Terahertz and Midinfrared Dynamics of Aligned Carbon Nanotubes

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Single-wall carbon nanotubes (SWCNTs) provide a unique one-dimensional (1D) environment in which the interplay between multivalley Dirac band structure and strong Coulomb interactions lead to a variety of novel electromagnetic phenomena [1]. Although the 1D nature of individual SWCNTs has stimulated much interest, its macroscopic manifestation has been difficult to observe. We have recently developed a controlled vacuum filtration technique to fabricate wafer-scale films of highly aligned and densely packed SWCNTs [2,3]. In this talk, we describe our recent studies using these unique SWCNT films in exploring their extremely anisotropic terahertz (THz) and midinfrared (MIR) response. We have made the first observation of intersubband plasmons – quantum plasmons whose excitation energy is comparable to the quantum confinement energy – in gated and aligned SWCNT films [4]. We have also demonstrated that these films are hyperbolic materials in the THz and MIR, making them a promising material platform for thermal emitters [5]. Aligned SWCNTs are thermally stable up to 1600 °C and exhibit extreme anisotropy: metallic in one direction and insulating in the other two directions. Such extreme anisotropy resulted in an exceptionally large photonic density of states in the MIR, manifesting as strong resonances in deeply subwavelength-sized cavities.

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