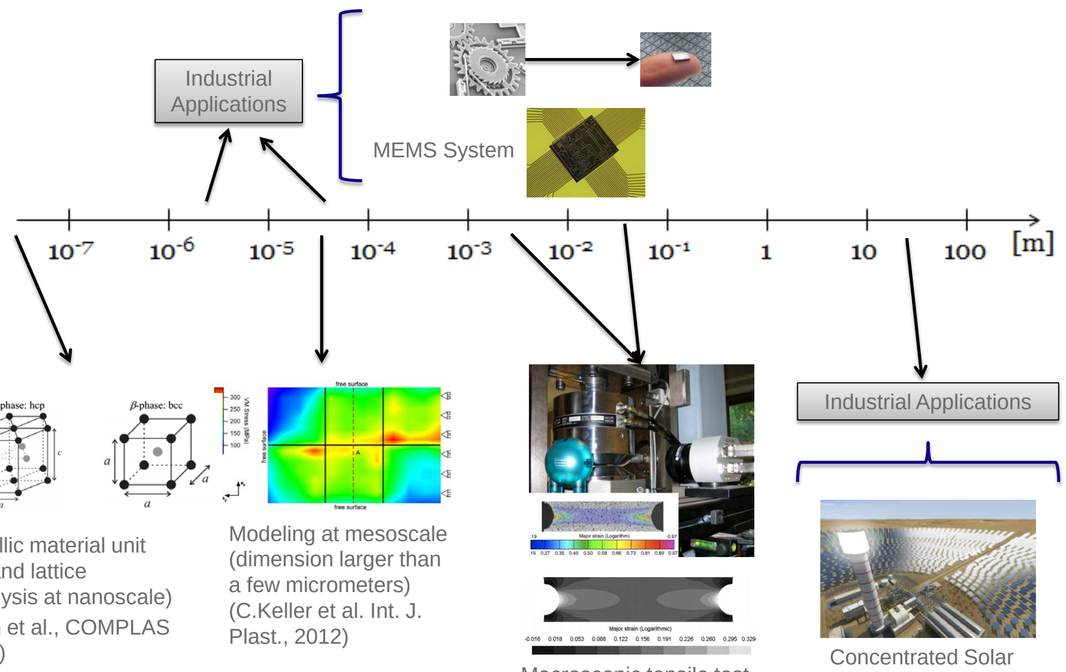
Materials and Solid Mechanics (MSM)

Modeling Material Mechanical Behavior at Various Length Scales

Multi-Scale Analysis of Materials



Metallic material unit cell and lattice (Analysis at nanoscale) (Tran et al., COMPLAS 2014)

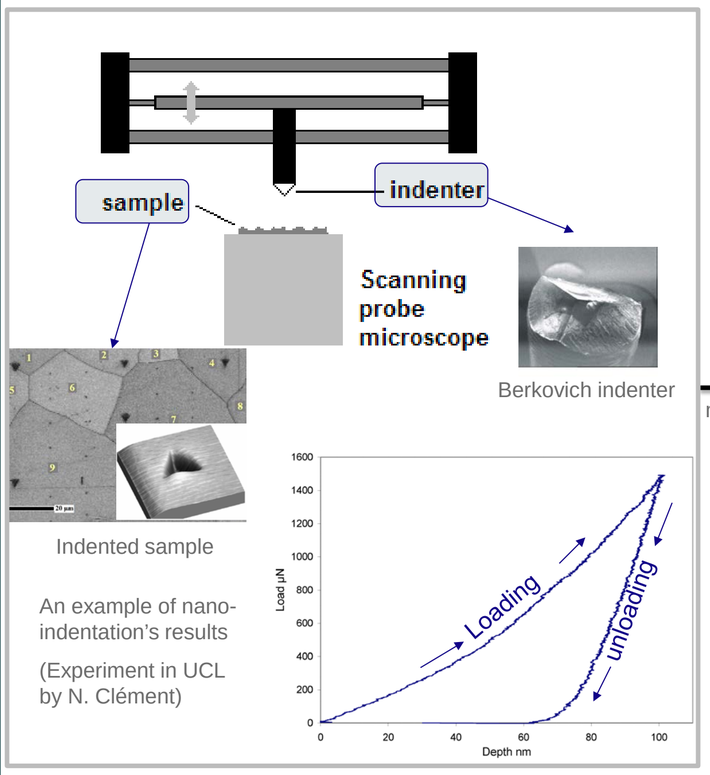
Modeling at mesoscale (dimension larger than a few micrometers) (C.Keller et al. Int. J. Plast., 2012)

Macroscopic tensile test and numerical modeling (P. Flores et al., J. Mat. Proc. Techn., 2010)

Concentrated Solar Power Tower (CSP)

