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Conductive Atomic Force Microscopy and its Use in Nanoelectronic Device Reliability

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Mario Lanza is Full Professor at Soochow University. Dr. Lanza got his PhD in Electronics in 2010 at Universitat Autonoma de Barcelona, and two postdocs, one at Peking University (2010-2011) and another one at Stanford University (2012-2013). He has published over 80 research papers (including Science), edited the first book on CAFM for Wiley-VCH, and registered four patents (one granted with 1M$). He has received several prestigious awards, including the Young 1000 Talent Award of China, the Elsevier Young Investigator Award, and the Marie Curie postdoctoral fellowship. He is member of the advisory board of the journals Advanced Electronic Materials, Nature Scientific Reports and Nanotechnology, as well as member of the technical committee of several IEEE conferences. His research interests focus on the improvement of electronic devices using two dimensional materials, with special emphasis on layered dielectrics for memory devices.

Conductive atomic force microscopy (CAFM) has become one of the most useful techniques to analyze the electronic properties of many electronic materials and devices. This tutorial will show the capabilities of the CAFM to study many crucial nanoscale phenomena of thin dielectrics, such as the effect of thermal annealing, polycrystallization, thickness fluctuations, local defects, charge trapping and de-trapping, stress-induced leakage current, negative bias temperature instability, dielectric breakdown and resistive switching. The tutorial will also describe how to apply combined electronic and mechanical stresses, which may be crucial for the study of future flexible devices. Data from HfO_2, Al_2O_3, and SiO_2 based devices will be mostly presented, although information about novel two dimensional dielectrics (i.e. hexagonal boron nitride) will be also disclosed. Modifications of standard CAFM setups to achieve higher performances will be also discussed. In the final part, indications about how to perform reliable experiments and how to avoid wrong CAFM data interpretations will be presented.