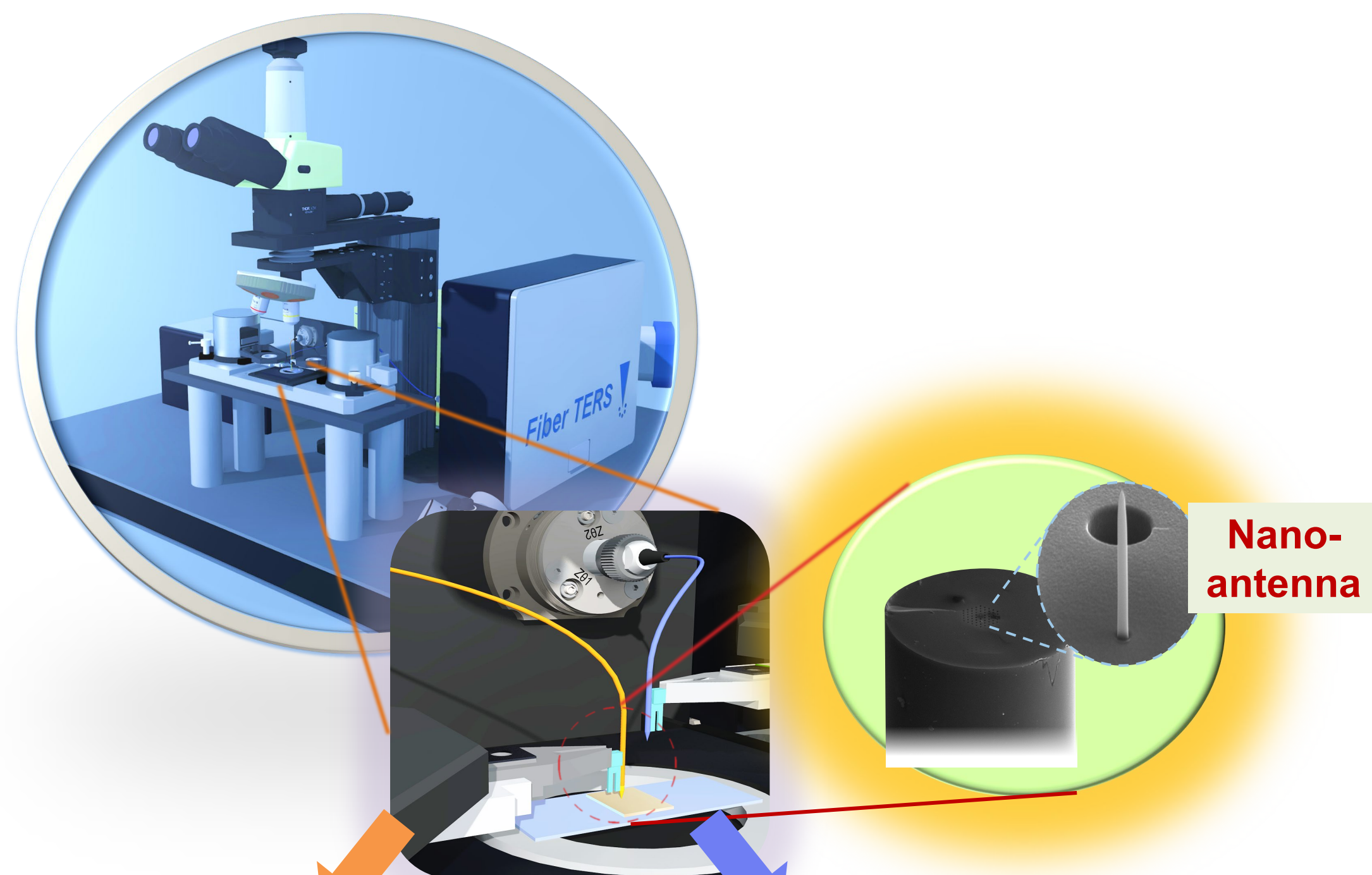
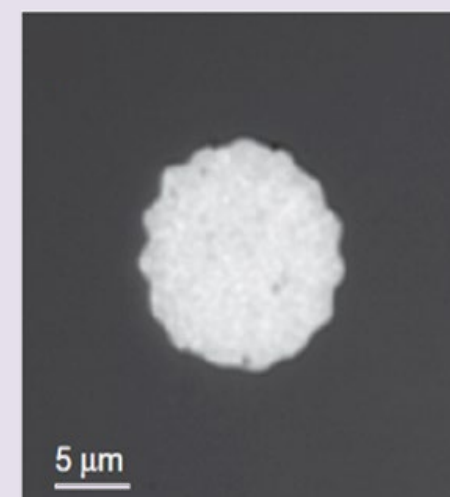


Proposed Engineering & Demonstration Prototype

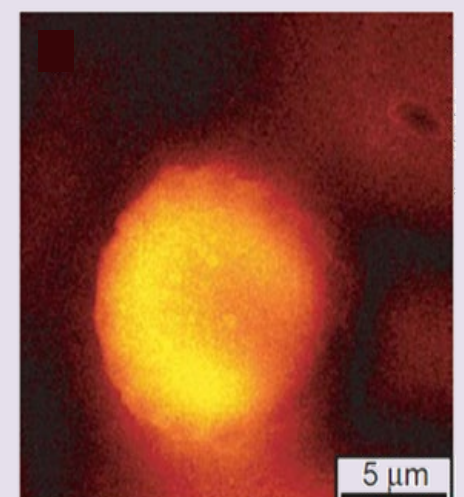


Nanoscale Thermal Imaging

Optical Image
Au Disk on SiC



Scanning Thermal
Radiation Image



Thermal Radiation Scanning Tunneling Microscopy.
Yanick de Wilde. Nature 444, 740–743 (2006)

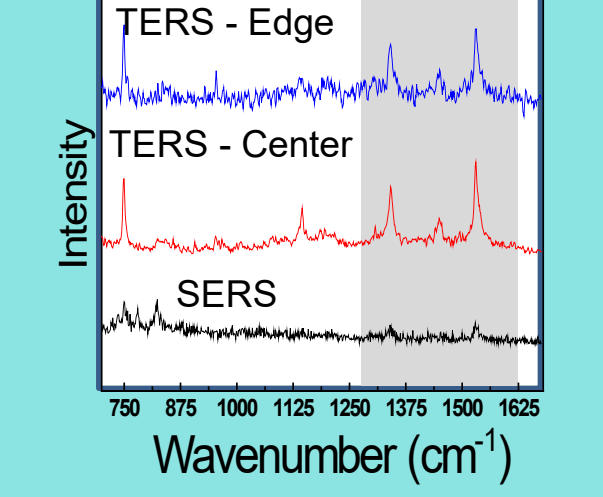
Zhang, Z.; Birmingham, B.; Minn, K.; Plasmonic Fiber Probe and Method for Nanoscale Temperature Mapping. U.S. Patent Pending. 22832092, 2019.

