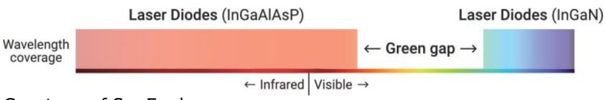
The Game Is Changing Due to Tiny Green Lasers

Posted by Okachinepa 09/03/2024

Courtesy of SynEvol

Red and blue light is produced by tiny, high-quality lasers that scientists have been creating for years. But their usual technique, which involves putting electricity into semiconductors, hasn't proven to be as effective in creating tiny lasers that emit light at green and yellow wavelengths. The "green gap" is the term used by researchers to describe the lack of steady, small lasers in this visible light spectrum. Closing this gap creates new prospects for undersea medical treatments, communications, and other fields.

Although green laser pointers have been around for 25 years, their light output is limited to a small range of green and they are not integrated with chips that allow them to function in tandem with other devices to do practical tasks.



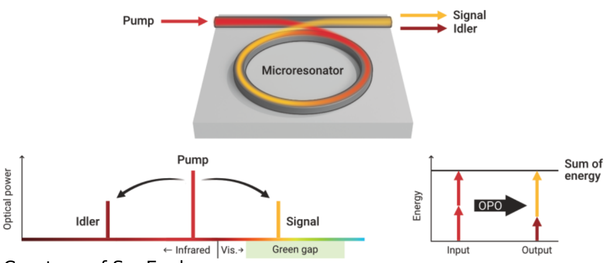
Courtesy of SynEvol
Credit: S.Kelley/NIST

Thanks to modifications made to a tiny optical component—a ring-shaped microresonator small enough to fit on a chip—scientists at the National Institute of Standards and Technology (NIST) have now bridged the "green gap."

As most aquatic settings are practically transparent to blue-green wavelengths, an underwater communication system could benefit from a small green laser light source. Additional possible uses include full-color laser projection displays and the use of lasers to treat medical disorders like diabetic retinopathy, which is characterized by an increase in blood vessels in the eyes.

Because they have the ability to store data in qubits, the basic building block of quantum information, compact lasers operating in this wavelength range are also significant for applications in quantum computing and communication. These quantum applications can't yet be used outside of laboratories since they require lasers that are bigger, heavier, and more powerful.

For a number of years, a group headed by Kartik Srinivasan of NIST and the Joint Quantum Institute (JQI), a collaboration between NIST and the University of Maryland, has been utilizing silicon nitride microresonators to change the color of infrared laser light. Light infrared is blasted thousands of times around the ring-shaped resonator until it reaches intensities high enough to interact with silicon nitride. The interaction, referred to as an optical parametric oscillation (OPO), generates the idler and the signal, two additional light wavelengths.



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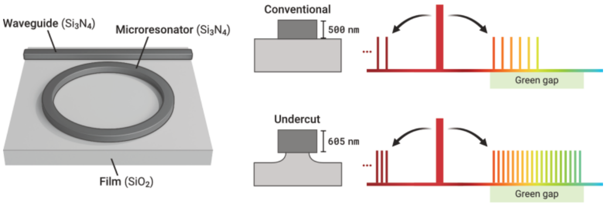
Credit: S.Kelley/NIST

The researchers produced a few distinct colors of visible laser light in earlier investigations. Researchers created red, orange, and yellow light as well as a wavelength of 560 nanometers, which is precisely at the hairy border between yellow and green light. The wavelengths of light generated depend on the dimensions of the microresonator. The group was unable to produce all the shades of green and yellow required to close the green gap, though.

The NIST scientist Yi Sun, who worked with the researchers on the current study, stated, "We didn't want to be good at hitting just a couple of wavelengths." "We aimed to utilize all available wavelengths within the gap."

The group altered the microresonator in two different ways to close the gap. Initially, the scientists thickened it a little bit. By altering its size, the scientists were able to produce light with more ease that passed through the green gap and reached wavelengths as low as 532 nanometers (billionths of a meter). The researchers were able to cover the whole gap with this enlarged range.



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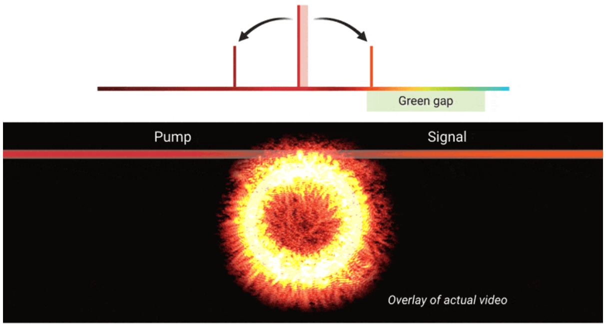
Credit: S.Kelley/NIST

The scientists also removed a portion of the silicon dioxide layer beneath the microresonator through etching, exposing it to additional air. As a result, the output colors were less affected by the infrared pump wavelength and microring diameters. The researchers were able to produce slightly varying green, yellow, orange, and red wavelengths from their device with greater control because of the decreased sensitivity.

The researchers discovered that they could produce and refine more than 150 different wavelengths throughout the green gap as a result. "With OPO, we could generate a wide range of laser colors, from red to orange to yellow to green, but it was difficult to make small adjustments within each of those color bands," Srinivasan said.



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Currently, scientists are attempting to increase the green-gap laser colors' energy efficiency. At the moment, the output power is only a small percentage of the laser's input power. Enhancements in the way the light is extracted from the microresonator and the coupling between the input laser and the waveguide that directs light into it could lead to a notable increase in efficiency.
