The Multiprobe IR Apertureless Advantage
Multiprobe Apertureless NSOM Key Features

- *Instrument and Probes* allowing aperturless IR NSOM with on-line Raman vibrational spectroscopic comparison at ambient and controlled environment conditions

- *Probes produced in-house with singular characteristics*
  - Can be made of a variety of materials to optimize scattering only from the probe tip and not the shaft or cantilever
  - Multiple probes can be brought into contact

- *Controlled environment & low temperature* 10oK operation with similar characteristics

- *Feedback With tuning fork independently shown to be superior*
  - Superior for apertureless imaging
  - With ten times higher force sensitivity of any AFM feedback method

- *Variable Magnetic Field Readily Integrated*

- *MultiProbe Transport Measurements*
Illumination from top bottom and 360° all around
Side Illumination Apertureless IR With Simultaneous Raman Excitation and Collection

Probes With Transparent IR Shafts & Scattering Tips That Do Not Block Any Ray of the Raman Lens
Multiprobe Apertureless NSOM Key Features

- *Instrument and Probes* allowing aperturless IR NSOM with on-line Raman vibrational spectroscopic comparison at ambient and controlled environment conditions
- *Probes produced in-house with singular characteristics*
  - Can be made of a variety of materials to optimize scattering only from the probe tip and not the shaft or cantilever
  - Multiple probes can be brought into contact
- *Controlled environment & low temperature* 10oK operation with similar characteristics
- *Feedback With tuning fork independently shown to be superior*
  - Superior for apertureless imaging
  - With ten times higher force sensitivity of any AFM feedback method
- *Variable Magnetic Field Readily Integrated*
- *MultiProbe Transport Measurements*
Probes With Transparent IR Shafts & Scattering Tips That Do Not Block Any Ray of the Raman Lens

What customers publish: ”...In our experimental configuration, the tip apex is not shadowed, as the laser beam is a focused beam with a converging angle of 26.7°, while the half angle of the tip is only about 4°. “ [Sun and Shen, Apertureless near-field scanning Raman microscopy using reflection scattering geometry, Ultramicroscopy 94, 237 (2003)]
Multiprobe Apertureless NSOM Key Features

- **Instrument and Probes** allowing aperturless IR NSOM with on-line Raman vibrational spectroscopic comparison at ambient and controlled environment conditions
- **Probes produced in-house with singular characteristics**
  - Can be made of a variety of materials to optimize scattering only from the probe tip and not the shaft or cantilever
  - Multiple probes can be brought into contact
- **Controlled environment & low temperature** 10oK operation with similar characteristics
- **Feedback With tuning fork independently shown to be superior**
  - Superior for apertureless imaging
  - With ten times higher force sensitivity of any AFM feedback method
- **Variable Magnetic Field Readily Integrated**
- **MultiProbe Transport Measurements**
Probes Can Be Brought Into Contact & Separated With Nanometric Precision For Investigating Nanotransport of Conductivity, Optical & Thermal Phenomena

What customers publish: "Collisions between both tips were effectively prevented by a proximity detection mechanism based on mechanical interaction between both tips. The minimum distance between both tips is reached when both tip coatings touch..” Klein et al, NanoLett. 14, 5010 (2014)
Multiprobe Apertureless NSOM Key Features

- *Instrument and Probes* allowing aperturless IR NSOM with on-line Raman vibrational spectroscopic comparison at ambient and controlled environment conditions

- *Probes produced in-house with singular characteristics*
  - Can be made of a variety of materials to optimize scattering only from the probe tip and not the shaft or cantilever
  - Multiple probes can be brought into contact

- *Controlled environment & low temperature* 10oK operation with similar characteristics

- *Feedback With tuning fork independently shown to be superior*
  - Superior for apertureless imaging
  - With ten times higher force sensitivity of any AFM feedback method

- *Variable Magnetic Field Readily Integrated*

- *MultiProbe Transport Measurements*
The Next Evolution In AFM

FREE OPTICAL AXIS

INTEGRATED INTERFEROMETER
For IR and Visible Apertureless NSOM

Fully Integrated Controlled Environment and 10°K Conditions Multiprobe Apertureless

The Next Evolution In AFM
Multiprobe Apertureless NSOM Key Features

- *Instrument and Probes* allowing aperturless IR NSOM with on-line Raman vibrational spectroscopic comparison at ambient and controlled environment conditions

- *Probes produced in-house with singular characteristics*
  - Can be made of a variety of materials to optimize scattering only from the probe tip and not the shaft or cantilever
  - Multiple probes can be brought into contact

- *Controlled environment & low temperature* 10oK operation with similar characteristics

- *Feedback With tuning fork independently shown to be superior*
  - Superior for apertureless imaging
  - With ten times higher force sensitivity of any AFM feedback method

- *Variable Magnetic Field Readily Integrated*

- *MultiProbe Transport Measurements*
Superiority of Tuning Fork For Scattering NSOM Independently Demonstrated