TERS

CuPc Island Vibrational Mode
Map



Raman Spectra of CuPc
Island



Probing Interaction between Individual Sub-monolayer Nano-islands and Bulk MoS2 using Ambient TERS. Birmingham, Zhang, et. al. J. Phys. Chem. C., 122, 2753-2760 (2018)

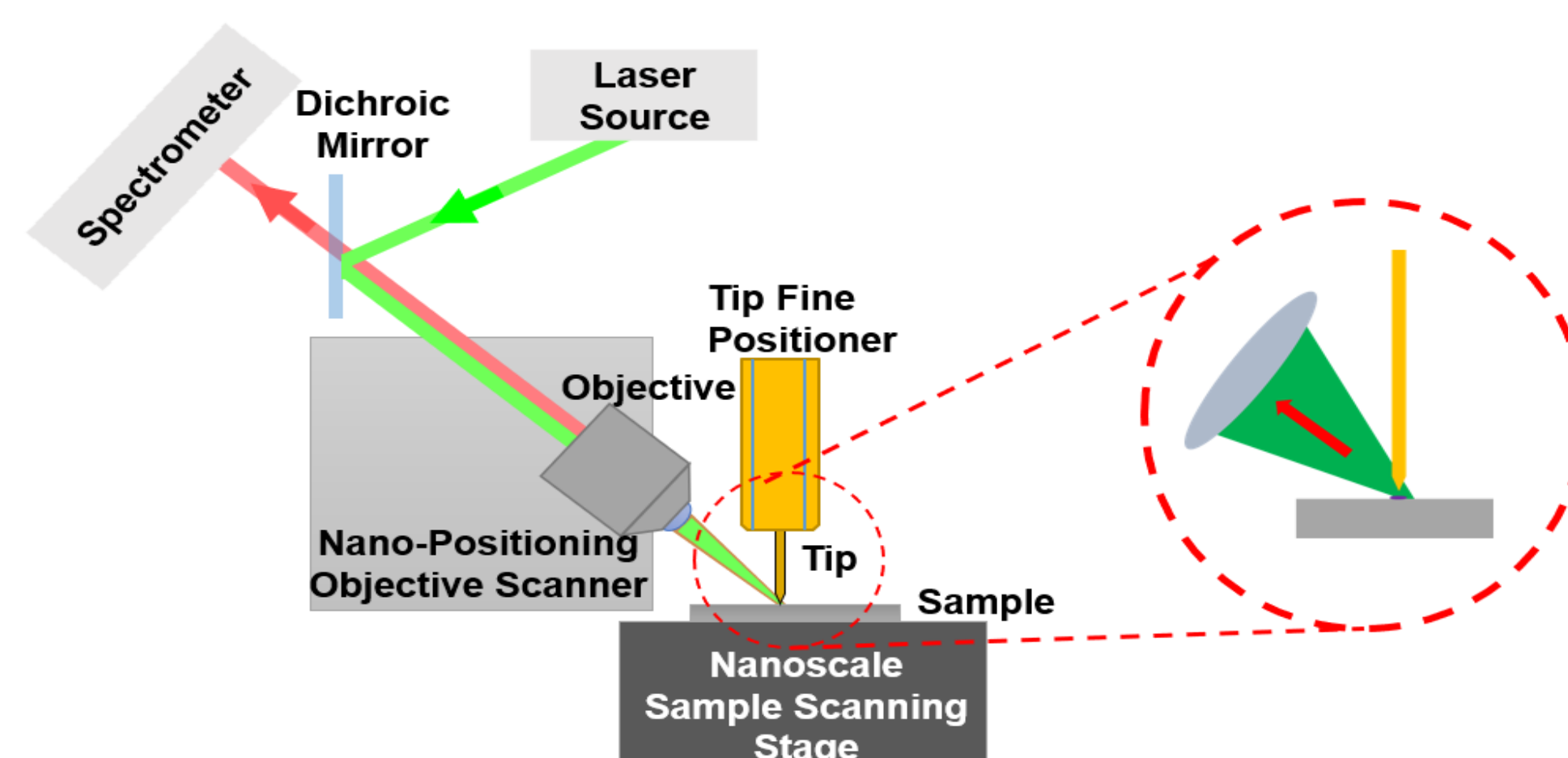
Zhang, Z.; Birmingham, B.; Lee, H.W; Fiber-Coupled Metal-Tip Near-Field Chemical Imaging Spectroscopy. U.S. 156751, 2018.

Capabilities

- ☒ Fiber Based Tip-Enhanced Raman Spectroscopy (TERS)
- ☒ Near-Field Scanning Optical Microscopy
- ☒ Conventional Tip-Enhanced Raman Spectroscopy
- ☒ Nanoscale Thermal Imaging

