Engineered structures that can alter the speed of light could benefit optical communication systems

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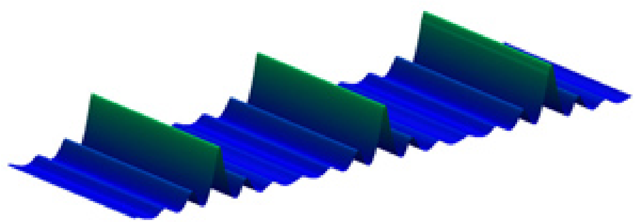

Combining photonic crystals can slow the propagation of light for applications in optical communications. Credit: A*STAR Institute of High Performance Computing

A method for designing materials capable of slowing the propagation of light over a broad range of wavelengths has been developed by researchers at the A*STAR Institute of High Performance Computing.

The speed of light in a vacuum is always constant—a fundamental concept made famous by Albert Einstein. But light propagates more slowly when it enters a different medium, such as glass. The degree to which the speed is reduced is given by a material's dielectric constant—a higher dielectric constant indicates slower propagation. Rather than rely on a limited source of natural substances, scientists have started to design optical materials with a broader range of beneficial properties including 'slow' light.

One approach is to combine two materials with different dielectric constants into a periodic structure. This can result in properties that dramatically differ from those of the constituent materials, particular when the length scale of the periodicity is similar to the wavelength of light. "These so-called photonic crystals, when appropriately designed and in ideal conditions, can almost stop the propagation of light altogether," says A*STAR scientist Gandhi Alagappan.

The requirement that the periodicity of the structure be similar to the wavelength of interest, however, is a limitation for practical applications. It means that most of these materials only work with light of a single color. Alagappan and his co-worker Jason Ching Png have now developed a scheme for designing photonic crystals that operate over a broader range of wavelengths.

Alagappan and Png considered a structure in which two different materials are layered on top of each other. To obtain two different periodicities, however, a third material with a dielectric constant midway between the two other materials would typically be needed. This makes physically creating the structure difficult. The researchers instead focused on developing a mathematical technique to combine two materials in such a way that the dielectric profile in the stacking direction is almost the same as in the more complicated three-material structure (see image).

Alagappan and Png simulated the optical properties of their combined photonic crystal. They identified a broad range of wavelengths known as the strong coupling region that has a high density of slow modes.

"We have invented a linear optical multi-scale architecture that facilitates the creation of broadband slow light," says Alagappan. "The proposed structure could potentially revolutionize current optical buffering technologies."

More information: "Broadband slow light in one-dimensional logically combined photonic crystals." *Nanoscale* 7, 1333–1338 (2015). dx.doi.org/10.1039/c4nr05810k

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