

Mechanical properties characterization of freestanding palladium films by on-chip internal stress controlled nanomechanical tensile testing

M.-S. Colla¹, M. Coulombier¹, A. Boé⁴, H. Idrissi³, B. Wang³, D. Schryvers³, J.-P. Raskin², T. Pardoen¹

¹ Institute of Mechanics, Materials and Civil Engineering, Université catholique de Louvain, Place Sainte-Barbe 2, 1348 Louvain-la-Neuve, Belgium

² Institute of Information and Communication Technologies, Electronics and Applied Mathematics, Université catholique de Louvain, Place du Levant 3, 1348 Louvain-la-Neuve, Belgium

³ EMAT, University of Antwerp, Groenenborgerlaan 171, 2020 Antwerpen, Belgium

⁴ IEMN / IRICICA, Université de Lille, 50 Avenue Halley, 59652 Villeneuve d'Ascq, France

E-mail : marie-stephane.colla@uclouvain.be

A new concept of nanomechanical lab-on-chip has been developed to study the mechanical properties of submicron freestanding thin films including the elastic stiffness, onset of plasticity, strain hardening capacity, and ductility. The main idea is to use the residual stress present in a long beam material (the *actuator*) to deform another material attached to it (the *sample*) through the release of the underneath sacrificial layer (see Figure 1) [1-2]. Uniaxial tensile tests are performed on pure palladium thin films with a thickness equal to 360 nm based on this technique. The tensile tests reveal that the films present a ductility of typically 3-4 percents, as well as a very large strain hardening capacity. Several size effects have also been identified. The width, the length and the thickness of the samples influence the mechanical properties in one way or another. Transmission electron microscopy (TEM) and high resolution TEM (HRTEM) are used to characterize the microstructure prior to deformation as well as of the deformed samples in order to elucidate the origin of the high strain hardening capacity and the failure mechanisms. The very small grains (20 nm) contain a high density of fine coherent growth twins (2-4 nm thickness) offering multiple barriers to dislocation motion, and sources for dislocation storage and multiplication.

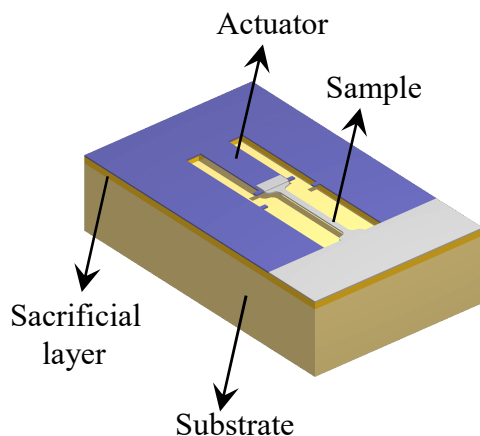


Figure 1 - Elementary microtensile testing machine

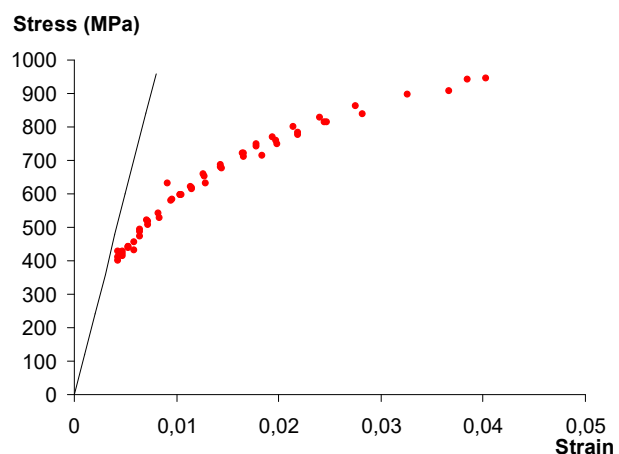


Figure 2 - Typical stress-strain curve of Pd thin film

[1] S. Gravier, M. Coulombier, A. Safi, N. André, A. Boé, J.-P. Raskin and T. Pardoen, *Journal of MicroElectroMechanical Systems*, vol. 18, no. 3, p. 555.

[2] D. Fabrègue, N. André, M. Coulombier, J.-P. Raskin and T. Pardoen, *Micro and Nanoletters*, vol. 2 (2007), p. 13.