Terahertz Nanoscopy of Plasmonic Resonances with a Quantum Cascade Laser

Riccardo Degl’Innocenti, Robert Wallis, Binbin Wei, Long Xiao, Stephen J. Kindness, Oleg Mitrofanov, Philipp Braeuninger-Weimer, Stephan Hofmann, Harvey E. Beere, and David A. Ritchie

Department of Engineering, University of Cambridge, J. J. Thomson Avenue, CB3 OHE Cambridge, United Kingdom

Terahertz Nanoscopy of Plasmonic Resonances with a Quantum Cascade Laser

Supporting Information

ABSTRACT: We present a terahertz (THz) scattering near-field optical microscope (s-SNOM) based on a quantum cascade laser implemented as both source and detector in a self-mixing scheme utilizing resonant quartz tuning forks as a sensitive nanopositioning element. The homemade s-SNOM, based on a resonant tuning fork and metallic tip, operates in tapping mode with a spatial resolution of ~78 nm. The quantum cascade laser is realized from a bound-to-continuum active region design with a central emission of ~2.85 THz, which has been lens-coupled in order to maximize the feedback into the laser cavity. Accordingly, the spatial resolution corresponds to >λ/1000. The s-SNOM has been used to investigate a bidimensional plasmonic photonic crystal and to observe the optical resonant modes supported by coupled plasmonic planar antennas, showing remarkable agreement with the theoretical predictions. The compactness, unique sensitivity, and fast acquisition capability of this approach make the proposed s-SNOM a unique tool for solid-state investigations and biomedical imaging.

KEYWORDS: near-field microscopy, terahertz, plasmonics, photonic crystals, quantum cascade laser, self-mixing detection
Multiprobe Apertureless NSOM Key Features

- *Instrument and Probes* allowing aperturless IR NSOM with on-line Raman vibrational spectroscopic comparison at ambient and controlled environment conditions
- *Probes produced in-house with singular characteristics*
  - Can be made of a variety of materials to optimize scattering only from the probe tip and not the shaft or cantilever
  - Multiple probes can be brought into contact
- *Controlled environment & low temperature* 10oK operation with similar characteristics
- *Feedback With tuning fork independently shown to be superior*
  - Superior for apertureless imaging
  - With ten times higher force sensitivity of any AFM feedback method
- *Variable Magnetic Field Readily Integrated*
- *MultiProbe Transport Measurements*
Published Characteristics of Nanonics Systems & Probes

*Highest Force Sensitivity*


Force Sensitivity Significantly <5 pN Improved Over Conventional AFM

Best Force Sensitivity Achievable In Other AFM Systems
What customers publish: "...high sensitivity in amplitude and phase, as well as high mechanical quality factor.... it provides conclusive information about the morphology of one-dimensional nanostructures."

Materials Letters 165 (2016) 67–70
Excellent XY Morphological Fidelity Even Compared To FESEM As Described in the literature

The Tuning Fork Uniquely Provides A High Quality Factor, Q, For Ultra Sensitivity In AFM And In AFM Morphology. This Is Not Available With Any Beam Bounce Feedback AFM (see green highlighted customer description). Also True Non-contact Is Achieved With The Nanonics Tuning Fork Systems. Thus, Nanonics Provides The Only AFM Systems That Allow For Switching Between AFM And STM Feedback With The Same Probe. Proving Non-contact AFM Operation
Multiprobe Apertureless NSOM Key Features

- *Instrument and Probes* allowing aperturless IR NSOM with on-line Raman vibrational spectroscopic comparison at ambient and controlled environment conditions

- *Probes produced in-house with singular characteristics*
  - Can be made of a variety of materials to optimize scattering only from the probe tip and not the shaft or cantilever
  - Multiple probes can be brought into contact

- *Controlled environment & low temperature* 10oK operation with similar characteristics

- *Feedback With tuning fork independently shown to be superior*
  - Superior for apertureless imaging
  - With ten times higher force sensitivity of any AFM feedback method

- *Variable Magnetic Field Readily Integrated*

- *MultiProbe Transport Measurements*
Variable Magnetic Fields Above or Below Sample

- Motors for Varying Magnetic Field
- Magnetic Bridge Assembly
- Magnetic Poles
- SPM Probe 1
- SPM Probe 2
- Open Optical Access From Above & Below The Sample

The Next Evolution in SPM™
Multiprobe Apertureless NSOM Key Features

- **Instrument and Probes** allowing aperturless IR NSOM with on-line Raman vibrational spectroscopic comparison at ambient and controlled environment conditions

- **Probes produced in-house with singular characteristics**
  - Can be made of a variety of materials to optimize scattering only from the probe tip and not the shaft or cantilever
  - Multiple probes can be brought into contact

- **Controlled environment & low temperature** 100K operation with similar characteristics

- **Feedback With tuning fork independently shown to be superior**
  - Superior for apertureless imaging
  - With ten times higher force sensitivity of any AFM feedback method

- **Variable Magnetic Field Readily Integrated**

- **MultiProbe Transport Measurements**
Collage Produced By Combining Apertureless Images of Amplitude & Phase of Plasmonic Transport

Plasmon Propagation On A Gold Waveguide

Line Scan From Image Above

22nm