Laser terahertz emission nanoscopy

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Laser terahertz emission spectroscopy has become a standard tool in the nonlinear optics toolbox. In this process, excitation of a sample by a femtosecond optical pulse produces a picosecond burst of terahertz radiation as a signature of ultrafast charge carrier dynamics. This versatile optical technique can provide valuable information about the initial phases of carrier motion immediately following photoexcitation, and has been applied to many different material systems, including both bulk and surface dynamics in semiconductors, as well as new materials such as graphene and strongly correlated materials such as high-Tc oxides and topological insulators. These studies have all been limited in their spatial resolution by the diffraction-limited focusing of the input optical beam. In this talk, we discuss the adaptation of this emission spectroscopy technique to the nanoscale. Inspired by recent results in scattering-type near-field terahertz imaging and spectroscopy, we have constructed a new microscope for performing terahertz emission spectroscopy with nanometer spatial resolution. We demonstrate that the nonlinear process giving rise to terahertz emission is confined to a tip-size limited spatial region, on the order of 20 nm. This development offers the exciting new possibility of performing emission spectroscopy on individual nanoparticles.