Creating light sources for nanochips

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(PhysOrg.com) -- "One of the most important goals in the optics community is to create and manipulate light on chip," Yinan Zhang tells *PhysOrg.com*. "This is especially important when it comes to improving the performance of semiconductor lasers with increasingly small device size. This device improvement, owing to recent developments in nanotechnology, will enable a high integration capacity of photonic devices in the future. This could take place in a fashion similar to what has happened to the semiconductor electronic industry."

Zhang is part of a group of scientists at Harvard University and the Georgia Institute of Technology working to develop high-quality nanometer-scale lasers. Their work is described in *Applied Physics Letters:* “Photonic crystal nanobeam lasers.”

“There are a couple of properties that we are interested in when it comes to creating an on-chip light source,” Zhang explains. “One feature is the threshold power, which represents the amount of energy needed to turn the laser on.” A low threshold is desirable, since it means that there is less power needed. “We want a light source that is energy friendly as well as being cheap to make.” Zhang and his colleagues have demonstrated a very low-threshold power on the order of the microwatt. (Conventional laser diodes have a threshold on the order of the milliwatt.)

Another property that is important to photonic devices is the modulation speed. The modulation speed represents the amount of information that can be carried by the laser. “Our nanobeam laser design has the potential to achieve very high modulation speed in addition to the low threshold," Zhang says. "We haven't demonstrated this high modulation yet, but it is our next step."

The nanobeam laser designed by the scientists at Harvard and GIT is fabricated with conventional nanofabrication technologies. "The team members in Georgia grew the quantum wells that have the electronic properties that allow the photon generation," Zhang explains. Once the chip arrived at Harvard, Zhang and his colleagues used electron-beam lithography and inductively-coupled plasma reactive ion etching to create a pattern on the structure. Then, the entire structure was suspended with the use of chemical acid. "The final structure is a 500 nm wide beam with an array of perforated holes on it, suspended like bridges. This geometry gives excellent properties of the optical nano-cavities," Zhang says. "After the fabrication, we characterize our devices on the optical set up."

There are a number of possible applications for a device like this. Interest in nanophotonics is growing, and the need for ultra-small light sources is increasing. "This could provide a cheap, on-chip light source for photonic integrated circuits," Zhang points out. "This is the sort of application that would benefit from a lower threshold and higher modulation."

Other applications include the possibility of use for sensors, says Zhang: "These devices would provide an intriguing platform for chemical or bio-sensing with extremely good spatial resolution, attributed to its small device size. Many of these applications are still demonstrated in scientific labs, and are probably not further away from commercialization, though."

More information: Y. Zhang, M. Khan, Y. Huang, J. Ryou, P. Deotare, R. Dupuis, and M. Loncar, "Photonic crystal nanobeam lasers,"

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