Product Line
neaspec

attocube
WITTENSTEIN group

Applications Collection

Nano-characterization of Semiconductors

free charge carrier profiling at 10 nm scale

NANOSCALE ANALYTICS
advanced imaging & spectroscopy

Recommended Product:

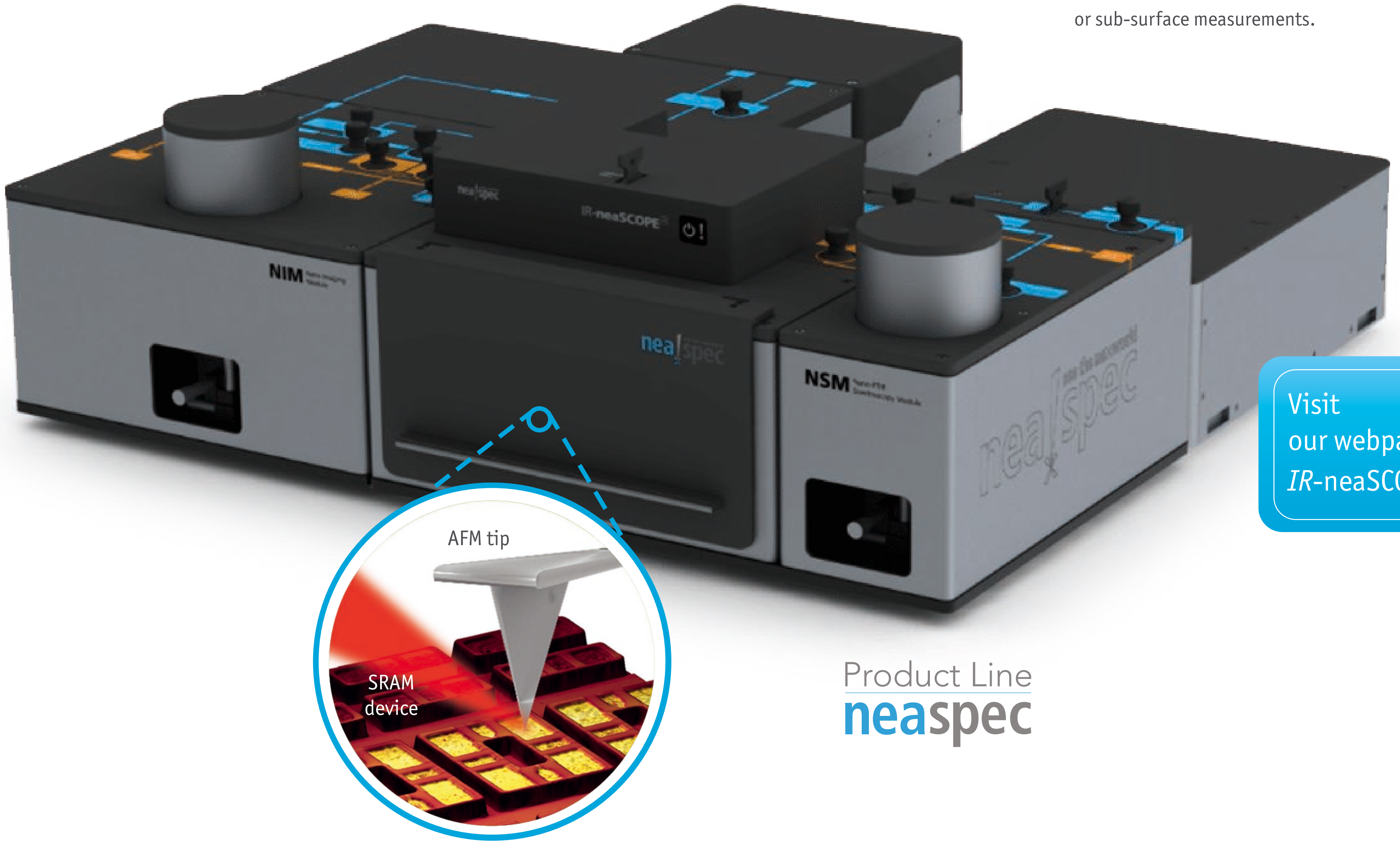
IR-neaSCOPE^{+s}

- universal performance on all samples
  → by detecting simultaneous absorption & reflection
- highest throughput without compromise on quality
  → using fastest & most reliable s-SNOM technology
- unlimited configuration options
  → combining multi-port beam-path design with best-patented technologies

provides s-SNOM & AFM-IR nanoscale infrared (IR) imaging and nano-FTIR spectroscopy.