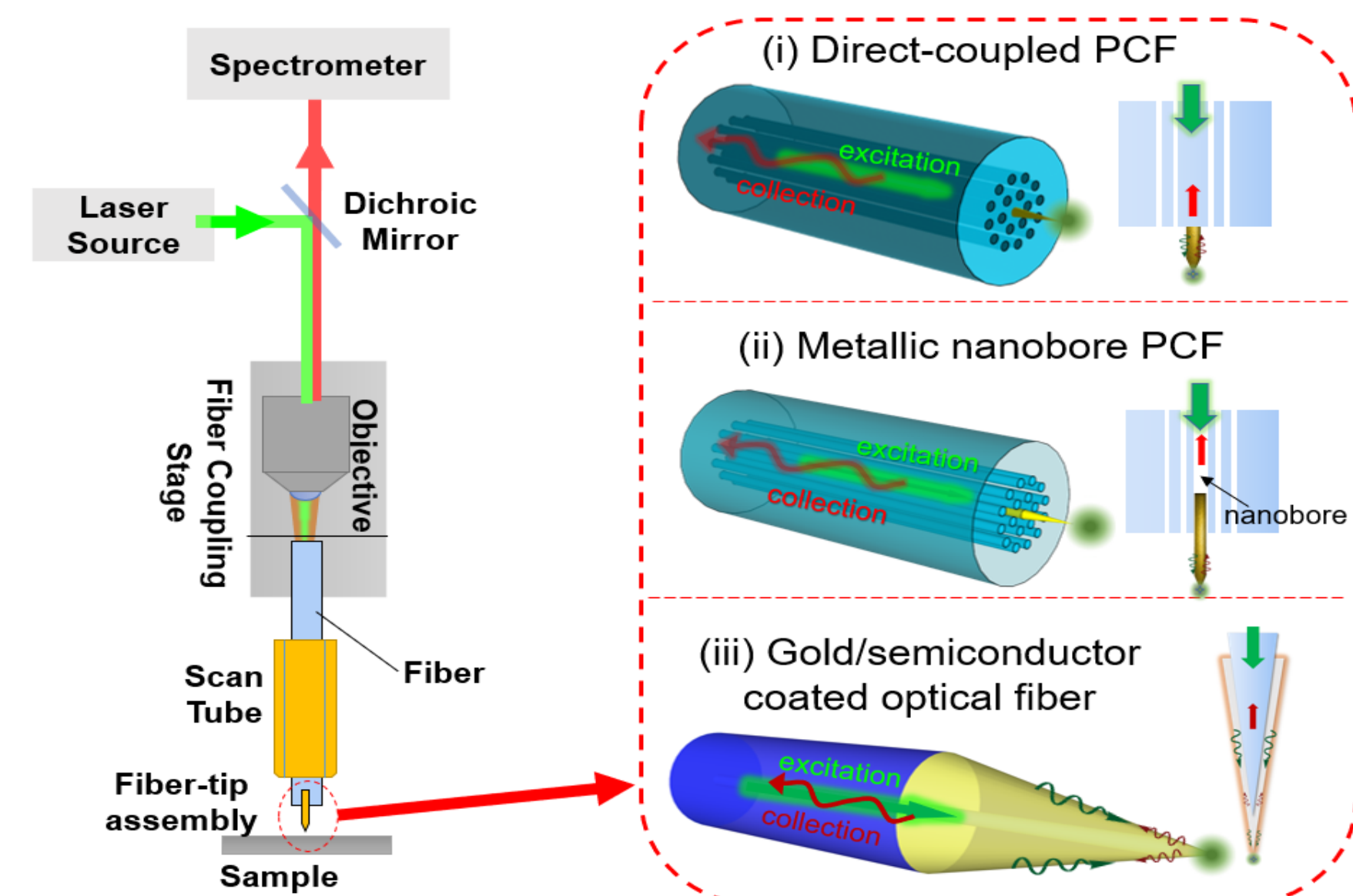
Fiber Based vs. Conventional Tip-Enhanced Sensing

Conventional TERS



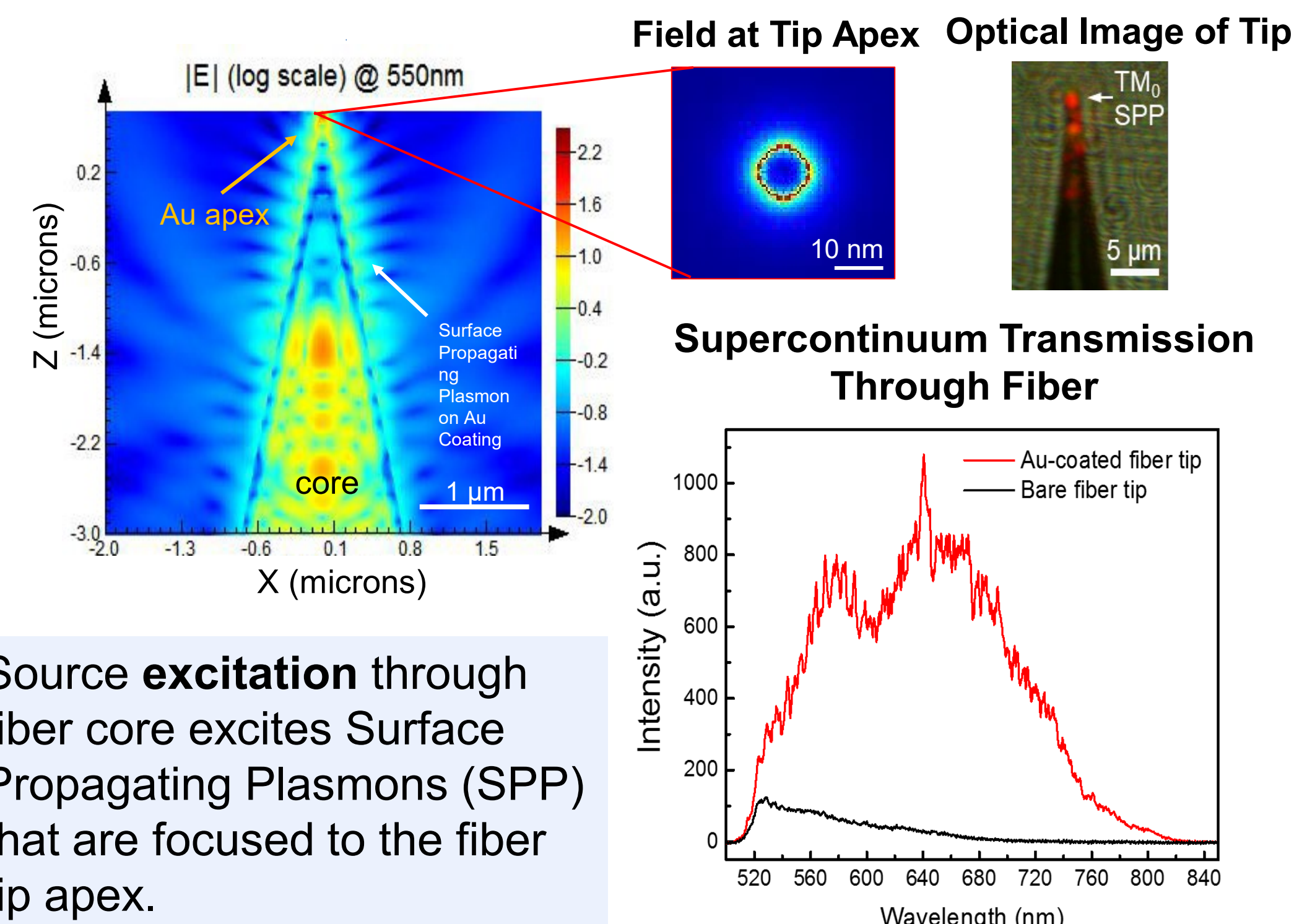
Fiber based tip **eliminates** requirement of optical alignment to tip and decreases unwanted sample excitation.

