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Chemical Imaging and Lasing of Nanoparticle Systems

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Scanned probe microscopy techniques are developed to investigate nanoscale materials and time-domain processes in nanostructured devices. These include apertureless near field microscopy probing of islanded semiconductor films, confocal microscopy ultrafast pump-probe experiments to interrogate stimulated emission processes in ZnO tetrapod species, and single pulse CARS microscopy using phase-shaped ultra-broad-band pulses for rapid spatial and spectral analysis of soft condensed matter. Apertureless near field microscopy studies of InN islands have revealed contrast mechanisms due to the real and imaginary parts of the index of refraction, providing measurements of nanometer size Ga metal islands and InGaN and InN islands on GaN. Pickup of gold nanoparticles permits tip enhancements with resolution of the electric field phase in the images. Ultrafast laser, differential gain experiments on ZnO stimulated emission in nanowires and tetrapods are performed to measure the timescales and ratios of the electron-hole plasma and exciton mechanisms during lasing in nanostructured materials. Two novel types of measurements are addressed, stimulated emission dumping and upconversion probing methods. A single pulse CARS microscopy instrument using an ultrafast laser and phase control with interferometric detection produces complete Raman spectra while spatially scanning. Polymer domains have been analyzed with vibrational spectral sensitivity. The merger of optical techniques with scanned probe methods to investigate nanoscale features is considered in relation to the scientific requirements for measurements and the results for each system.