Measurement of complex conductance and capacitance in the PHz frequency range with subnanometric spatial resolution: application to the grain boundary of monoclinic hafnia.

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New behavior and phenomena can emerge at oxide interfaces, and the nanocharacterization of these properties is a real challenge for the semiconductor industry[1]. To replace the conventional SiO_2 insulator, hafnium-based oxides have been introduced[2,3] into advanced CMOS devices such as MOSFETs or memories[4], but the nanometric control of their interfacial properties still remains a critical issue. For further industrial implementation of these oxides, it is necessary to obtain sufficiently high bandgaps, good scalability and sufficient reliability[5] at a reasonable cost. In this presentation, we have measured the spatial evolution of local complex conductivity and complex capacity across a grain boundary of hafnia, using energy filtered high-resolution transmission electron microscopy and valence electron energy loss spectroscopy (HRTEM-VEELS). A local increase in the real part of the conductivity inside the grain boundary is evidenced unambiguously. This methodology could be advantageously used to study the leakage pathways and the regions susceptible to early dielectric breakdown in the most advanced dielectric stacks, to further optimize the technological developments of this highly demanding industry.

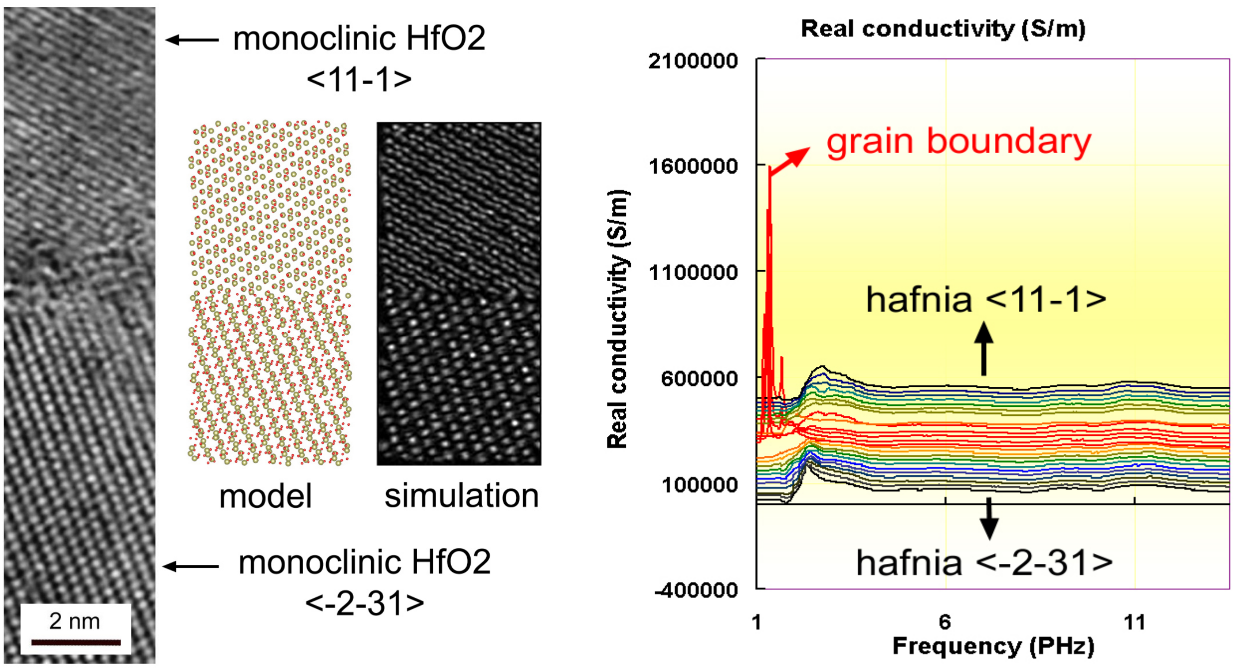

Fig. 1 Left: cross-sectional HRTEM image of the monoclinic HfO_2 grain boundary, with corresponding atomic-scale model and image simulation. Right: evolution of the real part of the electrical conductivity across the grain boundary, extracted from HRTEM-VEELS measurements and Kramers-Kronig transformation. The vertical step is 0.2 nm.

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