Precision gas sensor could fit on a chip

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Using their expertise in silicon optics, Cornell engineers have miniaturized a light source in the elusive mid-infrared (mid-IR) spectrum, effectively squeezing the capabilities of a large, tabletop laser onto a 1-millimeter silicon chip.

The breakthrough could lead to highly sensitive, handheld gas sensors for anything from atmospheric research to disaster-recovery missions.

This miniaturized mid-IR light source is called a frequency comb, and hails jointly from the labs of Michal Lipson, the Given Foundation Professor of Engineering in the School of Electrical and Computer Engineering, and Alexander Gaeta, the Samuel B. Eckert Professor of Engineering in the School of Applied and Engineering Physics. It is described online Feb. 24 in Nature Communications.

An optical frequency comb, in part the subject of research that was awarded the 2005 Nobel Prize in physics, is a light source made of very short, equally spaced pulses, which can be visualized like the teeth of a comb. Mid-IR frequency combs are of widespread interest for gas sensing applications, because in this wavelength, many different gases absorb in a strong way. Engineers want to exploit this wavelength range for sensitive detection of a large array of gases.

Today's most common method for gas sensing is optical spectroscopy, which identifies gas molecules by shooting light through them and detecting their unique frequencies, like a fingerprint, as the light is absorbed. But this requires a broad bandwidth of different colors of

light, typically generated by a giant laser inside a laboratory.

The Cornell researchers solved some long-standing puzzles in order to shrink this mid-IR frequency comb onto a chip. First, they fabricated the silicon structure with a special thermal oxidation process that makes the surfaces very smooth, leading to reduced optical losses compared with typical silicon optics.

Second, they solved the problem of silicon building up too much charge at high optical powers. They placed a diode on the device that swept out built-up electrical charges so that the light source did not "feel" the few charges that were left.

More information: "Silicon-chip mid-infrared frequency comb generation." *Nature Communications* 6, Article number: 6299 DOI: 10.1038/ncomms7299

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