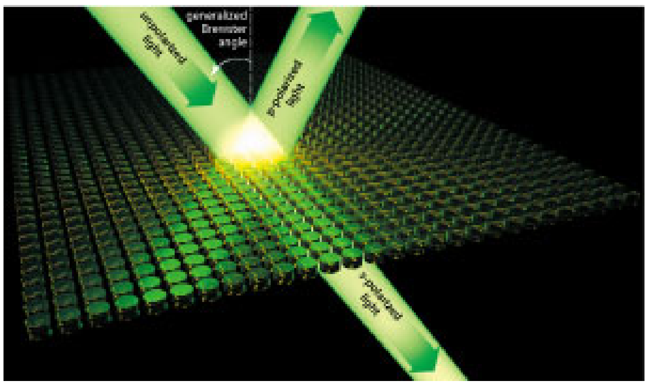
Technique enables newfound control of light polarization at any angle

July 27 2016



A periodic array of nanodisks in a silicon surface can generate two kinds of polarized light from any angle. Credit: A*STAR Data Storage Institute

Polarizing filters produce richer, less reflective images by limiting vibrating light waves to one specific orientation. However, these filters only work with light that is reflected from a certain angle. An A*STAR-led team now report that arrays of silicon nanodisks can polarize light at any angle, and into any desired orientation—a finding that opens the way to improved photonic control over ultra-thin optical devices.

When polarized light passes through air into an insulating dielectric crystal, it is partly reflected at the interface. But at one particular angle, known as Brewster's angle, incoming light travels through the dielectric with no reflection at all. Studies have shown that this trick arises when electric dipoles, induced by light in the dielectric, align with the reflection direction to inhibit optical reflection. However, this only happens naturally for a particular polarization of light.

Ramón Paniagua-Domínguez from the A*STAR Data Storage Institute and co-workers investigated ways to expand the Brewster effect beyond the restrictions of specific light polarizations and angles. To do so, they turned to metasurfaces—devices that use micro- and nanoscale surface patterns to manipulate electromagnetic radiation in ways not seen in nature.

The team realized that if magnetic dipoles could be excited at the same time as the electric dipoles, the subsequent interference patterns would produce other directions and polarizations where Brewster's effect would occur. Because natural materials have very weak magnetic dipoles at optical frequencies, Paniagua-Domínguez developed a theoretical model to engineer this kind of response from a metamaterial.

"Silicon has one of the largest refractive indices at optical frequencies, together with very low losses," he notes. "And when you shape it into nanospheres, with sizes smaller than the excitation wavelength, a high-quality magnetic-dipole response presents itself."

The researchers fabricated an array of protruding disks, a few hundred nanometers in scale, onto a silicon surface. Reflection tests with several different wavelengths and angles revealed results strikingly different from conventional runs—light polarized both parallel and perpendicular to the interface produced zero-reflection points, while Brewster angles could be controlled by selecting appropriate light wavelengths. Paniagua-Domínguez then developed a dipole-based model to understand the observed phenomenon.

"The generalized Brewster's effect may add numerous new functionalities to those already achieved with metasurfaces," says

Paniagua-Domínguez. "In particular, one could foresee devices that will perform particular operations, such as light-beam shaping, which will be controllable by the angle of incidence and polarization state of the incoming light."

More information: Ramón Paniagua-Domínguez et al. Generalized Brewster effect in dielectric metasurfaces, *Nature Communications* (2016). DOI: 10.1038/ncomms10362

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