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Applications Collection

nano-FTIR for Biomaterials

nanoscale compositional and structural analysis

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Recommended Product: *IR*-neaSCOPE+s

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 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.

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

Enables s-SNOM, AFM-IR nano-scale infrared (IR) imaging and nano-FTIR spectroscopy.

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IR-neaSCOPE+s

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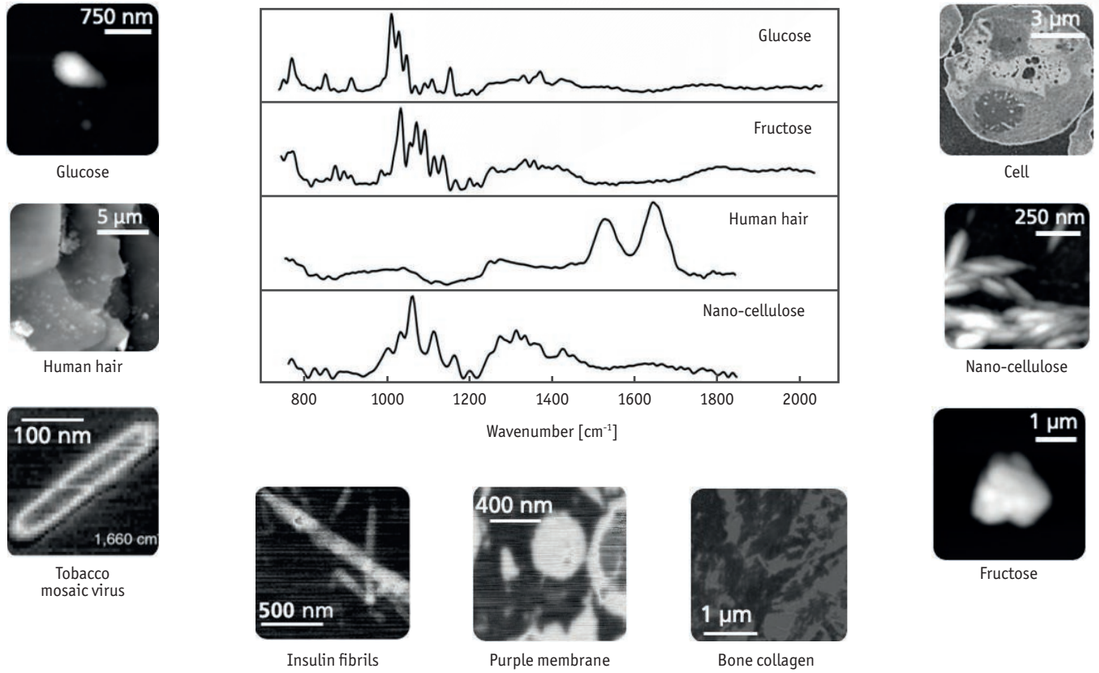
nano-FTIR measures characteristic IR spectroscopic signatures at the nanoscale

The combination of tapping-mode AFM technology and FT-IR spectroscopy (nano-FTIR) provides a unique tool to measure infrared absorption spectra of any AFM-ready biological sample with nanometer spatial resolution. nano-FTIR provides excellent correlation to conventional FT-IR spectroscopy data enabling detailed analysis of the measured absorption lines and bands.



The neaSCOPE performs chemical identification or structural analysis at 10-nm spatial resolution.

COMMUNICATIONS MATERIALS — A.L. Borja, et al., Communications Materials 2020, 1, 57

