COMPRESSION OF GOLD SUB-MICRON CRYSTALLITES: METHOD AND EXPERIMENTS

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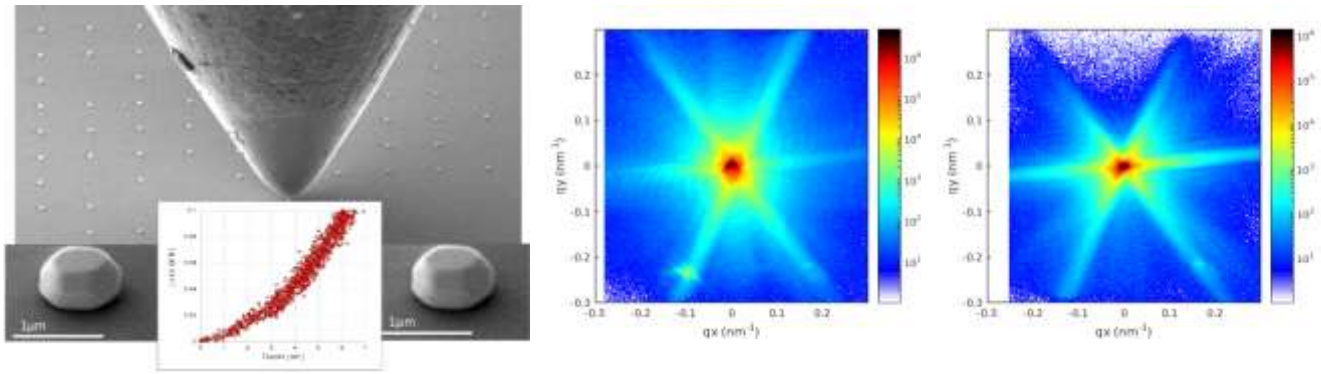
Understanding and characterizing the mechanical response of individual nanostructure is of great importance for both fundamental prospects and device reliability. Higher flow stress with decreasing sample size is observed together with jerky flow. Compression of pristine submicron gold crystallites yield at very large stress in a stochastic manner, followed by large displacement bursts reaching up to 50% of the initial height [1,2].
In this work, by collecting a large set of measurements, we investigate the small and large strain behavior of crystallites loaded in compression. Large arrays of [111] oriented gold crystallites are prepared by solid state dewetting of initial cylinders of different volumes on sapphire substrates. Dedicated flat punch compression *in-situ* a FEG-SEM (figure 1a) has been carried out in load controlled mode [3]. Microstructure of defects is investigated using synchrotron radiation by nanoscale 3D imaging (Bragg Coherent X-ray Diffraction Imaging) [4] and Atomic Force Microscopy observations. The analysis of the plastic instability and its amount of deformation is carried out taking into account the inertial effect of the instrument, using a 1D dynamic model and Finite Element Method calculations. Simulations are made with different estimates of the shape of each individual crystallite, from an ideal cylinder of equivalent volume to the one based on SEM or AFM observations. We show that prior to the displacement burst, plastic events take place and that the sudden displacement does not necessarily relates to the onset of dislocation nucleation (figure 1b). Moreover, using the collection of measurements, we show that a unique stress-strain response can be obtained which can be used as a lower bound estimate of the mechanical response in compression of the crystallites.



(a) *(b)*

Figure 1 – (a) Flat punch compression of Au crystallite array insitu a SEM-FEG, inset showing a reversible force-displacement, (b) associated coherent diffraction [111] Bragg before and after 'reversible' loading

[1] W M Mook, C Niederberger, M Bechelany, L Philippe and J Michler, Nanotechnology 21, (2010) 55701
[2] D.Mordehai, SW Lee, B. Backes, D.J. Srolovitz, W.D. Nix,E. Rabkin, Acta Mat. 59 (2011) 5202
[3] S.Comby, Univ. Grenoble Alpes Thesis (2018), https://tel.archives-ouvertes.fr/tel-01897366v1
[4] M. Dupraz, G. Beutier, T.W. Cornelius, G. Parry, Z. Ren, S. Labat, M.-I. Richard, G.A. Chahine, O. Kovalenko, M. De Boissieu, E. Rabkin, M. Verdier, O. Thomas, Nano Lett. 17 (2017) 6696