nano-FTIR: Chemical mapping of polymers, biomaterials and composites with 10 nm resolution

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Scattering-type Scanning Near-field Optical Microscopy (s-SNOM) is a scanning probe approach to optical microscopy and spectroscopy bypassing the ubiquitous diffraction limit of light to achieve a spatial resolution of 10 nm. s-SNOM combines the best of two worlds, the nanoscale spatial resolution of Atomic Force Microscopy (AFM) and the analytical power of optical spectroscopy. It employs the strong confinement of light at the apex of a sharp metallic AFM tip to create a nanoscale optical hot-spot. This can be exploited for any wavelength from the visible light to the THz-region.

Analysing the scattered light from the tip interferometrically enables the extraction of the complex dielectric function (absorption, reflectivity) of the sample directly below the tip and yields nanoscale resolved optical images simultaneous to topography. Illuminating with a broadband infrared laser and detecting the elastically scattered light interferometrically (nano-FTIR) allows chemical identification of different materials in a nanocomposite with 10 nm spatial resolution [1]. Multicomponent thin film polymer blends and nano-size impurities in polymer structures can be detected and determined. Furthermore, nano-FTIR has even capabilities to reveal their structural phases or crystallinity [2].

nano-FTIR shows the sensitivity for probing individual insulin and collagen fibres and detects clusters of ultrathin polymer brush layers. Thereby nano-FTIR results demonstrate the detection and spectroscopy of individual protein complexes, the sensitivity for the orientation of the molecules as well as the identification of the secondary structures of the proteins [3]. Also studies on an ancient ceramic piece dated about 4000 BC minerals have shown that very small quantities (10^{-19} cm^3) of crystalline nano-inclusions can be identified.

The exceptional nano-FTIR signal quality provides the basis to keep measurement times in the 100-200 millisecond time scale. This allows hyperspectral imaging in reasonable time. Consequently, a precise nanoscale compositional map of bio-materials, hybrids and nanocomposites can be realized [4].

References

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[2] C. Westermeier, *et al.* Nature Comm. (2014) 5, 4101
[3] I. Amenabar, et al. Nature Comm. 4, 2890 (2013)
[4] I. Amenabar, *et al.*, Nature Comm. (2017) 8, 14402

Figure

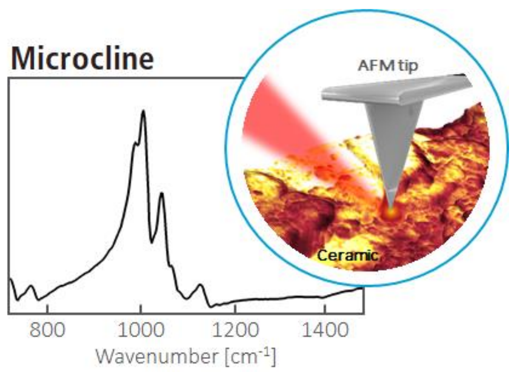

Figure: Mineral identification by nano-FTIR - Characteristic vibrational near-field spectrum of Microcline in a piece of ancient ceramics dated ca. 4000 BC.