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Correlative Multimodal Microscopy Using AFM-in-SEM in Material Science

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Correlative multimodal microscopy combines different imaging systems and benefits in understanding the principles in material sciences. Correlative microscopy has become an essential tool helping us understand the complexity of the sample properties. When we imagine the setup of two complementary techniques, atomic force microscopy (AFM) and scanning electron microscopy (SEM), it has several advantages, such as multimodal measurement, under in-situ conditions, and precise localization to the area of interest.

In material sciences, a lot of effort is spent on a fundamental understanding of the surface properties of metal and alloys, thin materials, or batteries. In the case of Mg-Ca-Zn alloy (Fig. 1), a biocompatible and biodegradable material, it is studied for medicinal applications. The content of Zn and Ca has a significant influence on the mechanical properties of the alloy. Certain conditions can lead to the precipitation of a Ca-rich phase, which hardens the material by blocking dislocation movement. Such precipitate was localized using AFM-in-SEM and imaged using the Kelvin Probe Force Microscopy (KPFM) technique, which maps the contact potential difference between the tip and sample. Thanks to the differences in the potential between both phases, we were able to distinguish the hardening precipitate from other islands present on the sample surface.

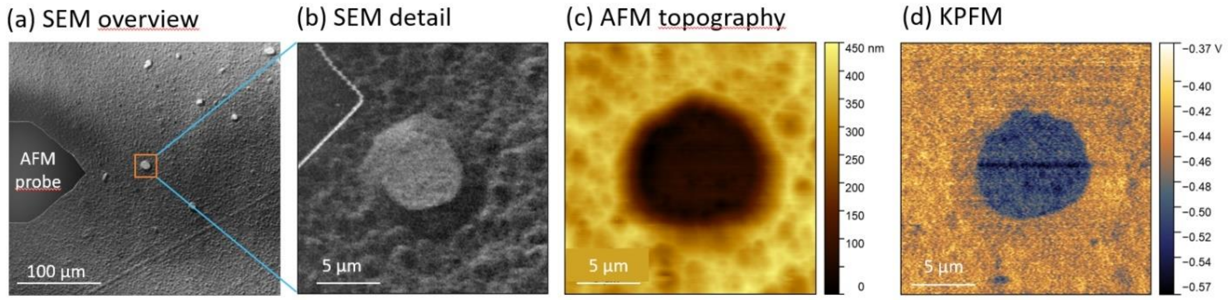

Figure 1: Mg-Ca-Zn alloy with Ca-rich precipitation: (a) SEM overview with detail, (b) AFM topography with surface potential image of the precipitate.

To be able to combine these techniques, a unique Atomic Force Microscope (AFM), LiteScope™, was developed by the NenoVision company for easy „plug & play“ integration into the SEMs. The connection of AFM and SEM enables to merge the strengths of both techniques, resulting in effective workflow and possibilities of complex sample analysis that was difficult or readily impossible by conventional, separate AFM and SEM instrumentation.

Additionally, Correlative Probe and Electron Microscopy, shortly CPEM, is a unique method allowing for precise AFM and SEM data correlation (Fig. 2). The images are acquired simultaneously from both devices in the same coordinate system and conditions and with identical pixel sizes. Thus, the resulting 3D CPEM view can combine multiple channels from AFM and SEM, enabling thorough sample analysis and clear data interpretation.

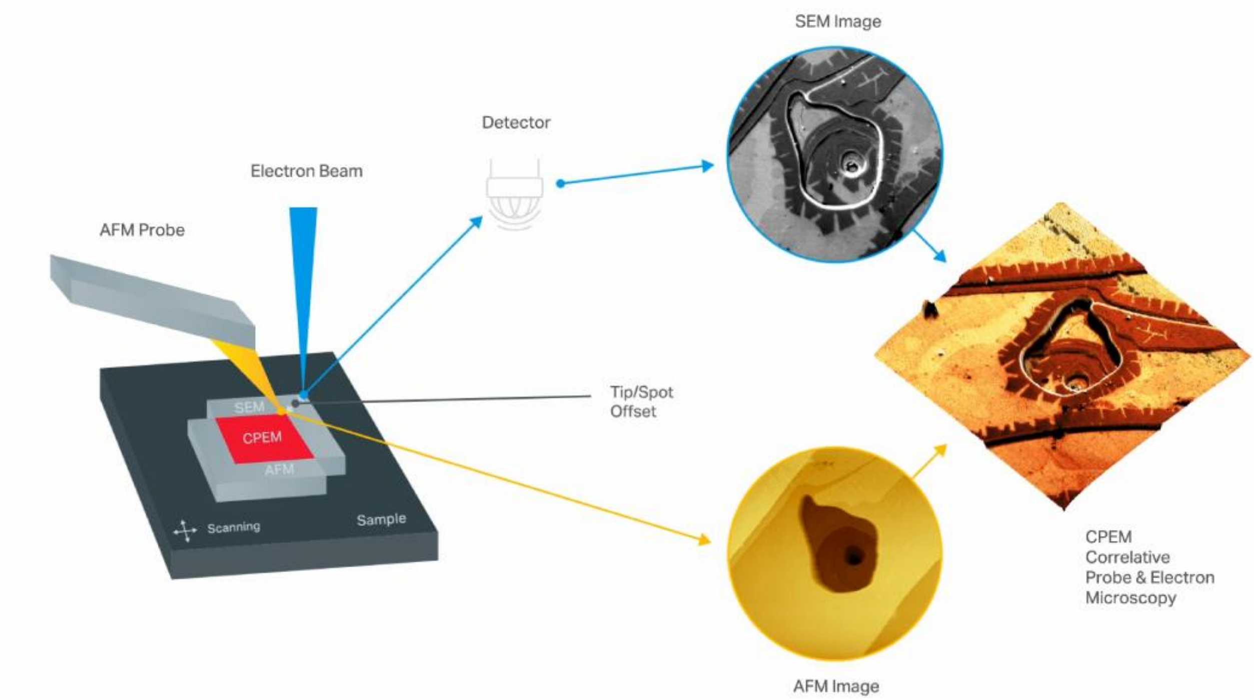

Figure 2: Scheme of CPEM Technology.

Thus, the AFM-in-SEM solution allows us multimodal analyses of AFM modes – such as 3D topography, electrical, magnetic, or mechanical properties – and SEM capabilities like fast imaging, chemical analysis, or surface modification. This way, the Correlative Multimodal Microscopy is essential not only in Material sciences but also in Nanotechnology, Semiconductor, Life sciences, and other areas in both research and industry [1].

References:

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