

Complex impedance, permittivity and other electrical materials properties at broadband 20 GHz: new SMM applications for semiconductors & buried structures, 2D materials, and living cells in buffer solution

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The Keysight Scanning Microwave Microscope (SMM) consists of an AFM interfaced with a vector network analyzer (VNA) allowing to measure complex materials properties for nano-electronics, materials science, and life science applications. The SMM operates at broadband frequencies between 1-20 GHz. We present novel calibration workflows for complex impedance imaging and dielectric quantification of various materials including semiconductor devices, buried structures, 2D materials like graphene and MoS₂, and biomaterials like cells and bacteria. Due to the measurement at high frequency laborious realization of back electrode contacts is not required; this makes it an easy applicable tool for electrical characterization on 2D materials. Due to the capability of the electromagnetic wave to penetrate the surface of the sample under study the technique can be used to selectively sense sub-surface features. Calibrated sub-surface and non-contact capacitance imaging of silicon samples is presented and dopant areas can still be detected under a silicon oxide layer. The sub-surface and quantitative resistivity measurement capabilities are demonstrated for silicon back-wafer imaging and semiconductor failure analysis. Finally, SMM imaging in buffer solution is presented on the 7500 SMM including life cell imaging. In summary, we present an extended SMM for advanced voltage and impedance spectroscopy and novel RF calibration workflows that can be applied to nanoscale semicon devices, advanced materials, and biosamples in water solution at 1-20 GHz frequency.

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