Bridge

Nano-Indentation Technique (10^{-6} ~ 10^{-4} m)



Berkovich indenter

Indented sample

An example of nano-indentation's results

(Experiment in UCL by N. Clément)

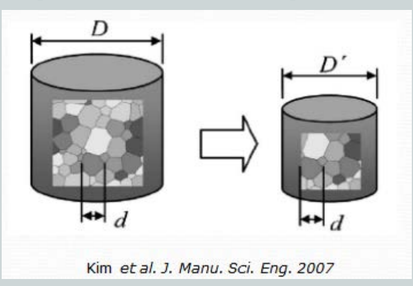
modeling

Mesh for the Crystal plasticity FE model

Constitutive law + Strategy of computation

Nano-indentation numerical simulation (A. Gerday et al., Acta Materialia, 2009)

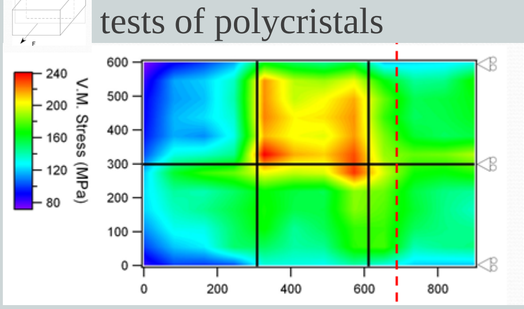
Micro-forming – Size effects on mechanical behavior (10^{-5} ~ 10^{-3} m)



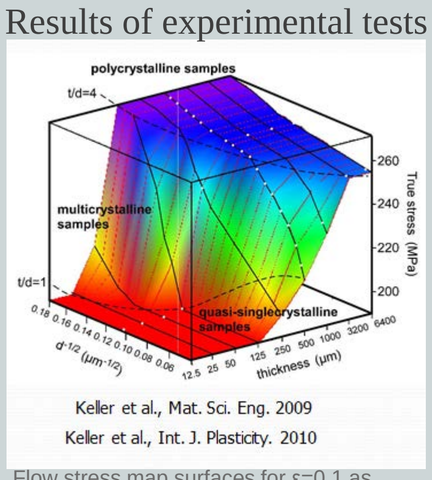
Kim et al. J. Manu. Sci. Eng. 2007

Decreasing the specimen size involves a decrease of the number of grains across the thickness or diameter (t/d or D/d ratio)

Numerical modeling – tensile tests of polycristals



Results of experimental tests

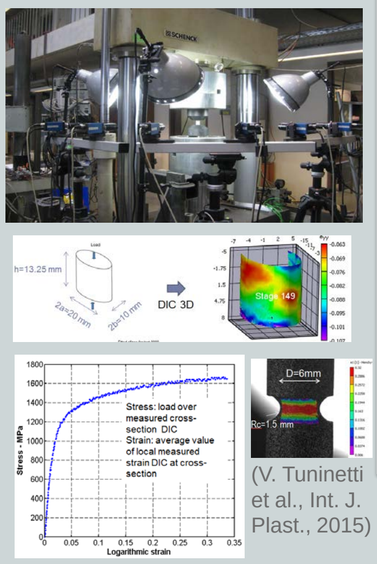


Keller et al., Mat. Sci. Eng. 2009
Keller et al., Int. J. Plasticity. 2010

Flow stress map surfaces for ε=0,1 as function of the thickness and 1/√d

Different kinds of mechanical tests (10^{-3} ~ 1 m)

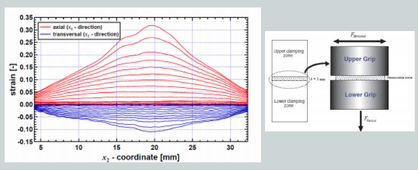
Digital Image Correlation System (DIC)



(V. Tuninetti et al., Int. J. Plast., 2015)

Biaxial test

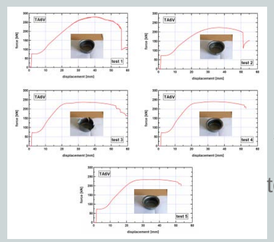
Biaxial machine ULg



Axial and transversal strain distributions for a rectangular shape specimen (G. Gilles, Ph.D. thesis, 2015)

Deep-drawing test

Experimental device used for deep-drawing test (ENSAM Metz)



Force – displacement curves and fractured specimens for deep-drawing tests (G. Gilles, Ph.D. thesis, 2015)

Nanoscale QuasiContinuum simulations (< 10^{-7}m)

