### Multi-Scale Analysis of Materials

**Digital Image Correlation System (DIC)**
- Biaxial test
- Deep-drawing test

**Nanoscale QuasiContinuum simulations (<10⁻⁷ m)**

**Different kinds of mechanical tests (10⁻³ ~ 1 m)**

**Micro-forming – Size effects on mechanical behavior**

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

**Results of experimental tests**

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

**Bridge OPTIBRI Project (>10m)**

- Optimal use of High Strength Steel grades within Bridges

**Concentrated Solar Power Tower (CSP)**

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

**Force-displacement curves and fractured specimens for deep-drawing tests**

**Digital Image Correlation (DIC)**

**Biaxial machine ULg**

**Axial and transversal strain distributions for a rectangular shape specimen**

**Numerical modeling – tensile tests of polycrystals**

- Fatigue tests by Vibrophore
  - Frequency 148Hz

**Experimental device used for deep-drawing test**

**Force-displacement curves and fractured specimens for deep-drawing tests**

**An example of nano-indentation's results**

**Nano-indentation numerical simulation**

**Stress versus strain**

- Atomic configuration is stable
- Atom shuffling at grain boundary

**Constitutive law**

**Strategy of computation**

**Mesh for the Crystal plasticity FE model**

**Illustration of bicrystal model**

**Force – displacement curves and fractured specimens for deep-drawing tests**

**Three Junction model**

**Fatigue tests by Vibrophore**

- Frequency 148Hz

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**Industrial Applications**

- Bridge OPTIBRI Project (>10m)
- MEMS System
- Digital Image Correlation System (DIC)
- Biaxial test
- Deep-drawing test

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**Multi-Scale Analysis of Materials**

**Nano-Indentation Technique (10⁻⁶ ~ 10⁻⁴ m)**

**Industrial Applications**

- 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)
- Metalic material unit cell and lattice (Analysis at nanoscale)

**C.Keller et al. Int. J. Plast., 2012**

**Tran et al., COMPLAS 2014**

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

**Material and Solid Mechanics (MSM)**

**Modeling Material Mechanical Behavior at Various Length Scales**