Fiber Based Chemical Probe



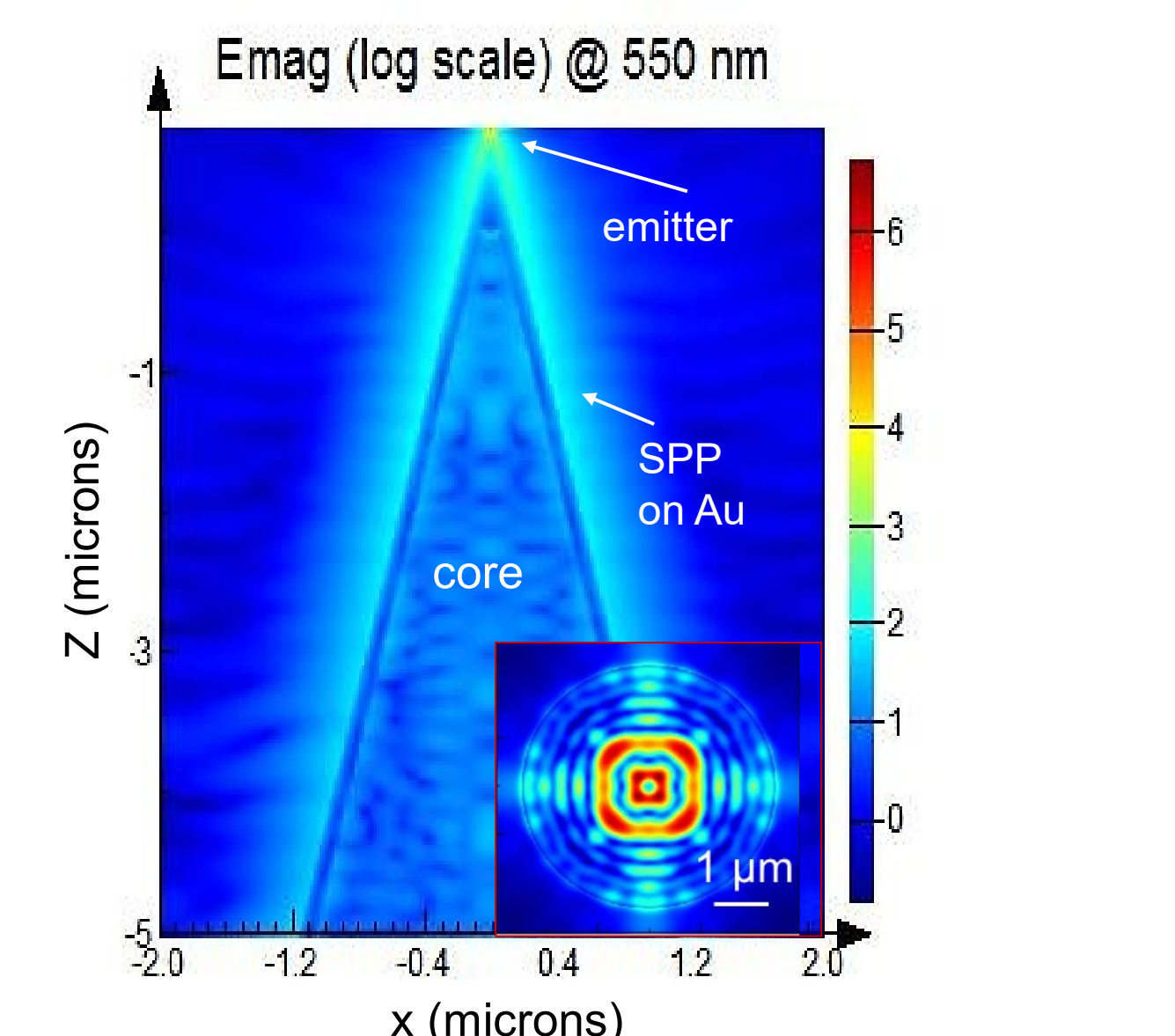
Fiber Excitation and Collection Modes

Fiber Excitation EM Simulation



Source **excitation** through fiber core excites Surface Propagating Plasmons (SPP) that are focused to the fiber tip apex.

