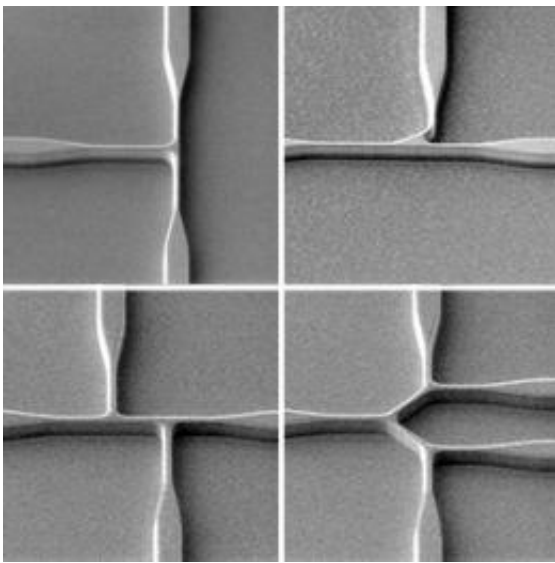


Waveguides that combine metallic and semiconductor structures can be made more compact

July 4 2012



A variety of nanoplasmic waveguides of complex shapes. Reproduced with permission, © 2012 Optical Society of America

(Phys.org) -- Increasing the areal density at which electronic components can be integrated onto a computer chip has always been key to the revolution of technological applications. However, achieving the same feat in the world of optics has been proven difficult as light waves cannot be compressed to sizes below their wavelength by conventional semiconductor-based optical waveguides.

[Metallic structures](#), in theory, are able to provide such functionality through so-called plasmonic effects. In practice, however, the large optical losses have hampered the implementation of such schemes. Combining the benefits of conventional optics with plasmonics, Shiyang Zhu and co-workers at the A*STAR Institute of Microelectronics have now demonstrated how structures made of semiconductor and metals represent a more viable approach to effectively miniaturize [optical circuits](#).

Plasmonic effects are based on motions of electrons at the surface of metals that act like an antenna on incoming light. They can be very effective to squeeze light into small volumes, although transport losses when guiding light along such small volumes are much higher than for conventional semiconductor waveguides.

Zhu and colleagues observed waveguides based on semiconductor silicon. First, ridges are etched out of [silicon chip](#) to form the basis for the waveguide architecture. The surface of the silicon is then oxidized to provide electrical insulation of the silicon before it is covered in a thin copper layer (see image).

This architecture has the benefit of very efficiently squeezing light into the waveguide via the surrounding copper layer, but travels mostly along the core made of silicon and not the metal. Silicon is transparent for light at telecommunications frequencies and thus shows low losses. "These waveguide structures are not only compatible with the fabrication processes of silicon [computer chips](#)," says Zhu. "More importantly, the use of silicon and silicon oxide and related semiconductors enables further possibilities to potentially achieve other effects, such as light amplification, and control over the plasmon properties."

Having previously shown that such waveguides are able to guide light efficiently, the researchers have now demonstrated a number of complex

photonic structures, including the splitting of light beams at multiple junctions, the propagation of light across multiple kinks and steps, resonator structures that show light interference effects and many more.

“This is only a first step towards the varied and complex effects possible with these structures,” says Zhu. “The next step is to demonstrate some of the active functionality, especially to combine waveguides with ultracompact plasmonic light modulators based on related designs for complete functional nanoplasmonic circuits.”

More information: Zhu, S., Lo, G. Q. & Kwong, D. L. Components for silicon plasmonic nanocircuits based on horizontal Cu-SiO₂-Si-SiO₂-Cu nanoplasmonic waveguides. *Optics Express* 20, 5867–5881 (2012). [dx.doi.org/10.1364/OE.20.005867](https://doi.org/10.1364/OE.20.005867)

Provided by Agency for Science, Technology and Research (A*STAR), Singapore

Citation: Waveguides that combine metallic and semiconductor structures can be made more compact (2012, July 4) retrieved 9 April 2024 from <https://phys.org/news/2012-07-waveguides-combine-metallic-semiconductor-compact.html>

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