Novel microscopic and spectroscopic imaging solutions in nanoparticles and surfaces characterization

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Recently a new approach has emerged in the field of fundamental and applied materials and surfaces analysis: direct express imaging in place of laborious point-by-point analysis with subsequent image generation. Imaging has become a useful tool for chemistry, composition and physical properties characterization. The new direct imaging approach, which involves special technical solutions and novel data treatment options, in addition to its rapidity, also allows retrieving the "classical" form of information from the images (spectra or data for each point of the obtained images), if required. Among such novel express imaging systems, several new instruments that were presented in 2014–2015 are of special interest. They are nano-IR systems nano-IR2 and nano-IR2-s (Anasys Instruments), new XPS systems (K-Alpha+, Escalab 250Xi, Theta Probe) and the latest Raman imaging system (DXRxi) manufactured by Thermo Fisher Scientific.

The revolutionary nano-IR method is a combination of IR-microscopy and AFM, which is basically an atomic force microscope combined with a custom-made optical system. The IR source (tunable pulse IR laser) can be adjusted in order to focus on the sample surface close to the AFM tip (Fig). Due to radiation absorption, a short-term local surface heating and reversible deformation take place. This process causes damped oscillations of an AFM tip, which is in contact with the surface. By analyzing the amplitude and frequency of these oscillations, one can obtain an IR absorption spectrum close to the AFM tip, as well as investigate the viscoelastic properties of the surface. The resulting IR spectra are in very good agreement with those obtained using classical FTIR, while the analysis is performed for very small areas down to 10-15 nm. This makes the new imaging nano-IR approach as a great candidate for nanotechnologies, biomaterials studies and reverse engineering.

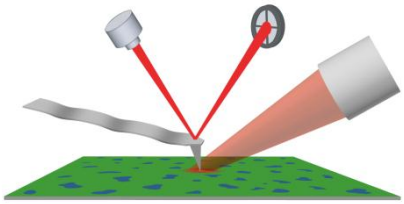

Fig. The principle of nano-IR illustrated

Another interesting imaging technique has been developed using XPS, which has become one of the most widely applied materials characterization technique due to is versatility, high surface sensitivity, possibility to conduct quantitative analysis, determine the chemical state of the elements, as well as electronic structure information. The versatility is determined by the possibility to use XPS for virtually any solid materials, including dielectrics, polymers, nanomaterials, etc. The imaging techniques allow researchers to study distribution of different elements in various chemical states across the surface. By combining the XPS imaging with other surface analysis techniques (e.g. ISS, AES, REELS and the corresponding imaging options), one can obtain the most comprehensive surface chemistry description with spatial resolution.

The report will focus on the theory and practice of the aforementioned methods for various materials, including nanoparticles, thin films, surfaces, catalysts and other functional materials.