Development and application of a multifunctional nanoindenter: coupling to electrical measurements and integration in-situ in a Scanning Electron Microscope

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Nanoindentation is a well-known characterisation technique dedicated to local mechanical testing of materials at small scales. In the past decades, numerous efforts have been made to expand the capabilities of nanoindentation technique: real-time electron imaging, coupling with multifunctional characterisation tools, high temperature measurements,...

The present talk will report the development of a home-made multifunctional characterisation device based on a commercial nanoindentation head. <u>This device combines mechanical to electrical characterisations, and can be integrated in-situ in a Scanning Electron Microscope (SEM) :</u>

- Electrical characterisations cover both resistive and capacitive measurements.
- In-situ SEM integration allows precise positioning of nanoindentation tests (precision better than 100nm) as well as the positioning of electrically-coupled indentation maps.

Selected applications will be shown:

- <u>Characterisation of dielectric films under mechanical load</u>: an experimental procedure and a data-processing method have been set up to quantitatively extract the dielectric permittivity of insulating films from capacitive-nanoindentation (Fig.1). The procedure eliminates the stray capacitance which usually disturbs local capacitance measurements by AFM. Small-scale piezoelectric structures have also been characterised (Fig.2).
- <u>Leakage current through insulators under mechanical load</u>: Insulating films are known to degrade when subjected to mechanical stresses. This phenomenon is critical for industrial applications (microelectronics, electrotechnics,…). The present device allows the real-time monitoring of this insulation degradation. Leakage mechanisms with or without mechanical load will be discussed.
- <u>Multifunctional property mapping</u>: The combined mapping of mechanical and electrical properties is also possible. An illustration will be shown on a multiphased metalic alloy developed for its compromise between high tensile strength and high electrical conductivity. Fig.3 shows the 'resistance' mapping performed in such a case.

Prospects are numerous : monitoring of bistable permittivities, improvement of electrical contact reliability, multifunctional property mapping;...

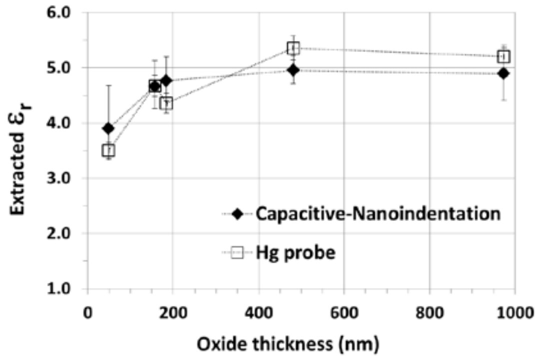

Figure 1: Local measurements of dielectric permittivity on different silica films.

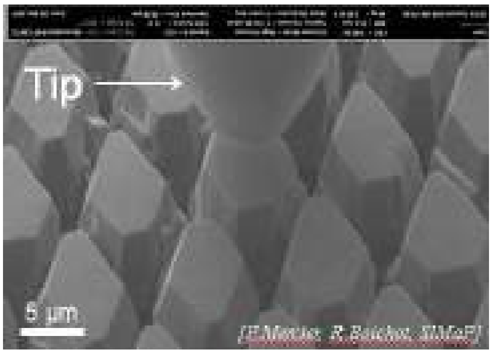

Figure 2: In-situ piezoelectric measurements.

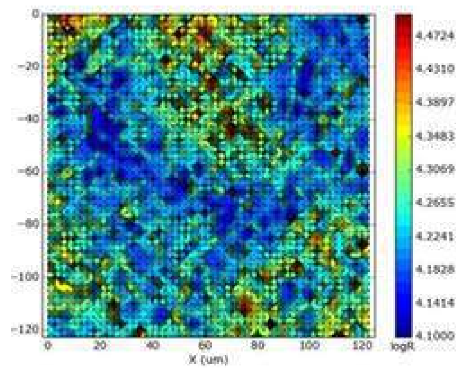

Figure 3: Electrical resistance mapping of a multiphased metallic alloy.

References:

1. H. Nili, K. Kalantar-Zadeh, M. Bhaskaran, S. Sriram, Prog Mater Sci. 58 (2013).