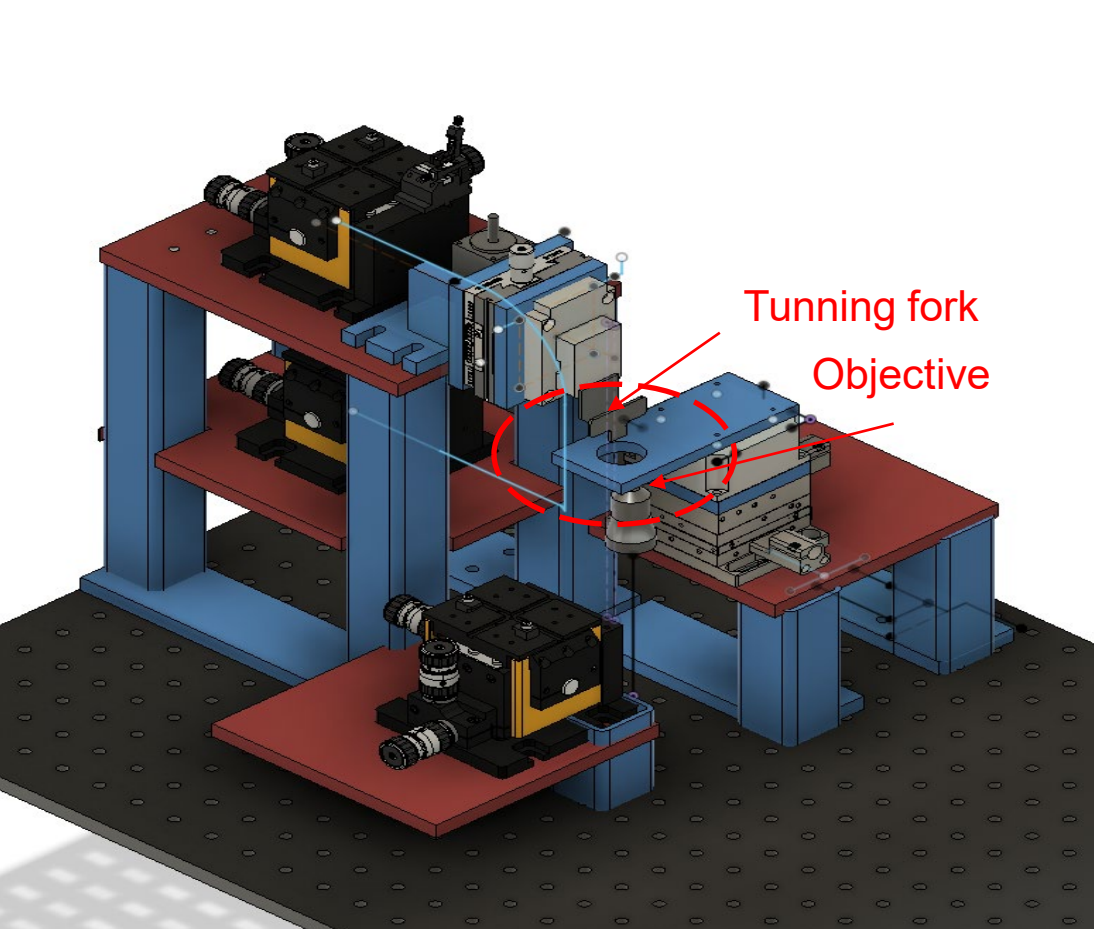
Fiber Collection EM Simulation



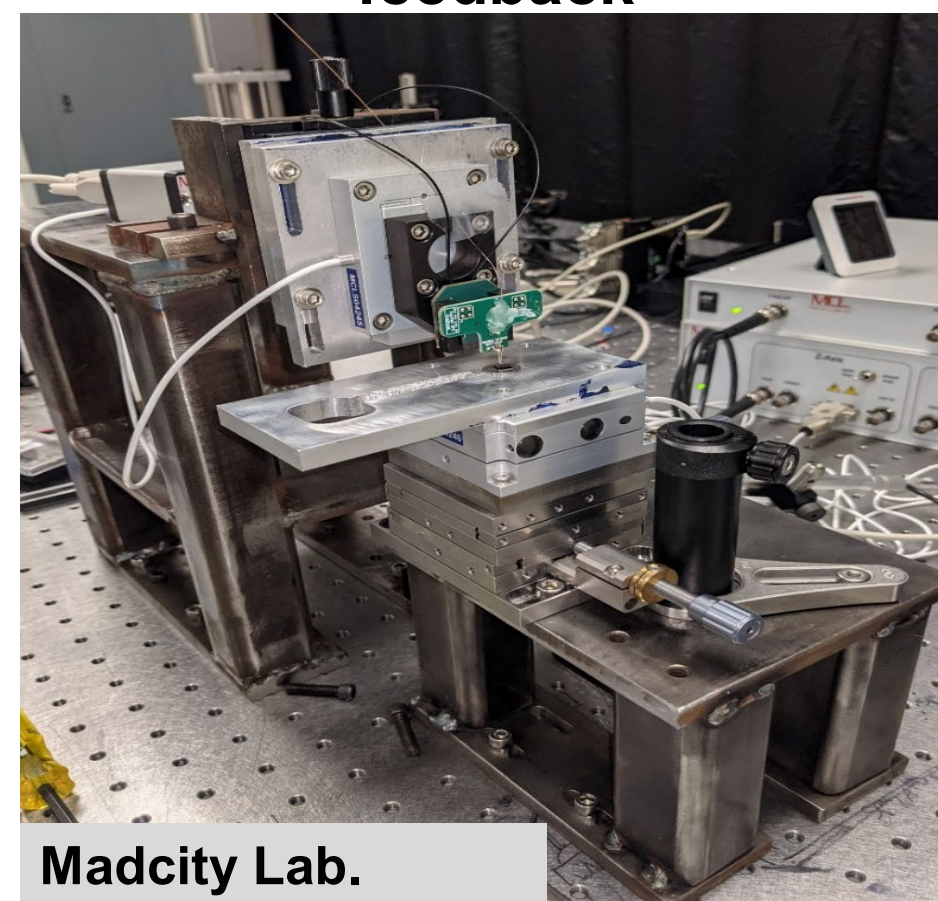
Signal **emitted** at tip apex couples to SPPs that decay into the fiber core and collected through the fiber.