IR-neaSCOPE^{+s} is designed for providing complete chemical analysis and field mapping at 10 nm spatial resolution. It utilizes state-of-the-art technologies of near-field microscopy to measure both IR absorption and reflectivity, as well as amplitude and phase of local electromagnetic fields.

It provides IR nanoimaging, point-spectroscopy and hyperspectral analysis with CW and pulsed (OPO) illumination sources as well as nano-FTIR spectroscopy using broadband lasers and synchrotron sources. *IR*-neaSCOPE^{+s} excels in both organic and inorganic materials analysis providing the broadest range of demonstrated applications and novel near-field methodologies such as quantitative s-SNOM or sub-surface measurements.



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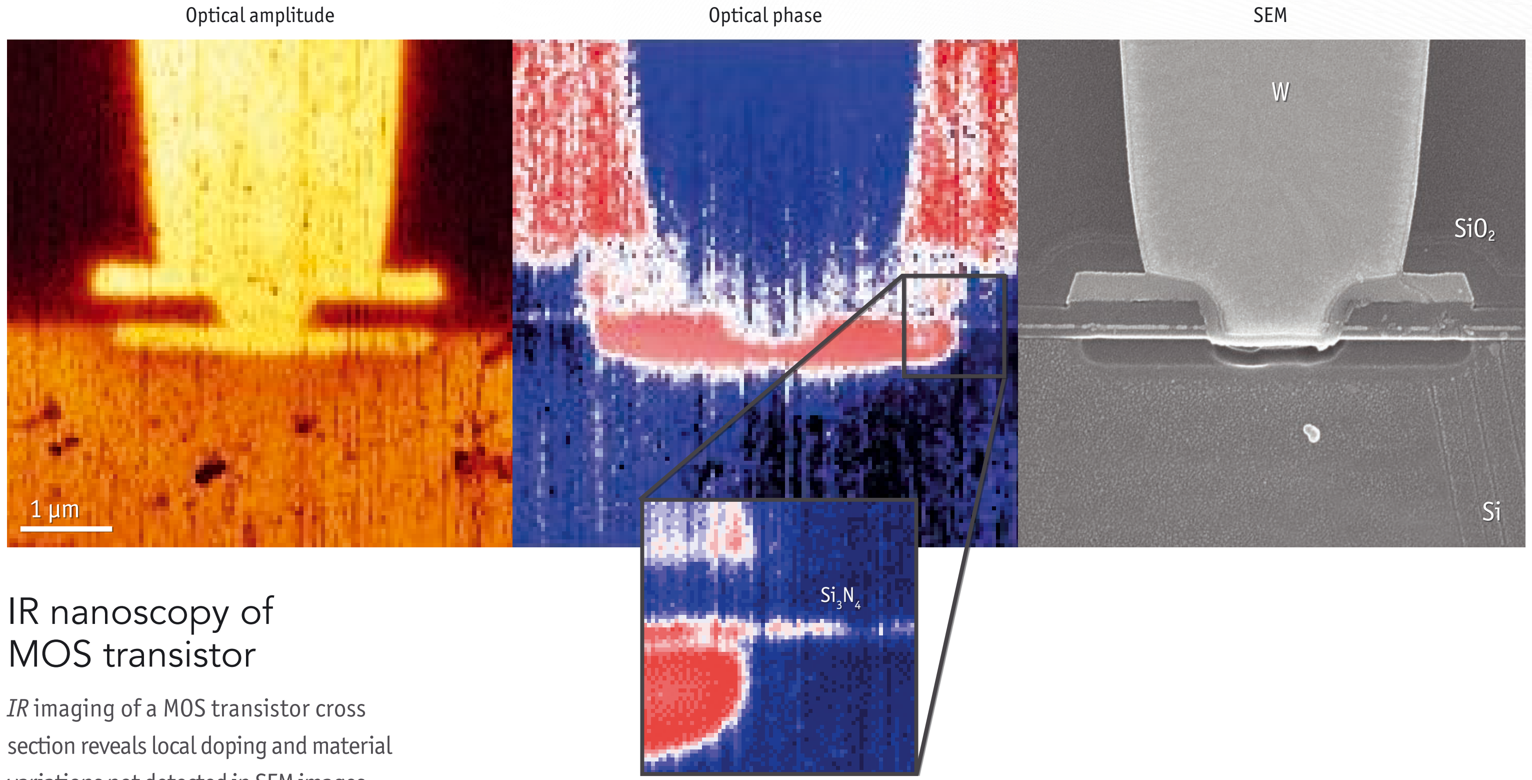
our webpage
IR-neaSCOPE^{+s}

Defect Analysis in Device Contacts

IR-neaSCOPE nanoimaging with sub-10 nm resolution directly probes charge carriers and provides high level of insight into device composition, doping concentration and carrier diffusion. This makes neaSCOPE an excellent tool for interface and strain analysis, device engineering and optimization.