Triple Junction by Quasi Continuum

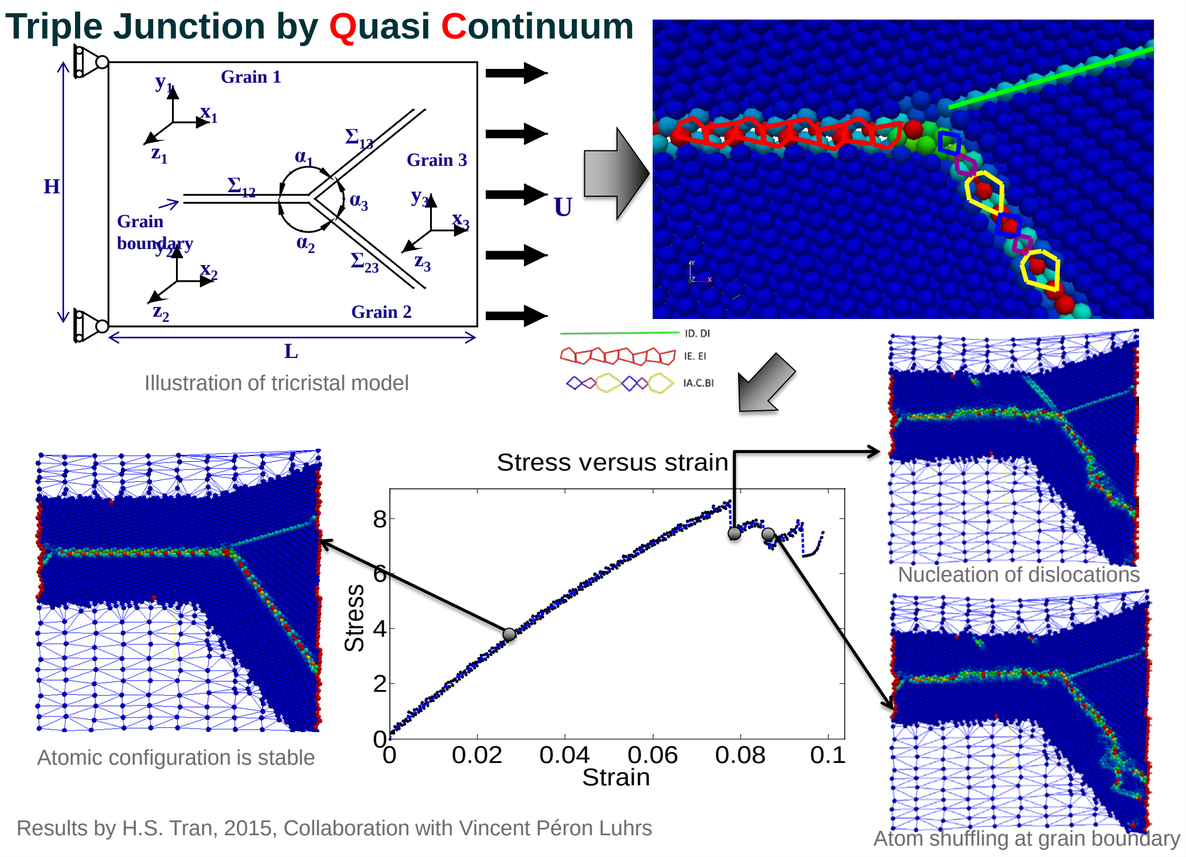


Illustration of tricristal model

Results by H.S. Tran, 2015, Collaboration with Vincent Péron Luhrs

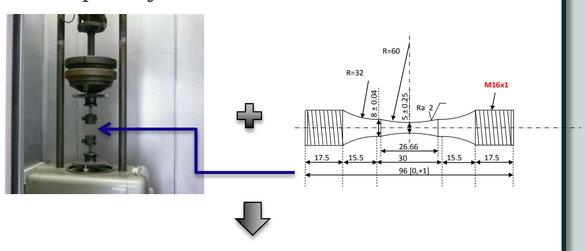
Bridge OPTIBRI Project (>10m)

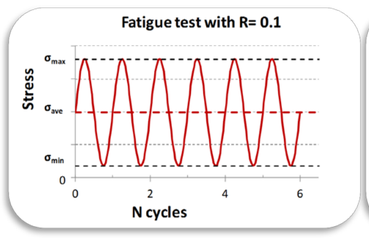
- Optimal use of High Strength Steel grades within Bridges

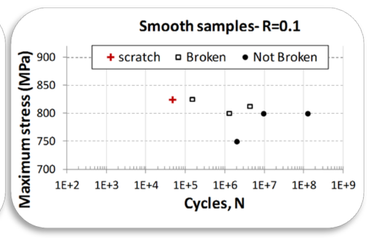
European Project – 6 Partners → Belgium (3), Germany (1), Portugal (2)

- Material Characterization (Base material, welding, HAZ)
  - Mechanical behavior
  - Fatigue Properties
- Numerical simulations
  - welded pieces
  - critical section

Fatigue tests by Vibrophore
- Frequency 148Hz







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