Facet-Specific Chemistry of Nanoscale Crystalline Alumina Using an Enhanced Scattering IR SNOM Instrument

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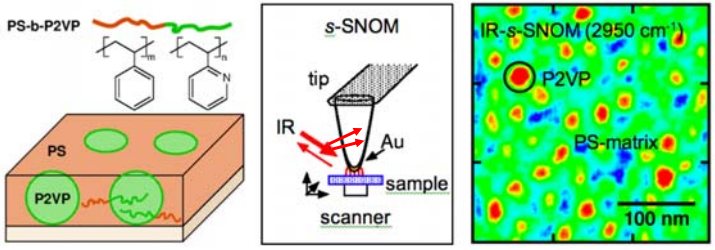
Purpose

- This project will combine Atomic Force Microscopy with Quantum Cascade Lasers to further enhance the scattering infra-red near-field optical microscope being developed.
- The work will enable the nanoscale study of interfacial processes in heterogeneous catalysis, energy and environment relevant material systems, and membrane biology.

Expected Outcomes

- A versatile imaging system enabling chemical-specific spectroscopic identification at high spatial resolution, promoting many research areas aligning with DOE's missions.
- This instrument will be used to examine the distribution of Brønsted acid sites (OH groups) and determine the *in-situ* catalytic activity of the different crystal facets of γ-Al_2O_3.

This proposal will couple Quantum Cascade Lasers with existing tip-enhanced scattering IR scanning near-field optical microscope to produce a rapid, robust, easy-to-use system that enables the nanoscale measurement of molecular signatures in the form of vibrational spectroscopy in controlled environments: •T = 20K to 500K •P = 10^{-6} T to ~2atm •Molecular-level sensitivity •Continuously tunable IR •10-nm spatial resolution

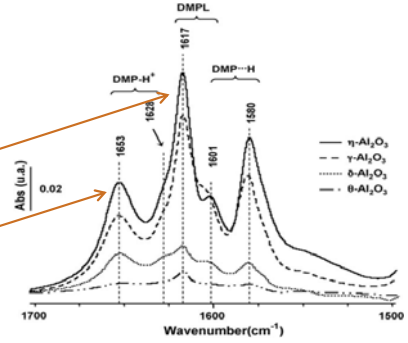


Data using existing femtosecond Ti-sapphire laser system.

Heterogeneous Catalysis

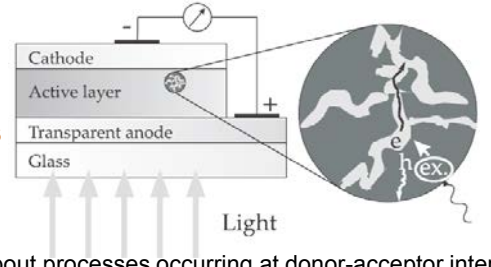
Lewis acid sites

Brønsted acid sites



- OH groups located on different crystal facets of γ-Al_2O_3 have characteristically different vibrational frequencies.
- Instrumentation would unambiguously assign the different stretching vibrational frequencies to OH groups located on the different crystal facets.
- Probe molecules enable investigation of acidities of OH groups located on the different crystal facets manifested through changes in characteristic vibrations of the probe molecules.
- Ultimate goal is to investigate the reactivities of the different crystal facets of γ-Al_2O_3 in alcohol dehydration reaction *in situ*.

Organic Photovoltaics



- Little is known about processes occurring at donor-acceptor interfaces of bulk heterojunctions in organic photovoltaics and their dependence on the interfacial property and heterogeneous materials' morphology.
- New instrumentation can simultaneously probe photonic and electronic processes occurring at interfaces as functions of the wavelength of absorbed light, and study their relation to the morphology of the material.

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The proposed system will enable research of interest to the Department of Energy such as heterogeneous catalysis, charge separation in organic photovoltaics.