Our Instrument – Fiber TERS using commercial SNOM components

Fiber AFM overview

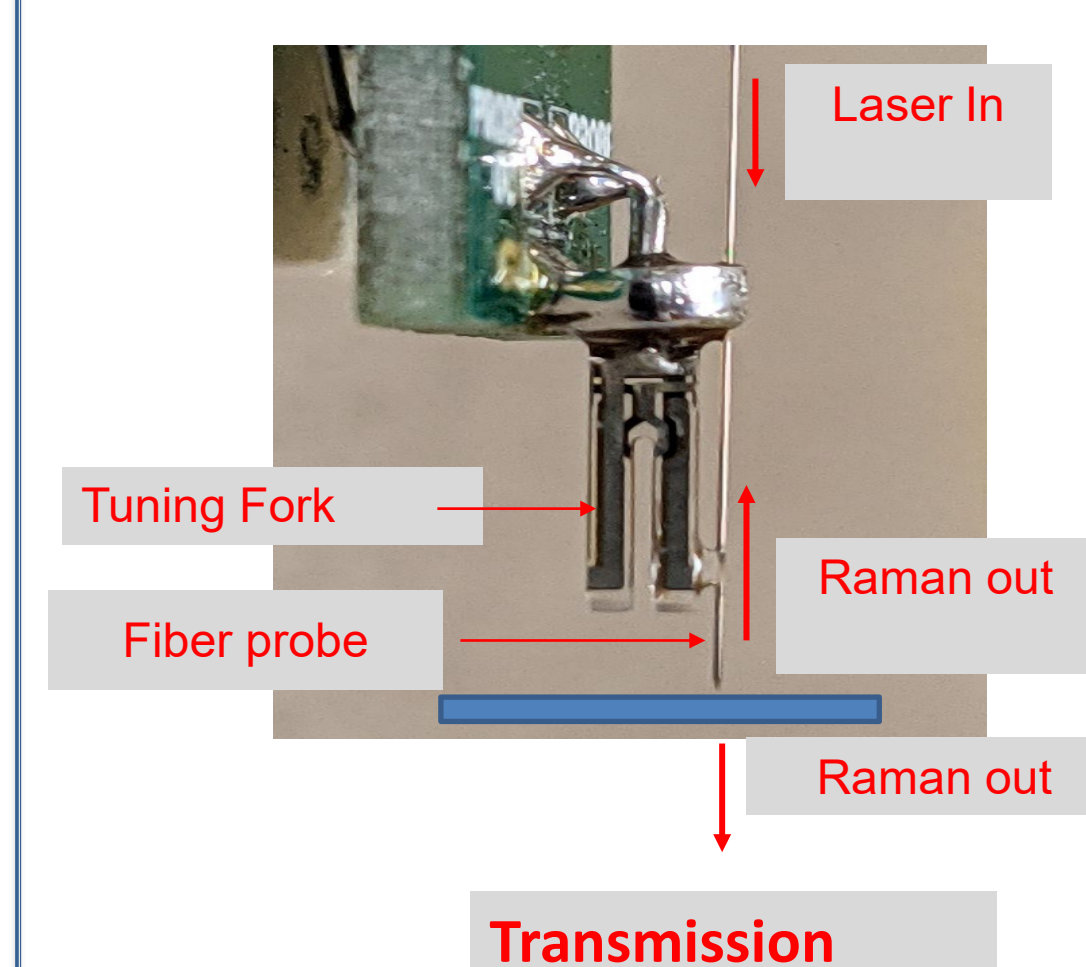


Scanning stages & tip position feedback

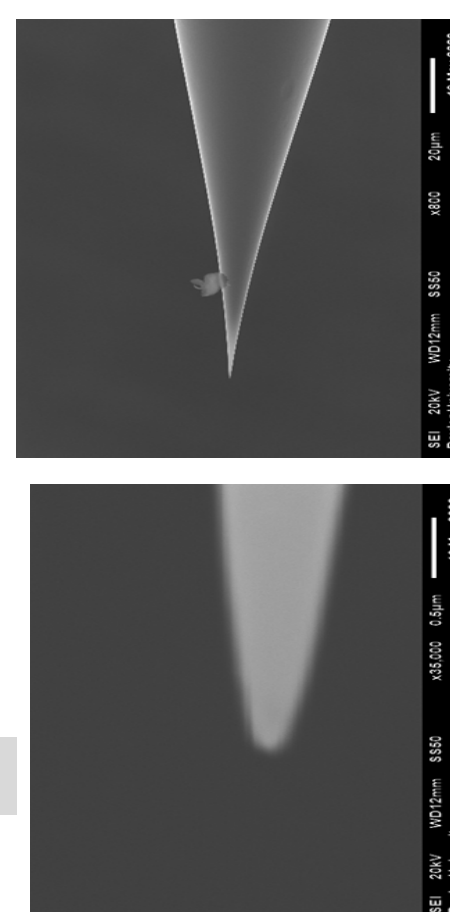


Madcity Lab.

Tuning fork force sensor



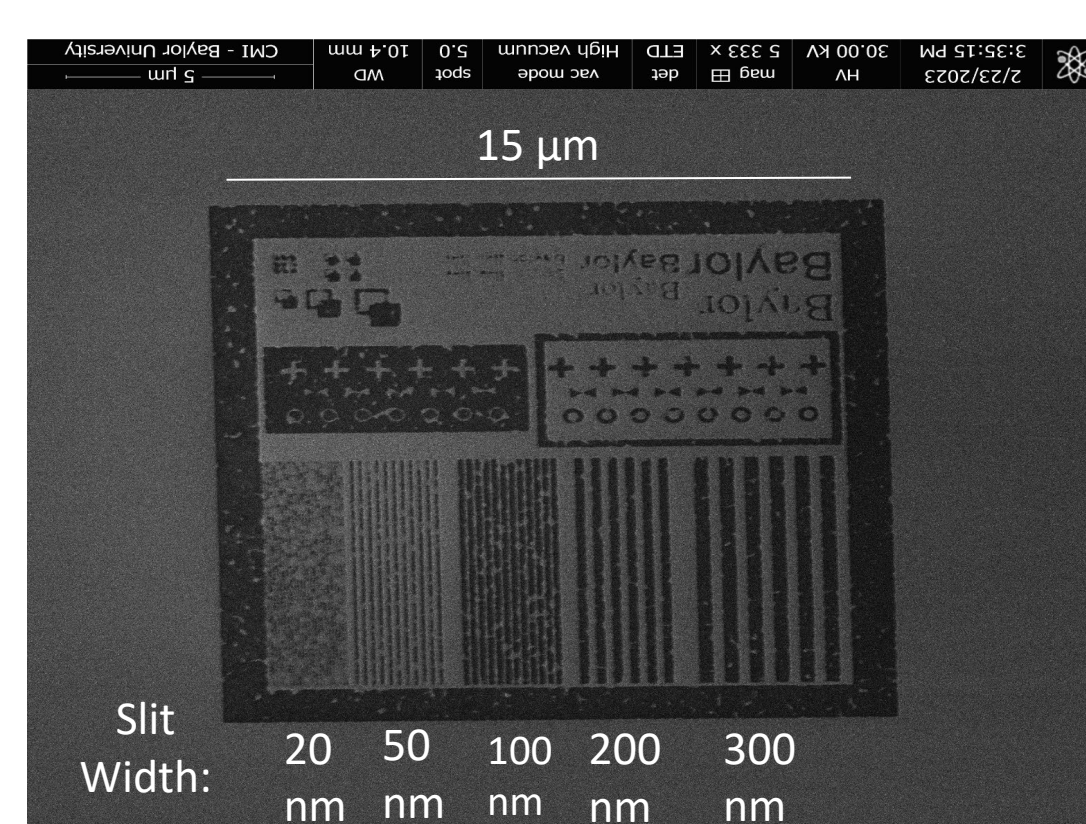
Fiber probe



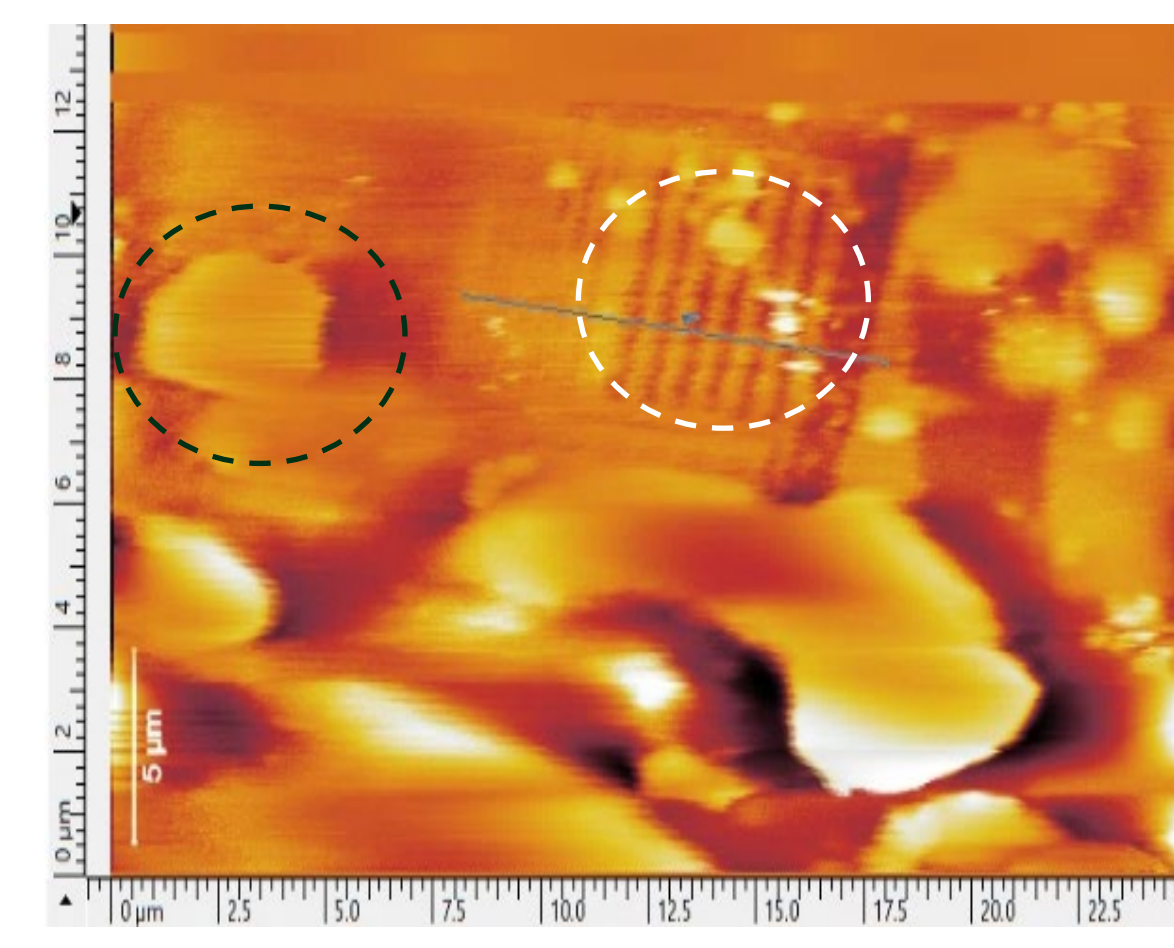
Tuning Fork force sensor with attached fiber probe. Fiber probe coated in plasmonic material for near-field collection.

