Abstract - Multimodal Sensing and Imaging Technology by Integrated Scanning Electron, Force, and Near-field Microwave Microscopy and its Application to Submicrometer Studies

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The disciplines of micro- and nanotechnology, materials science, life sciences and in particular the research of semiconductors requires combinatorial tools for the investigation, manipulation and transport of materials and objects in the submicrometer range. The coupling of multiple sensing and imaging techniques allows for obtaining complementary and often unique datasets of samples under test. By means of an integrated microscopy technique with different modalities, it is possible to gain multiple information about nanoscale samples by recording at the same time. The expansion with nanorobotics and an open-source software framework specifically engineered for the requirements in nanotechnology, leads to a technology approach for semiconductor research and material science.

This work contributes to this area of research and shows the potential of such a multimodal technology approach by focusing on a demonstrator setup. It operates under high-vacuum conditions inside the chamber of a Scanning Electron Microscope (SEM) and serves as a technology platform by fusing various microscopy modalities, techniques and processes. An Atomic Force Microscope (AFM) based on a compact, optical interferometer performs imaging of surface topography, and a Scanning Microwave Microscope (SMM) records electromagnetic properties in the microwave frequency domain, both operating inside an SEM. An open-source software framework, tailored for vision-based automation by nanorobotics, controls the instrument. The setup allows for observing the region-of-interest with SEM spatial resolution, while imaging and characterizing with interacting evanescent microwaves and intermolecular forces simultaneously.

In addition, a multimodal test standard is introduced which was designed for this technology and subsequently confirms the functionality of the demonstrator. Within this context, the work also includes an electrical analysis of micro-scale Metal Oxide Semiconductor (MOS) capacitors, including an approximation for use in the calibration of microwave microscopes.