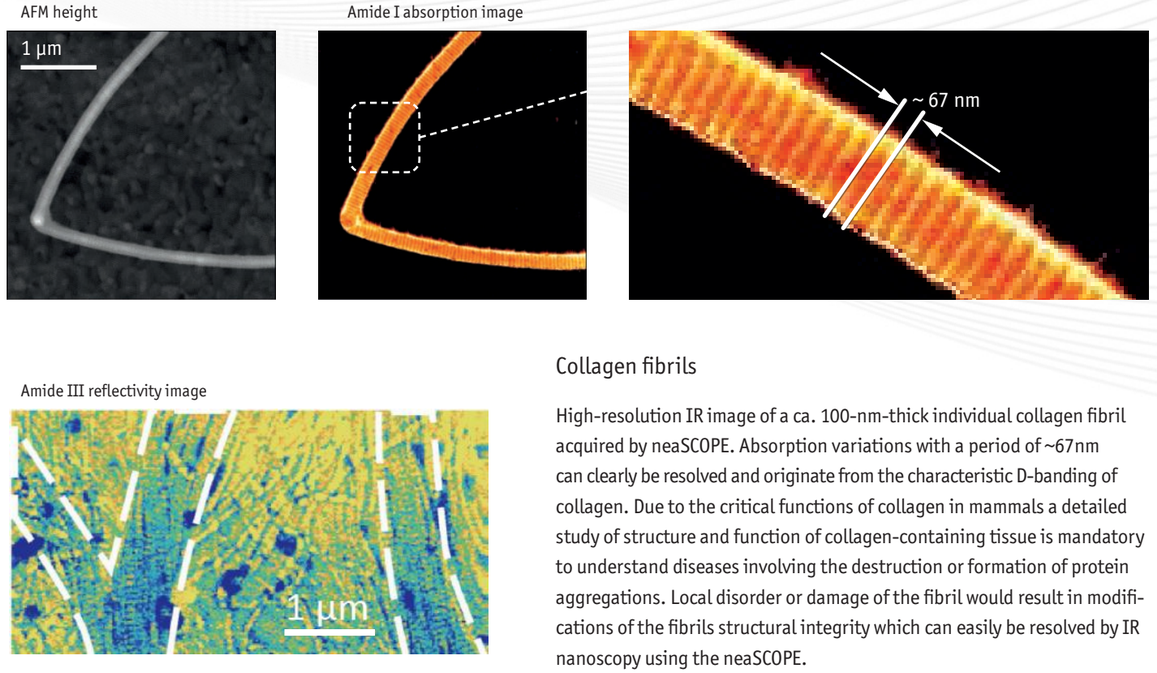
The Journal of Physical Chemistry Letters — A. M. Siddiquee, et al., J. Phys. Chem. Lett. 2020, 11, 9476

Plasma Science and Technology — L. Ten Bosch et al., Plasma Science and Technology 2019, 21, 125502

communications biology — Z. Qia K. Kanevche et al., Communications Biology 2021, 4, 1341

The neaSCOPE assesses composition and organization of proteins at the 10-nm scale

The *IR*-neaSCOPE+s provides extreme spatial resolution to resolve local properties and interactions in complex biological structures and specimens on the relevant length scales. This label-free technique offers significant improvement for nanoscale fundamental research, spectropathology and clinical applications.



IR nanoscopy maps the organization and local interactions of protein subunits at the nanoscale.

Collagen fibrils

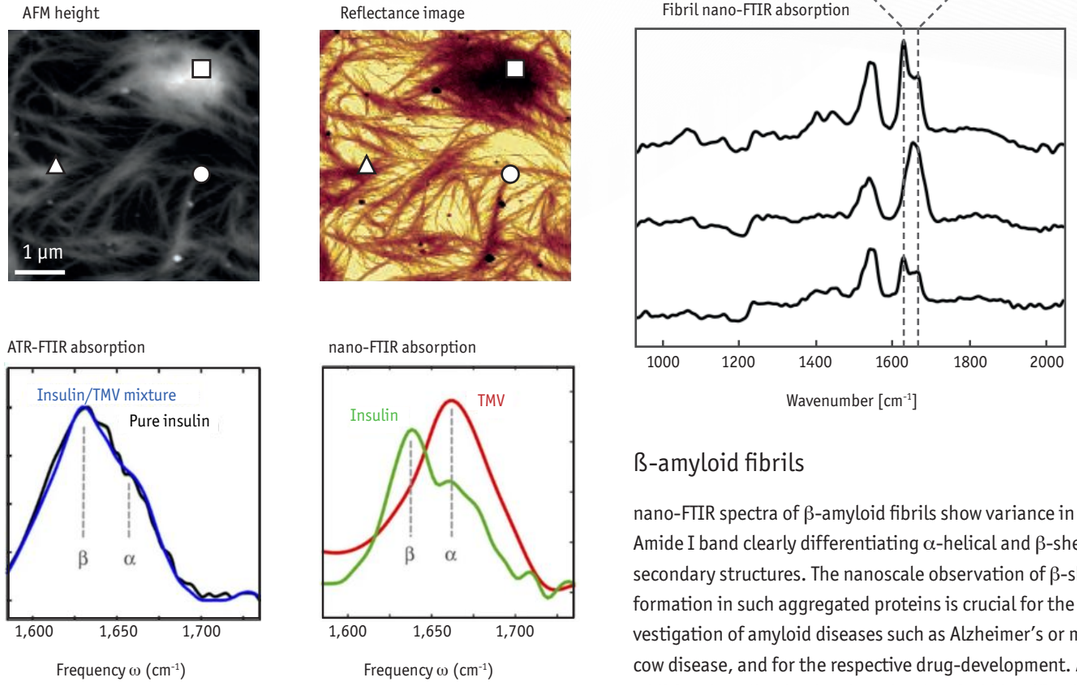
High-resolution IR image of a ca. 100-nm-thick individual collagen fibril acquired by neaSCOPE. Absorption variations with a period of ~67nm can clearly be resolved and originate from the characteristic D-banding of collagen. Due to the critical functions of collagen in mammals a detailed study of structure and function of collagen-containing tissue is mandatory to understand diseases involving the destruction or formation of protein aggregations. Local disorder or damage of the fibril would result in modifications of the fibrils structural integrity which can easily be resolved by IR nanoscopy using the neaSCOPE.

