From Unconventional to Extreme to Functional Materials

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Materials can control, tailor, mold, and sculpt photons. With recent developments in the field of materials science and engineering, particularly at the nano- and microscale, we are now equipped with capabilities to design and construct materials and structures that can provide unconventional "extreme" functionalities. With such "extreme" metastructures, we can explore unusual light-matter interaction. The cases that may relate to such extreme scenarios include extreme material parameters, such as epsilon-near-zero (ENZ), mu-near-zero (MNZ) and epsilon-and-mu-near-zero (EMNZ) structures in which the effective refractive index may be near zero, leading to unique optical features in wave physics and quantum optics and engineering, extreme dimensional platforms such as ultrathin metasurfaces, graphene and other two-dimensional materials for one-atom-thick optical devices and components, optical metatronics in which "materials become optical nanocircuit elements" for unprecedented optical processing at the nanoscale, and "informatic" metamaterials in which one can perform mathematical operations using light propagation in matter, to name a few. Such extreme photonic materials exhibit exciting functionalities for various applications. In this talk, I will present some of our ongoing work in these areas, will discuss some of the challenges and opportunities, and will forecast some future directions and possibilities.