SPIE Student Seminar Series

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(Purdue University)

Tuning And Tailoring the Permittivities of Transparent Conducting Oxides for Dynamic Nanophotonic Application

Tuesday, Oct. 6, 2020

11:00 am ~ 12:00 pm (CDT)

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Abstract: The permittivity of a material encapsulates the physics of how light interacts with it. Thus, controlling the permittivity of materials enables control over the amplitude, phase, and polarization of light acting with them. Transparent conducting oxides are a special class of materials which can be tailored to be dielectric, epsilon-near-zero, or metallic, at a specific wavelength. This is done by controlling the free carrier density in the materials either by doping with metals, or by photoexciting electrons via an optical pump. The large free-carrier-induced permittivity changes in transparent conducting oxides enable all-optical switching at femtosecond to picosecond timescales in planar, unpatterned films, without the need for lithography. In this talk, I will elaborate on the wide-tailoring and tuning of the permittivities of three oxides to achieve fast optical switching with large modulation depth. I will talk about how we tailored the epsilon-near-zero points of cadmium oxide from 11 to 5 microns by doping with yttrium. Then I'll elaborate on our work with zinc oxide, where we showed that undoped zinc oxide films can be optically pumped to show extraordinarily large permittivity modulation. We demonstrated Berreman-type metasurfaces to showcase optical switching at powers on the order of 1 mJ/cm^2. The switching speeds can vary from 50 ps in cadmium oxide, 20 ps in ZnO to 2 ps in aluminum-doped zinc oxides. Understanding the dynamics of permittivity modulation in robust, industry-relevant oxides will form the foundations to tunable spatial light modulators spanning the telecom to the mid-infrared wavelength regimes.

Bio: Soham Saha is a doctoral candidate in the School of Electrical and Computer Engineering at Purdue University. His research focuses on the development of optical materials for active nanophotonics, nonlinear optics, all-optical switching, low-loss waveguides, and modulators employing materials, including silicon, lithium niobate, transition-metal nitrides, transparent conducting oxides, and traditional noble metals. His awards include the Society of Vacuum Coaters Scholarship and the SPIE (the International Society for Optics and Photonics) Education Scholarship. Saha can be reached by email at saha11@purdue.edu.

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