ROYAL SOCIETY OF CHEMISTRY — R. Wiens et al., Faraday Discuss. 2016, 187, 555.

Nano Research — Z. Qiao et al., Nano Research 2022, 15, 2355

nano-FTIR resolves protein secondary structure with unprecedented resolution

The ultimate nanoscale resolution of nano-FTIR goes beyond spatial & ensemble averaged measurements known from conventional FT-IR spectroscopy and reveals the composition and orientation of single protein structures with an unmatched level of detail.



ß-amyloid fibrils

nano-FTIR spectra of β-amyloid fibrils show variance in the Amide I band clearly differentiating α-helical and β-sheet secondary structures. The nanoscale observation of β-sheet formation in such aggregated proteins is crucial for the investigation of amyloid diseases such as Alzheimer's or mad cow disease, and for the respective drug-development. An additional application involves the chemical identification of morphologically similar biological structures, such as distinguishing between Insulin fibers and the TMV virus. This type of identification would otherwise be impossible using standard ATR spectroscopy.

nano-FTIR quantifies α-helix and β-sheet content of single protein fibrils at the 10^{-nm}-scale.

NanoBio &Med2017 — P. Schaefer et al., NanoBio & Med 2017, 11, 22

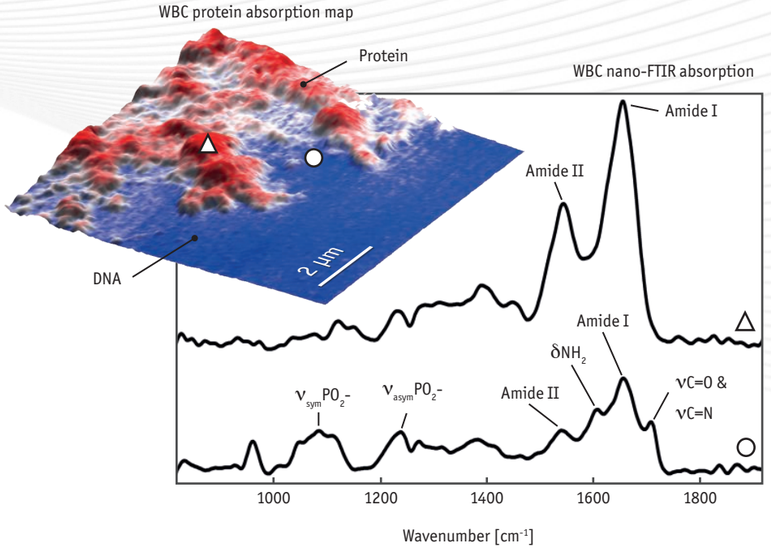
nature communications — I. Amenabar et al., Nature Communications 2013, 4, 2890

The neaSCOPE assesses composition and organization of proteins at the 10^{-nm} scale

IR-neaSCOPE^{+s} provides a ready-to-use solution to study the composition of biological specimens or to analyze sample organization and morphology at the 10nm length scale. The combination of nano-FTIR spectroscopy and IR nanoscopy results in a more complete understanding of the interface structures or interaction mechanisms of organic matter like individual cells or viruses on the single particle level.

DNA in white blood cell (WBC)

Nanoscale spectroscopy and nanoscopy of protein and DNA rich regions within a white blood cell (WBC) nucleus. The protein absorbance signature measured by nano-FTIR clearly shows the typical Amide I and Amide II bands. The DNA spectrum can be identified as a mixture of single- and double-stranded DNA. IR nanoscopy can be used to highlight the distribution of proteins and DNA within the nucleus. By directly resolving the nuclear organization of WBC nuclei, the neaSCOPE will open new possibilities to measure and to understand the significantly altered nuclear organization of e.g. classical Hodgkin's Lymphoma.