Fiber-TERS of ZnPc on Nanopattern

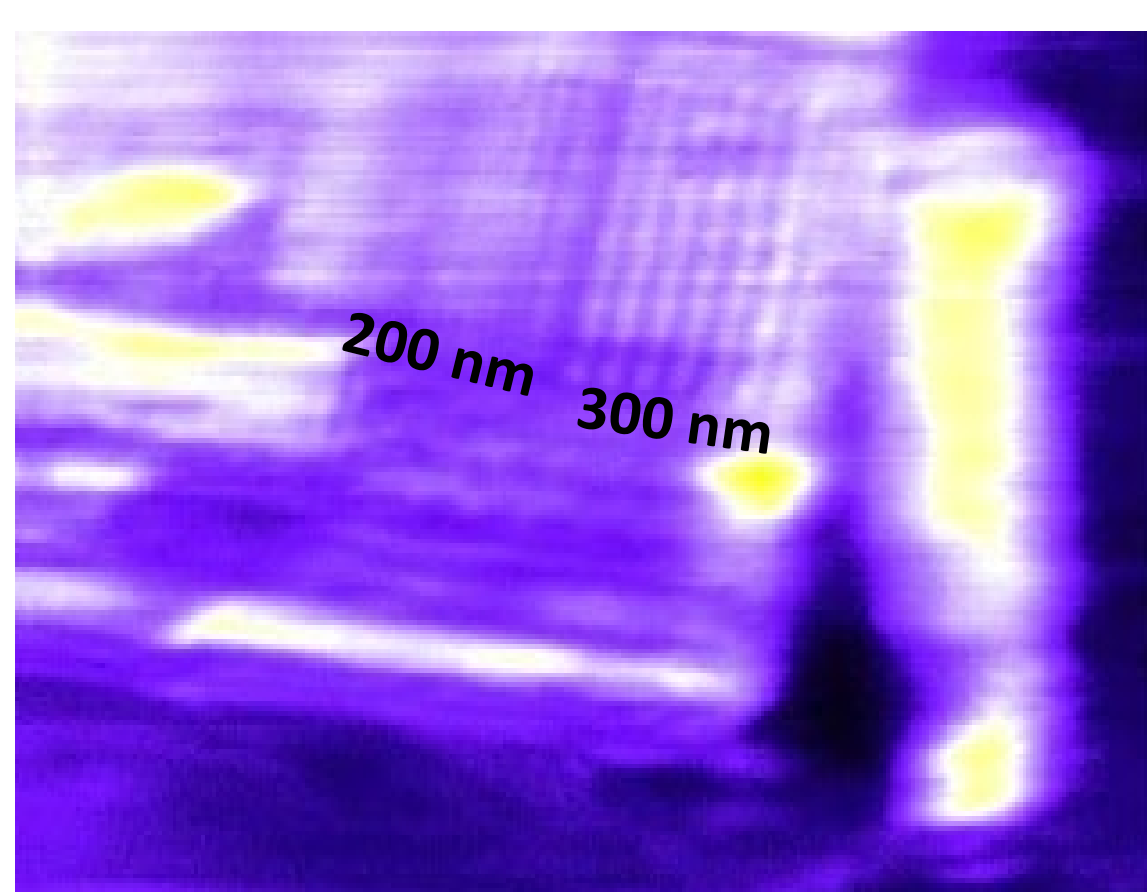
Calibration Nano-Pattern



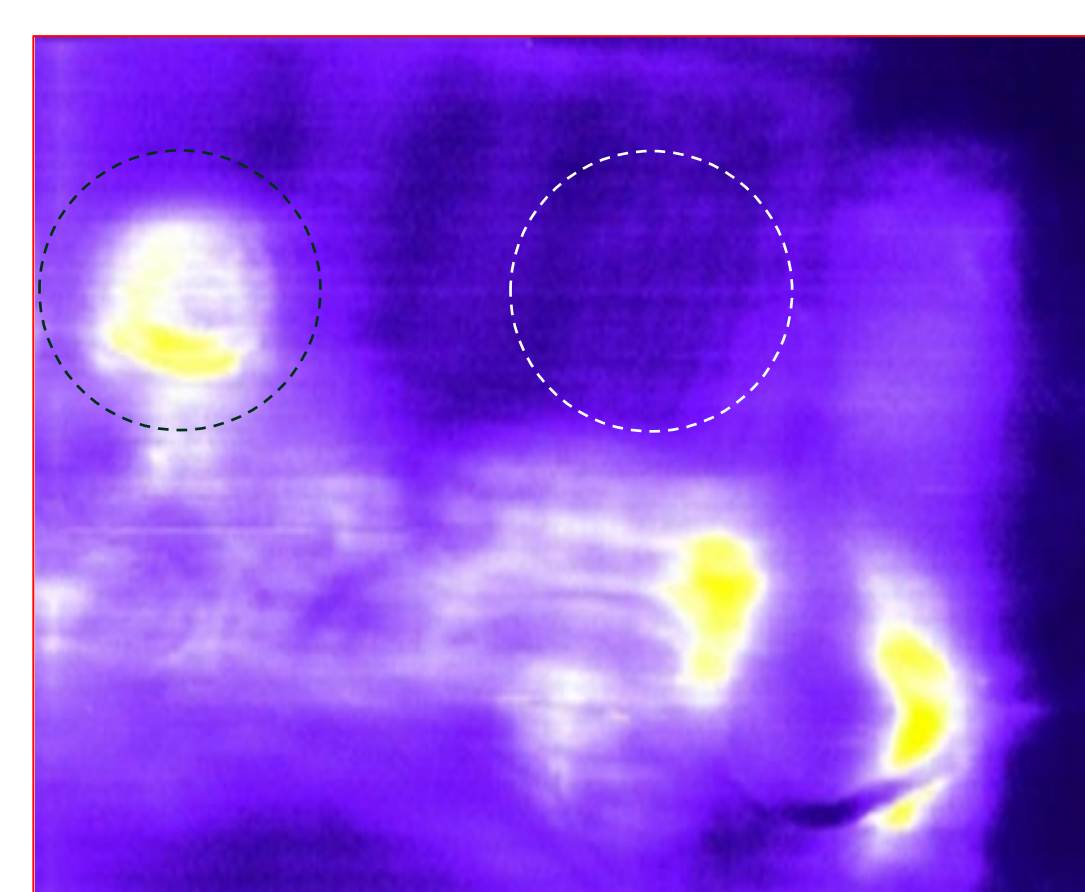
Atomic Force microscope Image



SNOM Image



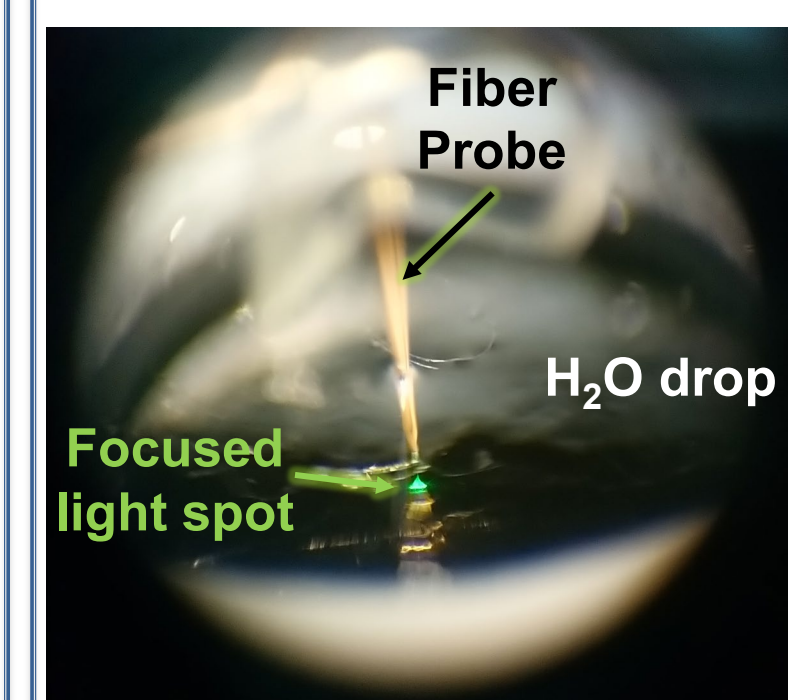
Raman Image



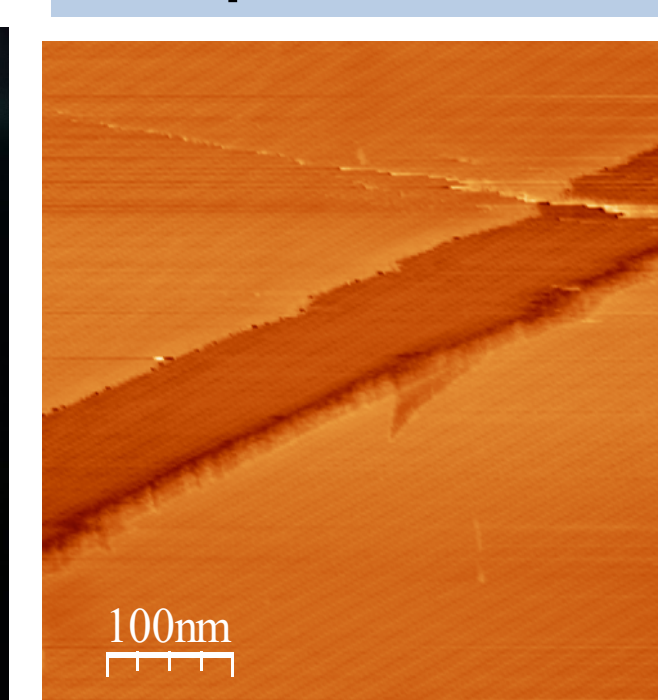
- ☒ Au-coated aperture SNOM fiber probe has been used for AFM and excitation for Raman imaging.
- ☒ 300 nm resolution in the Raman map is observed.

Fiber TERS in Liquid Environment

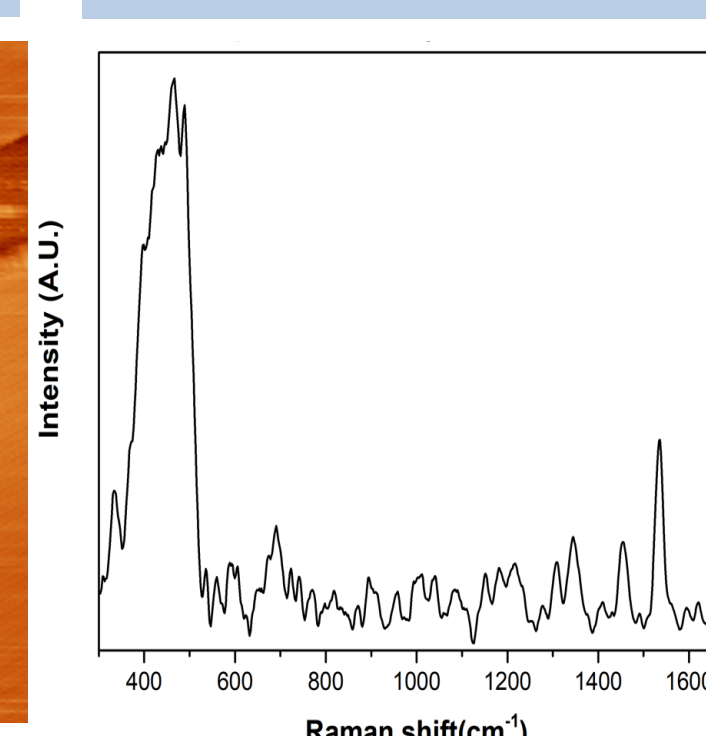
Nanoscale Chemical Imaging in Water



STM Image of HOPG taken In Liquid with Fiber



Raman Spectra of CuPc by Au-Coated vortex Fiber



Visible spectroscopy can be easily done in any **aqueous** or **dry** environment. Fiber coupled sensing is **insensitive** to medium or changes in refractive index.

Fiber TERS in Medical Application

Medical Applications:

- ☒ Fiber based TERS probes fingerprint chemical biomarkers in vivo on native tissue surfaces in real-time.
- ☒ FTTERS can be configured into hand-held or endoscopic devices for in vivo tumor identification, rapid novel drug discovery, or drug sample purity control
- ☒ FTTERS is portable, using benchtop laser sources and spectral analysis equipment

FTTERS for Tumor Margin Detection

