



Development and of a multifunctional nanoindenter: coupling to electrical measurements and integration in a Scanning Electron Microscope D5. Micro-and Nano-mechanics -Characterization and Modelling

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

D5. Micro- and Nano-mechanics – Characterization and Modelling

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Introduction/Purpose

In the past decades, numerous efforts have been made to expand the capabilities of nanoindentation technique [1]: real-time electron imaging, coupling with multifunctional characterisation tools, high temperature measurements,... The present submission reports the development of a home-made multifunctional characterisation device based on a commercial nanoindentation head.

Methods

This device combines mechanical to electrical characterisations, and can be integrated in-situ in a Scanning Electron Microscope (SEM).

- Quantitative electrical characterisations cover resistive, capacitive and current measurements.
- In-situ SEM integration allows precise positioning of local nanoindentation tests (precision better than 100nm) as well as the positioning of electrically-coupled nanoindentation maps.

Results

Different applications will be presented:

- Real-time monitoring of the contact area: a three-step procedure applied to resistive-nanoindentation has been set up, enabling the precise monitoring of the tip-to-sample contact area. Comparison to post-mortem AFM imaging shows excellent agreement.
- Dielectric permittivity determination under mechanical load: a complete procedure has been set up to quantitatively extract the dielectric permittivity of insulating films from capacitive-nanoindentation. The procedure eliminates the effect of the stray capacitance which usually disturbs local capacitance measurements.
- Leakage current through insulators under mechanical load: The degradation of the insulating performance of oxide films subjected to mechanical stresses is critical for industrial applications. Leakage mechanisms with or without load will be discussed.
- Multifunctional property mapping: The device allows the combined mapping of mechanical and electrical properties. A multiphase alloy (developed for its compromise between high tensile strength and high electrical conductivity) has been characterised, thus allowing the correlation of these properties (cf figure).

Conclusions

A promising multifunctional characterisation tool will be presented, as well as different applications. Prospects are numerous : resistive-nanoindentation can become an experimental alternative to analytical models for contact area determination; capacitive-nanoindentation can fill a gap between quantitative characterisations at macro-scales and spatially highly-resolved characterisations at nano-scale; SEM-integration opens to multifunctional property mapping;...

Selected references

[1] H. Nili, K. Kalantar-Zadeh, M. Bhaskaran, S. Sriram, In situ nanoindentation: Probing nanoscale multifunctionality, Prog Mater Sci. 58 (2013)