Analyst — G. C. Ajaezi et al., Analyst 2018, 143, 5926

communications biology — *Z. Qia K. Kanevche et al., Communications Biology 2021, 4, 1341*

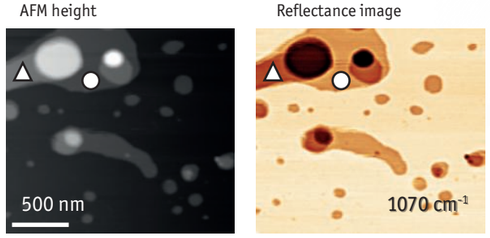
scientific reports — K. J. Kaltenecker et al., Scientific Reports 2021, 11, 21860

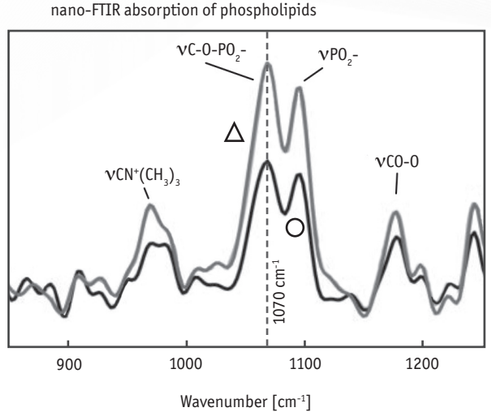
Research Square — G. Greaves et al., Research Square 2023, 25, 2443252

nano-FTIR spectroscopy and IR nanoscopy disentangle the nuclear organization within white-blood cells.

Superior nano-FTIR spectroscopy quality with sub-monolayer detection sensitivity

The unique and market-leading measurement performance of nano-FTIR is the prerequisite to perform local measurements on single monolayers. The measured nanoscale spectroscopy information is used for precise material identification, analysis of present chemical bonds (e.g. C-O), or even quantitative analysis of functional coatings and thin films consisting of single molecules with thicknesses <2nm.





Phospholipids

Using nano-FTIR the characteristic IR spectral signature can be detected even for ultrathin structures such as a 5-nm-thick phospholipid monolayer. Being quantitative, the signal strength is indicative of the specimen thickness, differentiating between the 5 nm mono- and 10 nm bilayers. These experiments represents the first step towards a complete description of the biochemistry of cell membranes and model systems.

nano-FTIR spectroscopy discriminates mono and double layer lipid structures with unmatched signal-to-noise

analytical chemistry — A. Cernescu et al., Anal. Chem. 2021, 93, 3, 1851

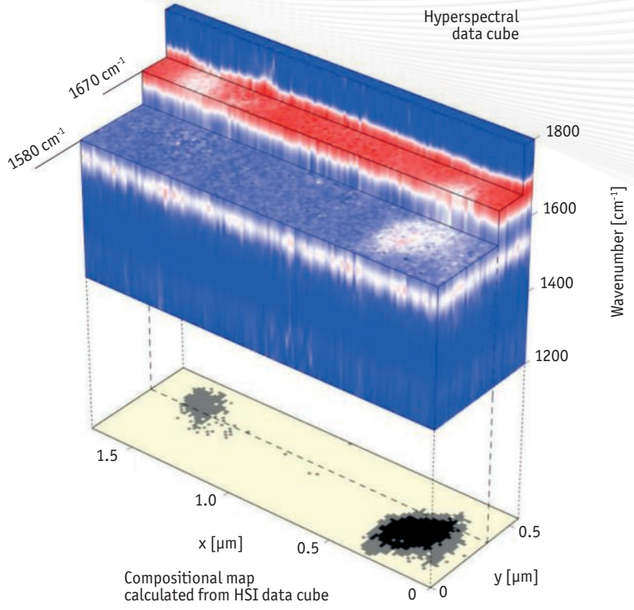
The Journal of Physical Chemistry Letters — A. M. Siddiqueeet al., J. Phys. Chem. Lett. 2020, 11, 9476

Plasma Science and Technology — B. Kärstner et al., ACS Omega 2018, 4, 4141

analytical chemistry — A. Blat et al., Anal. Chem. 2019, 15, 9867

Complete sample analysis of biological specimens with nano-FTIR and hyperspectral imaging

nano-FTIR hyperspectral imaging (HSI) provides full broadband spectroscopic information at every pixel. The neaSCOPE microscope provides unmatched data quality which can be harvested by established methods, e.g. multivariate data analysis, for comprehensive nanoscale analysis of complex biostructures.



Human hair

In-situ infrared vibrational chemical analysis of a medulla cross-section in a resin-embedded human hair performed with nano-FTIR HSI. The infrared hyperspectral imaging data cube (partially cut at different frequencies for improved visibility) allows for a multivariate cluster analysis, resulting in a compositional map (bottom) that reveals natural nanoscale Melanin inclusions (grey and black) in the cortex region (light yellow).

nano-FTIR & hyperspectral imaging provide compositional maps of biostructures at 10-nm spatial resolution

ROYAL SOCIETY OF CHEMISTRY — I. Amenabar et al., Nature Comm. 2017, 8, 14402.

Nano Research — V. Stanic et al., Nanoscale 2018, 10, 14245

Other Applications realized with IR-neaSCOPE+s

nano-FTIR for Polymers

chemical characterization at the nanoscale

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

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.

Additional Services

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