The first electrically powered nanolasers capable of being operated at room temperature

July 16 2013, by Robert White, Ph.d.

(Phys.org) —Significant proof of the critical importance of long term basic research funding has been demonstrated with the first convincing operation of a room temperature, continuous wave nanolaser powered by electricity.

Funded by the Air Force Office of Scientific Research (AFOSR) and the Defense Advanced Research projects Agency (DARPA), Dr. Cun-Zheng Ning and his team at Arizona State University accomplished something that may very well result in a key solution to keeping Moore's Law on track.

Moore's Law is the prediction that, over the long term, the number of transistors embedded on integrated circuits would double about every two years. Shrinking the size of lasers is crucial to integrating photonic with electronic components as they become not only smaller, but faster. By placing more lasers into the same space, far greater processing speeds are attained—which makes possible the next generation of computers.

Much of the research that led up to this breakthrough concerned nanolasers powered by larger light sources as opposed to being powered directly by electrical current. Light powered nanolasers can readily operate at room temperature, but there was a problem relating to their practical application—they were not powered by electricity, and were therefore not a solution for electronic applications, simply because embedding an additional light source, to power the nanolasers, was impractical; actually negating whatever space you saved by using nanolasers in the first place.

Dr. Ning noted that for nanolasers to be useful in electronic and photonic technologies—it is necessary that the laser operates at room temperature— without a cooling system, that it be powered by a simple battery instead of by another laser light source, and that it is able to emit light continuously.

Previous experiments at electrically powered nanolasers have failed due primarily to overheating—including attempts by Dr. Ning's team. What was different this time came down to a matter of thickness.

Dr. Ning's latest approach employed the same indium phosphide/indium gallium arsenide/indium phosphide (InP/InGaAs/InP) rectangular core and the same silicon nitride (SiN) insulating layer—encapsulated in a silver shell—used in a previous mockup, which failed due to overheating. When the team refined the fabrication process and adjusted the thickness of the SiN layer, the heat dissipated at a much faster rate—enough to keep the nanolaser in continuous operation.

In an ASU press release, Dr. Ning noted that, "In terms of fundamental science, it shows for the first time that metal heating loss is not an insurmountable barrier for room-temperature operation of a metallic cavity nanolaser under electrical injection; for a long time, many doubted if such operation is even possible at all."

What is significant from a basic research perspective is that this breakthrough was the culmination of nearly seven years of work by Professor Ning and his colleagues. But they will not rest at this point, as Dr. Ning wants to pursue two significant steps to follow up on his success: integration on a silicon waveguide and to pursue high speed modulation, which Dr. Ning foresees going as high as several 100 GHz, but ultimately the integration of nanolasers into a photonic system on chip platform.

Dr. Gernot Pomrenke, the AFOSR program officer who has funded Dr. Ning throughout this research endeavor notes that Ning's success will have a significant impact on the further development and integration of nanolasers as it addresses thermal issues and the role of metals in such nanostructures. Ultimate solutions to such difficult problems will pave the road toward full integration of photonic and electronic micro and nanoscale components for use in various practical applications.

Provided by Air Force Office of Scientific Research

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