IR nanoscopy of MOS transistor

IR imaging of a MOS transistor cross section reveals local doping and material variations not detected in SEM images. An ultra-thin Si_3N_4 liner of only 10 nm width is clearly visble.

In collaboration with Infineon.

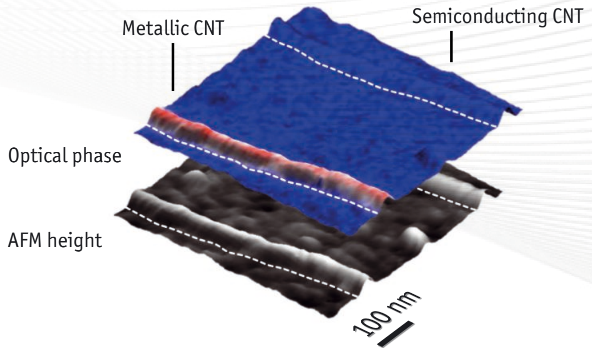
neaSCOPE is a perfect tool for nanoscale quality control & failure analysis of semiconductor devices.

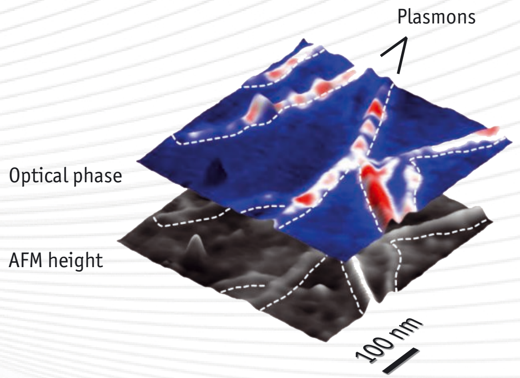
ADVANCED MATERIALS
A. J. Huber et al.,
Advanced Mater.
2007, 19, 2209.

IOP Publishing
A. J. Huber et al.,
Nanotech.
2010, 21, 235702.

Investigating Plasmons in Carbon Nanotubes

State-of-the-art patented technologies allow neaSCOPE to perform artifact-free near-field phase imaging at the nanoscale–an ultra sensitive technique for noninvasive contact-free analysis of low- dimensional materials.





CNT Conductivity

The extreme sensitivity of the **neaSCOPE** allows for probing conductive properties of individual single-wall carbon nanotubes (CNT) (diameter ~3 nm). While being nearly in- ditinguishable in the AFM topography, metallic nanotubes exhibit strong contrast compared to the semiconducting CNTs in the nanoscale optical phase image due to their higher carrier densities.

Luttinger-Liquid in Metallic CNT

High resolution IR nanoscopy images reveal Luttinger-liquid plasmons in metallic CNTs (diameter ~1 nm). The unprecidented sensitivity of **neaSCOPE** allowed for the first time to directly observe the optical signature of this quantum phenomenon in one-dimensional electron gas of single-wall CNTs.

IR imaging provides unique insights into optical properties of nanometer-sized carbon allotropes.

pss a
G. Nemeth et al.,
Phys. Status Solidi B.
2017, 1700433.

