中央大學物理學系

Department of Physics, National Central University

Probing Chemistry at the Angstrom-Scale via Scanning Tunneling Microscopy Combined Tip-Enhanced Raman Spectroscopy

Prof. Nan Jiang

Department of Chemistry & Department of Physics,
University of Illinois Chicago

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Venue: S4-623
Time: 11:00-12:00

Abstract:
My research group is interested in investigating how local environments affect single-molecule and nanostructure properties on surfaces with Ångström scale resolution. This talk will start with Tip-Enhanced Raman Spectroscopy (TERS), which affords the spatial resolution of traditional Scanning Tunneling Microscopy (STM) while collecting the chemical information provided by Raman spectroscopy. By using a plasmonically-active material for our scanning probe, the Raman signal at the tip-sample junction is incredibly enhanced, allowing for single-molecule probing. This method, further aided by the benefits of ultrahigh vacuum, is uniquely capable of controlling localized plasmons via an atomistic approach. We are able to obtain (1) single-molecule chemical identification;1 (2) quantum characterization of adsorbate-substrate interactions at the single chemical bond level;2, 3 (3) atomic-scale insights into the oxygen reactivity of 2D materials;4, 5 (4) local strain effects in an organic/2D materials heterostructure.6 By investigating single molecules, superstructures, 2D materials lattices, and the adsorption orientations obtained from the vibrational modes, we extract novel surface information at an unprecedented spatial (< 1 nm) and energy (< 10 wavenumber) resolution. Another application of localized surface plasmons is to achieve site-selective chemical reactions at sub-molecular scale. We recently selectively and precisely activated multiple chemically equivalent reactive sites one by one within the structure of a single molecule by scanning probe microscopy tip-controlled plasmonic resonance.7 Our method can interrogate the mechanisms of forming and breaking chemical bonds at the Ångström scale in various local environments, which is critical in designing new atom- and energy-efficient materials and molecular assemblies with tailored physical and chemical properties.