

Effect of ageing on the mechanical behavior of nanocrystalline metallic thin films

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Nanocrystalline (nc) materials are used in a large variety of micro- and nanoscale devices. The reliability of these devices requires maintaining adequate mechanical integrity of structural elements over time. This represents a real challenge due to their far from equilibrium microstructure. The stability of nanocrystalline materials is most often addressed in the literature in terms of thermal stability of a microstructure under heating or under severe plastic deformation.

In this work, the mechanical stability is characterized experimentally and commented regarding different ageing methods based on the evolution of internal stress by defect recovery and creep. On-chip microtensile testing technique and nanoindentation, coupled with advanced TEM microscopy, are used to quantify and understand the level of rate sensitivity of nanocrystalline Pd thin films.

Nanoindentation is performed by maintaining the stiffness constant during the test in order to solicit the material similarly to what is done during the relaxation of on-chip tensile structures. The mechanical perturbation applied via the indenter or using internal on-chip actuation of the material is evaluated and compared for the different ageing conditions of nanocrystalline Pd thin films. Microtensile tests reveal a similar strain rate sensitivity of aged films although high resolution TEM shows an evolution of the initial microstructure upon ageing. A careful choice of the nanoindentation method is mandatory for challenging and confirming the microtensile results.