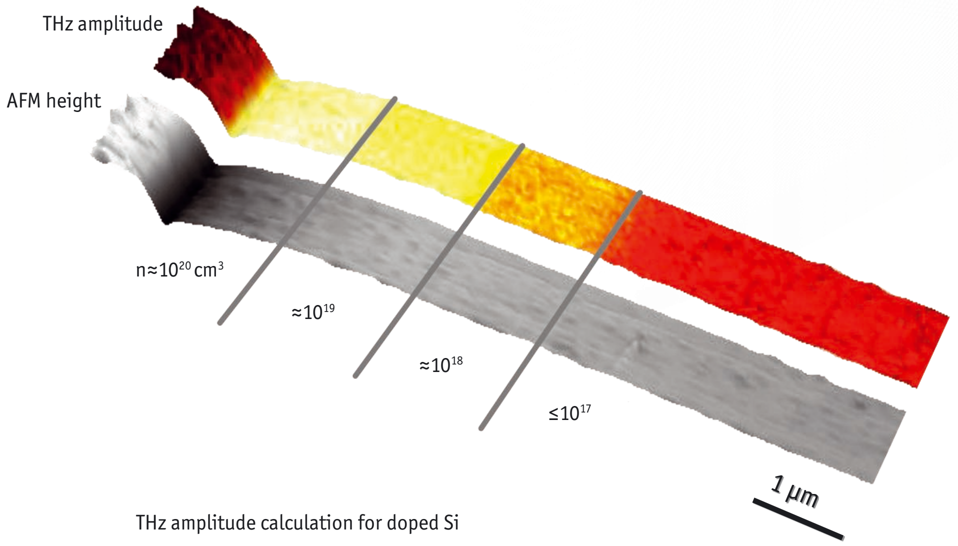
NANO LETTERS
G. Nemeth et al.,
nano Letters.
2022, 22, 8, 3495.

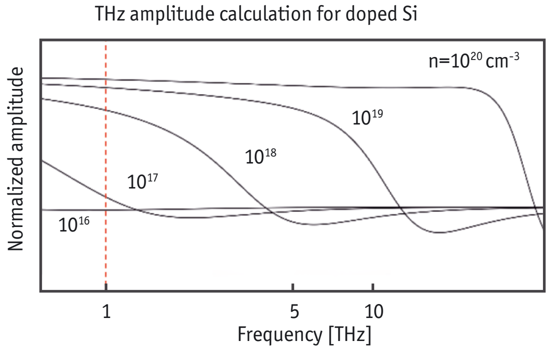
ROYAL SOCIETY OF CHEMISTRY
X. Tian et al.,
Nanoscale
2018, 10, 6288.

nature photonics
Z. Shi et al.,
Nature Photonics
2015, 9, 515.

Mapping Doping Concentration in Si

neaSCOPE THz nanoimaging and spectroscopy is an excellent ready-to-use solution for quantitative carrier density profiling at 20 nm scale, which does not require complicated calibration procedures and can be applied to any doped semiconducting material.





Carrier Density Quantification

Reflectance image at 1 THz acquired by **neaSCOPE** on the IMEC calibration sample exhibits contrast that depends on the free carrier density. Comparison of this contrast with the calculated reflectance at the imaging wavelength (red dashed line in the bottom plot) for p-doped Si of different doping levels allows for calibration-free extraction of the carrier concentration with nanoscale spatial resolution.

THz nanoscopy accurately determines the doping concentration of semiconductor materials.

NANO LETTERS

A. J. Huber et al.,
Nano Lett.
2008, 8, 3766.

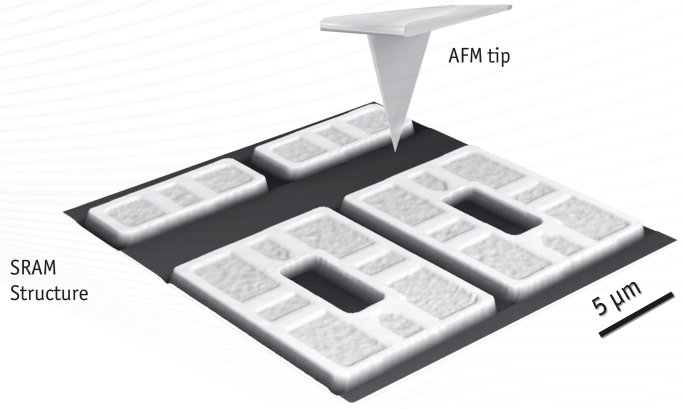
OSA The Optical Society

H.-G. von Ribbeck et al.,
Opt. Express
2008, 16, 3430.

Correlative Nanoscopy of SRAM Devices

neaSCOPE is built on the highest quality AFM platform and can utilize all well-established AFM- based techniques such as KPFM, EFM, etc. A combination of these techniques with cutting-edge state-of-the-art cutting-edge IR & THz imaging and spectroscopy paves the way towards better understanding of semiconductor nanostructures.

Correlative nanoscopy enables all-around nanoscale characterization of functional devices in a single instrument.



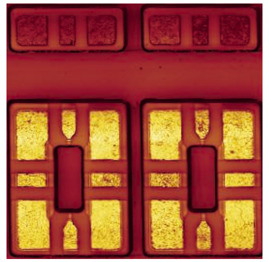
Near-Field Correlation Nanoscopy

OPTICA

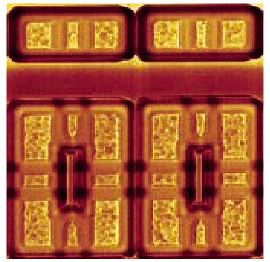
C. Liewald et al.,
Optica.
2018, 5, 159.

