex Fang’s Ph.D. research at UCSB and very productive collaborations with Intel, HPE and Aurrion, now Juniper Networks. The most important aspects are just beginning to happen: automated packaging and automated wafer-scale testing using tools that are only available at 200- and 300-mm wafer sizes, and that will be the real revolution.

Q: Has the hybrid silicon III-V laser reached commercial viability?

A: Yes, Intel has successfully introduced a 100G PSM4 QSFP transceiver and a 100G CWDM4 transceiver, and is shipping them in volume. Other companies are also planning integrated PIC products with integrated lasers.

Q: In 2015, the AIM initiative was formed and you were tasked with heading up UC Santa Barbara's Institute for Energy Efficiency's involvement in the program. Can you discuss recent advances?

A: The AIM photonic process line at SUNY is running wafers, and is just starting the second multiprocess wafer run. Cadence, Synopsys, Mentor and Analog Photonics are rapidly evolving a variety of photonic design tools and coming out with new versions of the PDK every six months. An advanced photonic packaging line in Rochester is being designed and should come online next year. UCSB's focus is III-V integration to bring lasers and amplifiers into the AIM platform and that is moving very rapidly.

Q: How is integrated photonics likely to transform the world in which we live in the years and decades ahead?

A: The big revolution is taking photonics from the edge of the circuit board and embedding close to electronics, increasing capacity and reducing power and cost by eliminating the SerDes [serializer/deserializer] required today. We will move to 3D integration of electronics and photonics, enabling processors, memory, switching chips, and sensors with far more capability than is available today. This photonic revolution has only just begun. The line between electronics and photonics will blur to the point that we don't recognize the integrated circuits of the future and that will enable many new applications.

GLOSSARY

lidar

An acronym of light detection and ranging, describing systems that use a light beam in place of conventional microwave beams for atmospheric monitoring, tracking and detection functions. Ladar, an acronym of laser detection and ranging, uses laser light for detection of speed, altitude, direction and range; it is often called laser radar.