

# THE *Current*

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## Shrinking SWaP

If the parts in a satellite, a drone or other specialized device are large in size, weight and power consumption — in other words, if their SWaP is high — the device itself has to be bigger and heavier and is usually more expensive to build, launch or operate.

With a new grant, UC Santa Barbara engineers Jonathan Klamkin and Larry Coldren aim to reduce SWaP to improve performance. The pair has received one of 12 highly competitive NASA research awards to produce low-SWaP integrated microphotonic circuits for satellite-based Lidar applications. The three-year award is part of NASA's \$14 million Advanced Component Technology Program.

Lidar is a light-based remote-sensing method that uses a pulsing laser to map environments. Ultra-low SWaP photonic integrated circuits (PICs) are intended for precise measurements of atmospheric constituents such as carbon dioxide.

"Photonic integrated circuits can reduce SWaP dramatically — by several orders of magnitude — so they can be deployed on smaller spacecraft that cost much less and launch more frequently," said Klamkin, an associate professor in UCSB's Department of Electrical and Computer Engineering. The upshot is significantly more scientific measurements at substantially reduced cost.

"We are shrinking down a very capable system from the size of a small refrigerator to pocket size and making it perform even better," he added. "That opens up a lot of doors, not only for space missions but also for other applications. For space

specifically, you could map Earth's carbon dioxide — or methane or other gases — by putting our technology on CubeSats — modular satellites consisting of one or more 10-by-10-by-10-cm cubes. Today, systems like this don't fit on even large satellites."

The Lidar PIC will enable spectroscopic measurements of the Earth's atmosphere with increased sensitivity and enable near-infrared multi-wavelength analysis, so that a single integrated device can be used to monitor carbon dioxide and other greenhouse gases. PICs have been highly developed for the telecommunications industry, but those circuits do not meet the requirements for remote-sensing Lidar and have not been qualified for space.

"The level of integration we are applying is well beyond what is available commercially," said Coldren, a professor in UCSB's Department of Electrical and Computer Engineering. "We are building an entire Lidar sensing system on a single chip or, at most, a few chips. The objective is to realize a pocket-size system for sensing carbon dioxide that can be deployed on small spacecraft."

According to Klamkin, their approach relies on measuring just a small trace of carbon dioxide — which is like trying to find a needle in a haystack. It also requires fast, precise and tunable lasers. "We are building on prior work in optical phase-locked loop technology to achieve these metrics," Klamkin said.

The PICs could eventually be qualified for space, thus setting a path for use on future NASA missions, provided they could pass fairly rigorous qualification testing.

"I am particularly excited for the UCSB students and researchers involved," Klamkin said. "They will collaborate with world-renowned scientists and engineers at NASA to develop very important technology that may one day fly into space."

Both Klamkin and Coldren are experts in integrated photonics and are affiliated with the UCSB-based West Coast hub of the American Institute for Manufacturing Integrated Photonics, a federally funded Institute for Manufacturing Innovation. They will collaborate with NASA Goddard Space Flight Center Lidar experts who have successfully built and flown instruments using discrete components.

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