Tailoring Nitrides and Oxides for Epsilon-Near-Zero and Dynamic Nanophotonics

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We report on various methods to actively tune and passively tailor the optical properties of emerging nanophotonic materials, namely, transparent conducting oxides (TCOs) and transition metal nitrides, for dynamic nanophotonic applications such as all-optical switches, modulators, photonic time crystals and beyond. We demonstrate great tailorability in the epsilon-near-zero (ENZ) response of TCOs such as aluminum-doped zinc oxide (AZO) and polycrystalline cadmium oxide via yttrium doping. We also investigate the strong thickness dependence of the optical properties of both TCOs and polycrystalline titanium nitride (TiN). Employing the Berreman modes of TiN and AZO films on the same platform, we demonstrate variable switching speeds of an optically-pumped metasurface. Building upon our work with the transient optical properties of optically doped zinc oxide, we demonstrate phase and polarization shifters made with ZnO. To explore possible experimental realization of photonic time crystals, we investigate the fastest material response to an optical pump in aluminum-doped zinc oxide, showing sub-10 femtosecond rise time. Our approach paves the way to novel device design and the study of novel optical phenomena with ultrafast tunable and tailorable materials.

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