Novel material shows its credentials to facilitate integration of photonic, electronic components in practical device

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Many devices used in everyday life—whether they be televisions, mobile phones or barcode scanners—are based on the manipulation of electric currents and light. At the micro- and nano-scales, however, it is typically challenging to integrate electronic components with photonic components. At these small dimensions, the wavelengths of light become long relative to the size of the device. Consequently, the light waves are barely detectable by the device, just as passing waves simply roll past thin poles in a water body.

Better integration of photonic and electronic components in nanoscale devices may now become possible, thanks to work by Khuong Phuong Ong and Hong-Son Chu from the A*STAR Institute of High Performance Computing and their co-workers in Singapore and the US. From computer simulations, they have identified that the compound BiFeO3 has the potential to be used to efficiently couple light to electrical charges through light-induced electron oscillations known as plasmons. The researchers propose that this coupling could be activated, controlled and switched off, on demand, by applying an electrical field to an active plasmonic device based on this material. If such a device were realized on a very small footprint it would give scientists a versatile tool for connecting components that manipulate light or electric currents.

"The fact that, in theory, the properties of BiFeO3 [could] be [so readily controlled] by applying an electric field makes it a promising material for high-performance plasmonic devices," explains Ong. He says that they expected such favorable properties after they had calculated the behavior of the material. But when they studied the behavior of the proposed BiFeO3-based device, they found that it could outperform devices based on BaTiO3, which is one of the best materials currently used for such applications.

Like BaTiO3, BiFeO3 can be fabricated relatively easily and cheaply. The new material is therefore a particularly promising candidate for device applications. Ong, Chu and their collaborators will now explore that potential. "We will design BiFeO3 nanostructures optimized for applications such as optical devices for data communication, sensing and solar-energy conversion," says Ong.

According to Ong and Chu, an important step on the path to producing practical devices will be assessing the compatibility of BiFeO3-based structures with standard technologies, which typically use materials known as metal-oxide semiconductors. This future work will involve collaborations with experimental groups at the A*STAR Institute of Materials Research and Engineering and at the National University of Singapore.

More information: Chu. S. et al. High optical performance and practicality of active plasmonic devices based on rhombohedral BiFeO3. *Laser & Photonics Reviews* 6, 684–689 (2012). onlinelibrary.wiley.com/doi/10 … r.201280022/abstract

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