Infrared spectroscopy and nanoscale imaging of the metal-insulator phase transition in vanadium dioxide

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A grand challenge of contemporary condensed matter physics is to understand how perturbations like chemical doping, strain, and temperature induce anomalous conducting phases in ordered, correlated materials. I will report on the optical properties of a prototypical correlated insulator vanadium dioxide (VO_2) in which the metallic state is induced by increasing temperature. The pioneering technique of scanning near-field infrared microscopy allows us to directly image nano-scale metallic puddles that appear at the onset of the metal-insulator transition (MIT) in a VO_2 thin film. In combination with far-field infrared spectroscopy, the data reveal enhanced optical mass in the metallic puddles. I will also present x-ray nano-imaging data on the structural phase transition (SPT) that accompanies the MIT in VO_2. Both the SPT and MIT proceed via percolation in the VO_2 film. In addition, nanoscale x-ray diffraction reveals local, non-monotonic switching of the lattice structure, a phenomenon that is not seen in the electronic MIT mapped by near-field infrared microscopy.