***IR*-neaSCOPE**$^{+s}$ and THz imaging of a commercial SRAM device allows for the quantitative free-carrier profiling of functional structures in the whole technologically relevant range of doping concentrations. KPFM and EFM can be used to correlate these profiles with the structures electronic properties, differentiating between p- and n-doped regions.

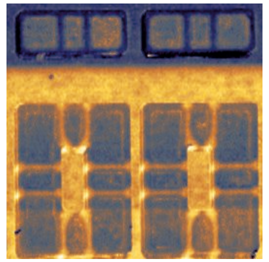
IR image



THz image



KPFM image



EFM image

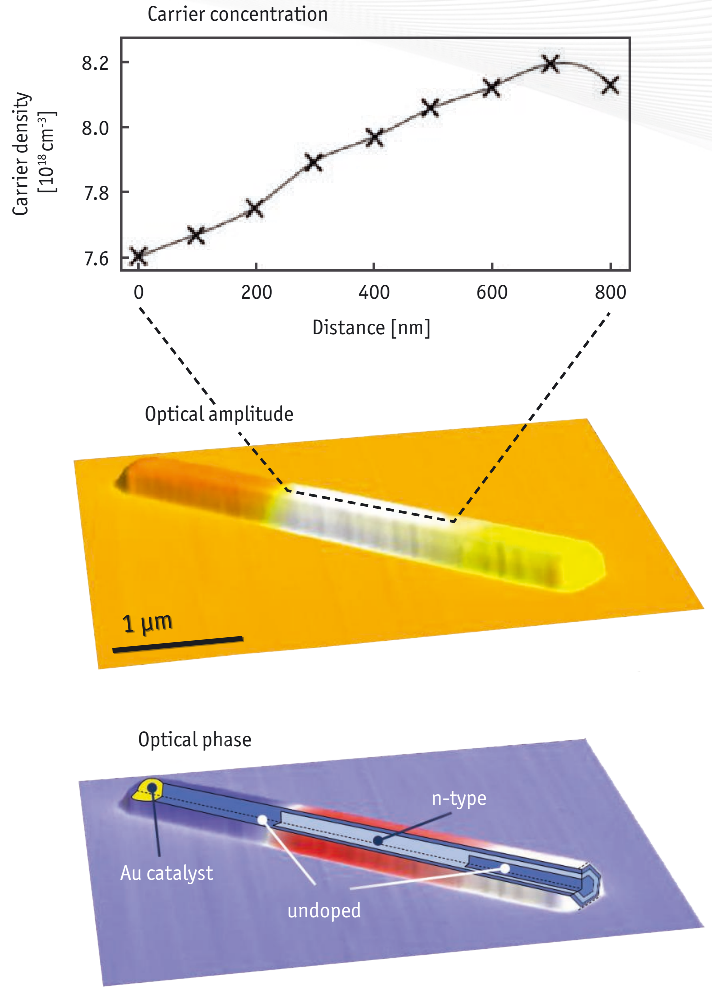
Offset 0 mV

EFM image

Offset 700 mV

Conductivity Profiling of InP Nanowires

IR nanoimaging measures the local conductivity without the need for electrical contacts. Thus, local conductivity changes at interfaces or defects can be mapped in real-space at 10 nm spatial resolution.



neaSCOPE facilitates development of the next generation semiconducting materials.

IR nanoscopy of a single modulation-doped InP nanowire highlights three differently doped, ca. 1-µm-long, segments along the nanowire growth direction. Measured reflectance and absorbance maps yield the local free-carrier concentration, revealing a ca. 10% variation along the center segment that directly relates to the specific growth conditions, thus allowing for the optimization of growth procedures.

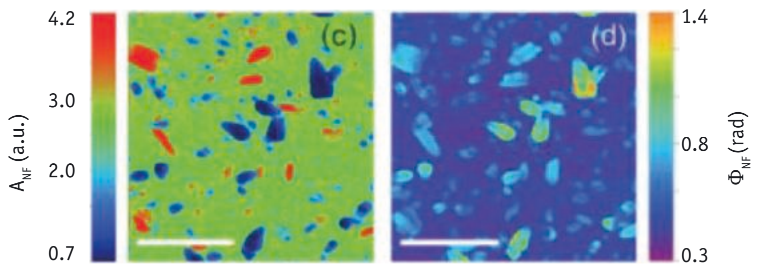
NANO LETTERS
J. Stiegler et al.,
Nano Lett. 2010,
10, 1387.

