Size-Effect on Superelasticity at Nano-scale in Shape Memory Alloys for Potential Applications in MEMS

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Shape Memory Alloys exhibit a superelastic stress-induced phase transformation with a high displacement actuation, which are promising for applications in Micro Electro-mechanical Systems (MEMS). Previous works demonstrate a completely reversible and reproducible behaviour at nanoscale [1,2], even for thousands of cycles [3]. However, some fundamental aspects at nanoscale remain unclear, in particular whether the critical stress for superelasticity exhibits a size-effect similar to that observed in confined plasticity. Our results provide the evidence of a strong size-effect on the critical stress that induce such phase transformation [4]. This has been observed in pillars, milled by FIB in single crystal slides from Cu-Al-Ni and other SMA, from 2 μm to 260 nm in diameter. The critical stress for superelasticity has been measured by nano-compression tests.
A power-law size dependence of n=-2 has been determined for the superelasticity at nanoscale. Our observations are explained through an atomistic model, involving the atomic lattice shearing triggered by the elastic strain during homogeneous martensitic transformation.

References

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[3] J. San Juan, J.F. Gómez-Cortés, G.A. López, C. Jiao, M.L. Nó, Appl. Phys. Letters, 104 (2014) 011901
[4] J.F. Gómez-Cortés, M.L. Nó, I. López-Ferreño, J. Hernández-Saz, S.I. Molina, A. Chuvilin, J.M. San Juan, Nature Nanotechnology, 12 (2017) 790

Figures

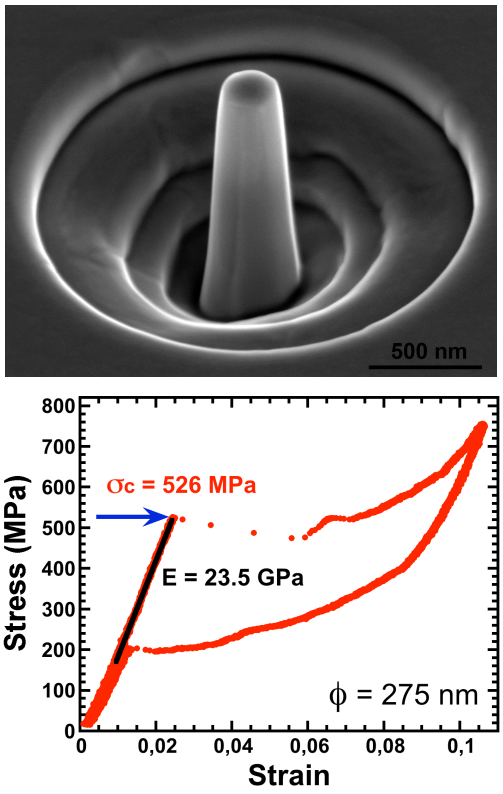

Figure 1: Cu-Al-Ni pillar, 275 nm in diameter, and the nano-compression superelastic test

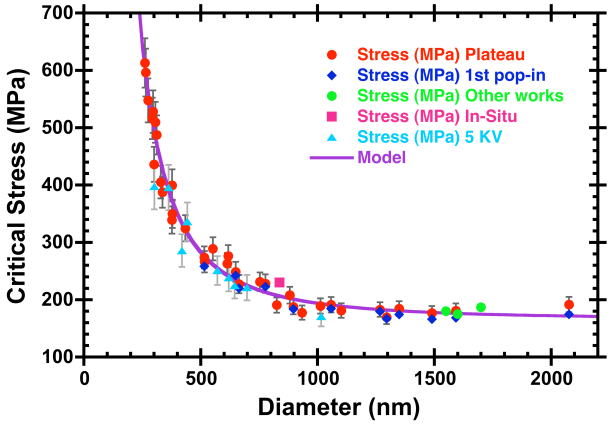

Figure 2: Size-effect measured on the critical stress for superelasticity, versus pillar diameter, and the prediction of the proposed model [4].