Less is More: Extreme Optics with Zero Refractive Index

Nanotechnology has enabled the development of nanostructured composite materials (metamaterials) with exotic optical properties not found in nature. In the most extreme case, we can create materials which support propagating light waves that have infinite phase velocity, corresponding to a refractive index of zero. This zero index can only be achieved by simultaneously controlling the electric and magnetic resonances of the nanostructure. We present an in-plane metamaterial design consisting of silicon pillar arrays, embedded within a polymer matrix and sandwiched between gold layers. Using an integrated nano-scale prism constructed of the proposed material, we demonstrate unambiguously a refractive index of zero in the optical regime. This design serves as a novel on-chip platform to explore the exotic physics of zero-index metamaterials, with applications to super-coupling, integrated quantum optics, and phase matching.