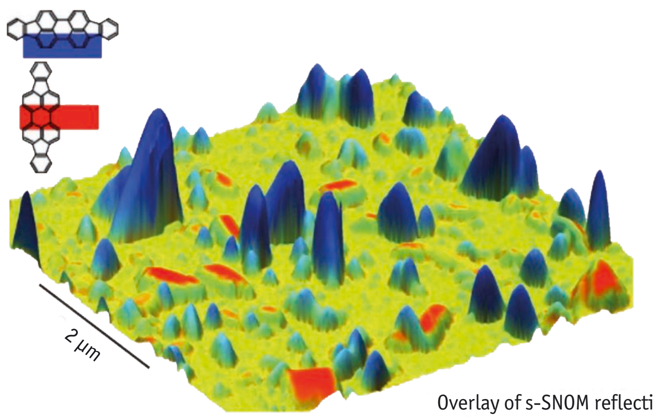
nature COMMUNICATIONS
J. Stiegler et al.,
Nature Commun.
2012, 3, 1131.

ACS NANO
J. Vaishnavi et al.,
ACSnano 2021,
15, 12, 20466

Detecting Defects in Organic Semiconductors

Nanoscale images of IR reflectivity enable investigation of defects due to molecular orientation in thin organic films. *IR*-neaSCOPE^{+s} is equipped with neaspec patented s-SNOM technology, which simultaneously measures reflectivity and absorption of organic compounds, proving an invaluable tool for advancing organic semiconductor materials and devices.





Overlay of s-SNOM reflectivity (1450 cm^{-1}) on AFM topography

nanoscale surface reflectivity, revealed by *IR* s-SNOM amplitude ANF, proved to be invaluable for determining the molecular orientation of islands inside a diindenoperylene (DIP, $C_{32}H_{16}$) organic semiconductor film, which has a profound impact on the device performance. This is because light-induced anisotropic response of vibrational modes strongly affects the s-SNOM amplitude, while not causing significant changes in material absorption (s-SNOM phase or AFM-IR). High-resolution images measured at 1450 cm^{-1} reveal distinct regions in the s-SNOM amplitude signal: red areas where molecules lie down and blue areas where they stand up relative to the sample. Thus, *IR*-neaSCOPE^{+s} stands out as a unique tool for molecular defect analysis, which is essential for the advancement of devices based on organic molecular semiconductors.

IR nanoscopy reveals molecular orientation in organic semiconductors.

ACS Publications
Most Trusted. Most Cited. Most Read.
N.Mrkyvkova et al.,
The Journal of Physical Chemistry C 2021,
125 (17), 9229-9235

Other Applications

nano-FTIR for Polymers
chemical characterization at the nanoscale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Application Collection
nano-FTIR for Polymers
chemical characterization at the nanoscale
NANOSCALE ANALYTICS

Nanocomposite polymers, multilayer thin films, nanofibers and other polymer nano-forms often offer new properties or enhanced performance compared to bulk materials, demanding tools for chemical analysis with nanoscale spatial resolution for their investigations. nano-FTIR and s-SNOM are two leading techniques for nanoscale chemical mapping and identification.

Inorganic Materials
spectroscopic chemical analysis at the nanoscale


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Inorganic Materials
spectroscopic chemical analysis at the nanoscale
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nano-FTIR spectroscopy and imaging have been successfully applied for material identification & mapping with nanometer precision using material-specific infrared spectroscopic signatures. This applications collection focuses on nanoscale investigation of inorganic materials in energy-storage, mineralogy, archaeology and corrosion sciences.

nano-FTIR for Biomaterials
nanoscale compositional and structural analysis


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nano-FTIR for Biomaterials
nanoscale compositional and structural analysis
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nano-FTIR can perform in-situ study of melanine in human hair for cosmetics treatment analysis. Shed light on bio-chemistry of cell membranes & improve efficiency of drug delivery. Analyze protein secondary structure in amyloid fibrils. And elucidate the nuclear organization of white-blood cells.

Additional Services

demo LAB

Evaluate the capabilities of our technology & products.

Successful test results could significantly increase the approval chance of your grant application.

Monthly reviews of neaspec publications.

Keep you up to date in the field of nanoscale analytics and help you discover new neaSCOPE applications.

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