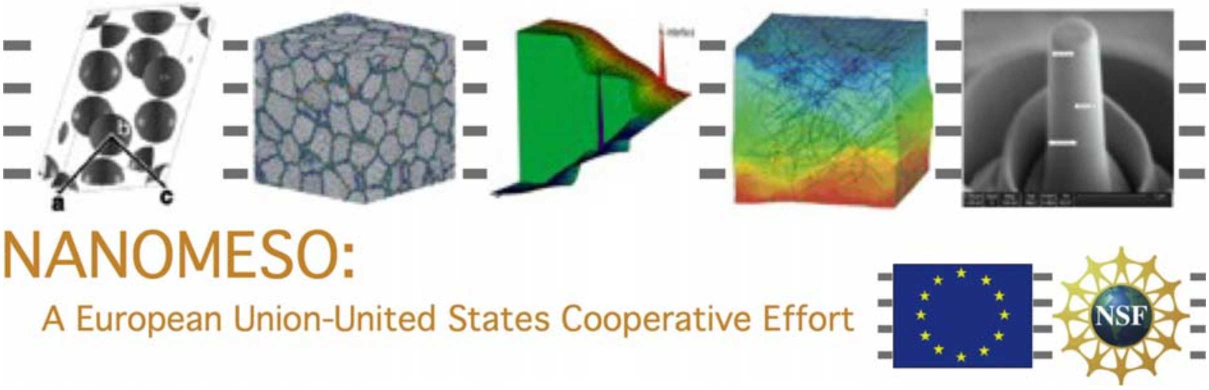
NANOMESO: Size Effects in Mechanical Properties



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NANOMESO is a European Commission and United Stated Cooperative Research project. The project brings together modeling and experimental expertise for investigating size effects in the mechanical properties of micro samples and nanocrystalline materials. It is funded by the European Commission and the National Science Foundation, USA. This project started in March 2006 and will finish in February 2009.

The following groups are involved:

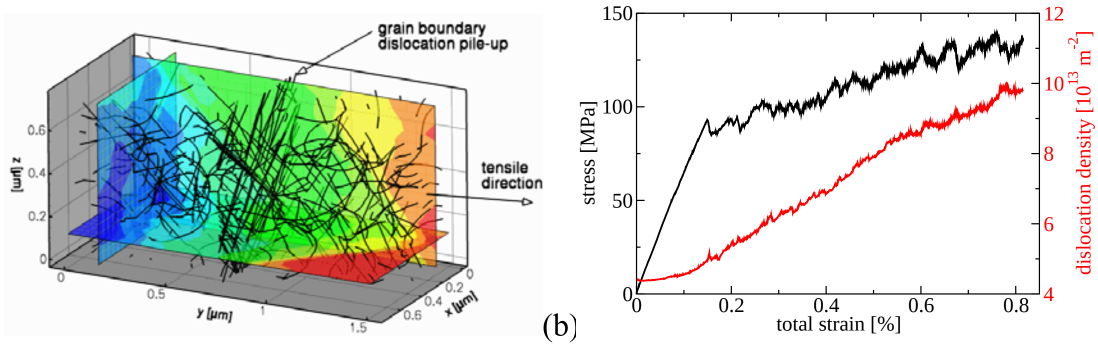
EU – research groups:
- Prof. Helena von Schwygenhoven, Paul Scherrer Institut (PSI), CH, Project leader
- Prof. Erik van der Giessen, University of Groningen (RUG), NL
- Prof. Peter Gumbsch, izbs, University of Karlsruhe
- Prof. Oliver Kraft, IMF II, Forschungszentrum Karlsruhe

USA – research groups:
- Prof. Peter Anderson, Ohio State University
- Prof. Ju Li, Ohio State University
- Prof. Richard G. Hoagland, Los Alamos National Laboratory
- Prof. William D. Nix, Stanford University

Plasticity in small dimensions is found to be size-dependent in experiments. Motivated by these results, the aim of this project is to bridge experimental observations with simulations to gain insight into micro structural behavior. Between the individual research groups, different length and time scales are concatenated with a multi-scale modeling approach. The goal is to develop and validate a computational tool which allows simulations at the meso-scale. It captures the important atomistic aspects of dislocation nucleation at interfaces and free surfaces under loading conditions. A better understanding of the mechanical properties in micrometer samples that emerged in this project enable an improvement of metallic parts in technical devices like Micro-Electro-Mechanical Systems.

The “International Workshop on Small Scale Plasticity” in Braunwald (CH) from September 5th – 8th 2007 was organized by the NANOMESO group and attracted more than 80 participants from Europe and USA. The workshop gave an excellent summary of state of the art small scale plasticity and size effects.

At izbs, two topics are investigated using our three-dimensional discrete dislocation dynamics tool (DDD): (i) analysis of the size effects in single crystalline micro-meter pillars and (ii) the influence of grain boundaries (GB) on the evolution of the dislocation microstructure. The dislocation GB interaction is studied for bi-crystalline samples, shown in Fig. 1 and in thin films.



(a) (b)

Fig. 1: **(**a) Pillar with a horizontal GB (arrow) under tensile loading. Dislocations (black lines) and displacement in tensile direction due to dislocations at 0.8% total strain are presented. b) Stress strain curve and evolution of dislocation density of pillar

The aluminium pillar with 1.5 µm cross section and a height of 3 µm has a horizontal GB with a twist angle of 8° around the common <100> loading axis (y-direction). Due to the formation of dislocation pile ups at the GB under tensile loading, which leads to an increase of the overall dislocation density, a hardening rate of 8 GPa is observed in the stress vs. strain curve shown in Fig. 1b.