ATOM PROBE TOMOGRAPHY: ANALYSIS OF SURFACES AND INTERFACES AT THE TOP OF THE TIP

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Atom probe tomography is an exciting tool in the analysis of interfaces and surface coatings. The method stands out by combining single-atom sensitivity with a direct volume reconstruction, which delivers three-dimensional maps of the atomic arrangement. Due to its direct 3D information, the method is especially suitable for the investigation of complex microstructures that comprise curved or rough interfaces. By extension with laser-assisted evaporation modes, the analysis of semiconductors and ceramics has recently become possible. Nowadays, the method is close to breaking the materials barrier towards soft matter and even liquids.

The talk will first provide an overview of the experimental technique, its physical principles and the extension with laser-assisted evaporation modes. Modern concepts for improving the data processing and the tomographic volume reconstruction are described. Atom probe tomography is well established in the analysis of solid-state materials. So, the analysis of metal/metal and metal/semiconductor interfaces, including the obtained physical insight in interfacial reactions and transport, are demonstrated with examples of nano-crystalline thin films and silicide formation.

In contrast to this, atom probe analysis of soft matter is still a widely unexplored landscape. Proper field-desorption of macromolecular materials, in the form of single atoms or at least small molecular fractions has already been confirmed by experimental studies of self-assembling monolayers and polyelectrolyte coatings. Indeed, the impact of different layer deposition conditions is well reflected in the measured mass spectra, and a basic volume representation has been obtained. An accurate volume reconstruction, however, would become possible only after having derived a detailed understanding of the complex evaporation sequences.

Finally, the possibility of combining atom probe tomography with methods of cryo-preparation is addressed. For this purpose, at the University of Stuttgart, a dedicated atom probe has been directly attached to a dual beam scanning microscope, the latter equipped with a cryo-stage to make the transfer of cryogenic samples as direct as possible. Furthermore, a new preparation technique is enabled through a more flexible atom probe geometry. The unique direct combination of techniques has the potential of analysing liquid/liquid and solid/liquid interfaces. Exemplary successful analyses that demonstrate the cutting-edge possibilities of the innovative instrument are presented.