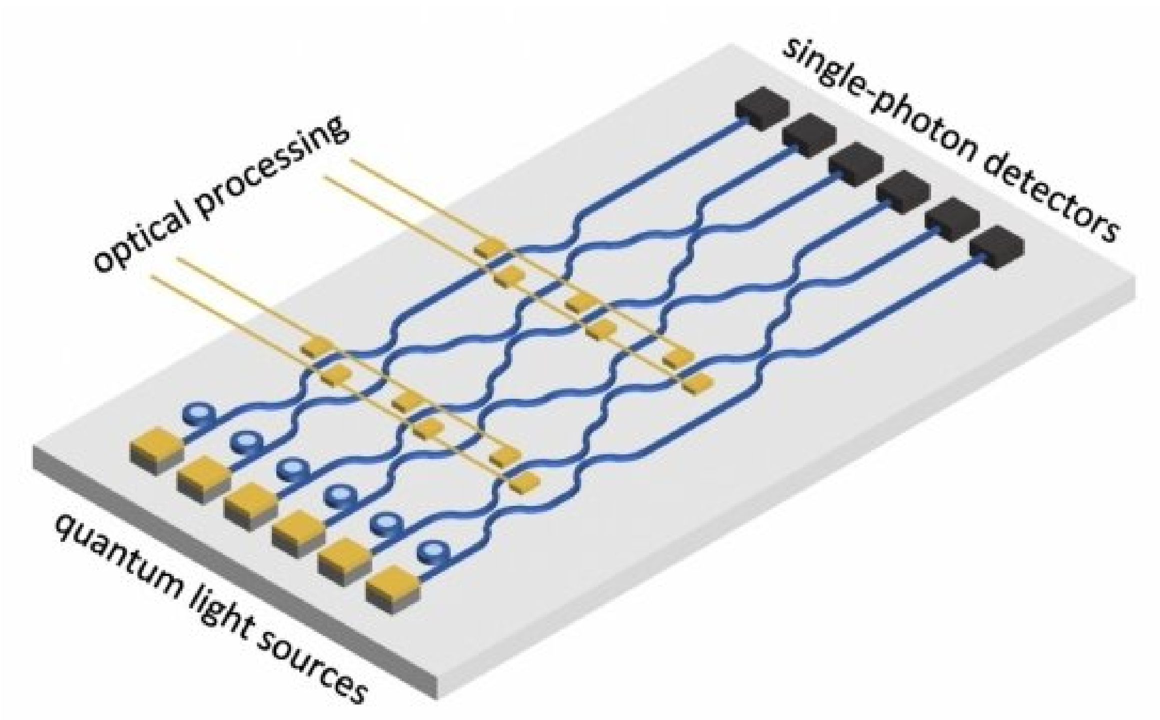
Pushing quantum photonics

October 22 2019, by Andrew Masuda



A proposed all-electric, all-on-chip quantum photonic platform. Credit: Galan Moody

Quantum computers use the fundamentals of quantum mechanics to potentially speed up the process of solving complex computations. Suppose you need to perform the task of searching for a specific number in a phone book. A classical computer will search each line of the phone book until it finds a match. A quantum computer could search the entire phone book at the same time by assessing each line simultaneously and return a result much faster.

The difference in speed is due to the computer's basic unit for processing information. In a classical computer, that basic unit is called a bit, an electrical or optical pulse that represents either 0 or 1. A quantum computer's basic unit is a qubit, which can represent numerous combinations of values from 0 and 1 at the same time. It is this characteristic that may allow quantum computers to speed up calculations. The downside of qubits is that they exist in a fragile quantum state that is vulnerable to environmental noise, such as changes in temperature. As a result, generating and managing qubits in a controlled environment poses significant challenges for researchers.

UC Santa Barbara engineer Galan Moody, an assistant professor of electrical and computer engineering, has proposed a solution to overcome the poor efficiency and performance of existing quantum computing prototypes that use light to encode and process information. Optical systems are attractive because they naturally link quantum computing and networking in the same physical framework. However, existing technology still requires off-chip optical operations, which dramatically reduce efficiency, performance and scalability. In his project, "Heterogeneous III-V/Silicon Photonics for All-on-Chip: Linear Optical Quantum Computing," Moody aims to create an optical quantum computing platform in which all of the essential components are integrated onto a single semiconductor chip.

"Integrated electronic circuits enabled revolutionary advancements in classical computing. Our goal is to create integrated photonic circuits that have the same impact on quantum computing," said Moody, who joined UCSB's College of Engineering this fall after spending six years at the National Institute of Standards and Technology as a postdoctoral fellow and research scientist. "This could lead to a dramatic improvement in efficiency and processing speed and enable entirely new methods of processing and transmitting information using light."

Moody's research project has now received a significant boost from the United States Air Force. He is one of 40 early-career scientists selected for a 2019 Young Investigator Award from the Air Force Office of Scientific Research. Winners receive $450,000 over three years to support their work. The program is intended to foster research by young scientists that supports the Air Force's mission to control and maximize utilization of air, space and cyberspace, as well as related challenges in science and engineering.

"It's an honor to be among this group of talented awardees, and I am grateful for being selected," said Moody. "This award will allow my research group to make a more meaningful impact on the exciting and rapidly evolving quantum-information landscape."

In order to develop an all-electrical, all-on-chip quantum photonic platform, Moody proposes to integrate three technologies that have been developed for different platforms and applications. The components are electrically driven quantum dot single-photon sources, silicon-based photonics for optical operations, and superconducting nanowire single-photon detectors.

"We'll use physical modeling to guide the design and fabrication of the device," he said. "Quantum optical spectroscopy will give us insight into material properties and noise sources, and on-chip optical interferometers will enable measurements allowing us to improve material purity, monitor the light source and perform computations. Ultimately, we want to better understand and leverage any advantages that quantum mechanics can provide for computing and networking."

According to Moody, the new technology could also have transformative impacts in areas like turn-key quantum light sources for secure communications, and for reducing the size, weight and power consumption of classical photonic devices such as lasers and LEDs.

Provided by University of California - Santa Barbara