MSMP Mechanics, Surfaces and Materials Processing

TCM-IMS

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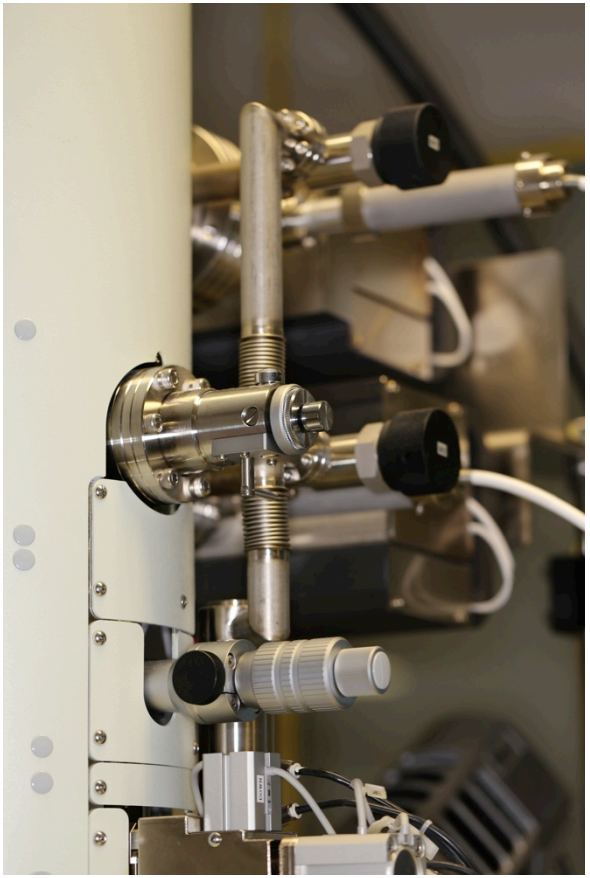
ARTS ET MÉTIERS ParisTech

Surface integrity and durability of mechanical parts



MEB-FEG Jeol 7001F

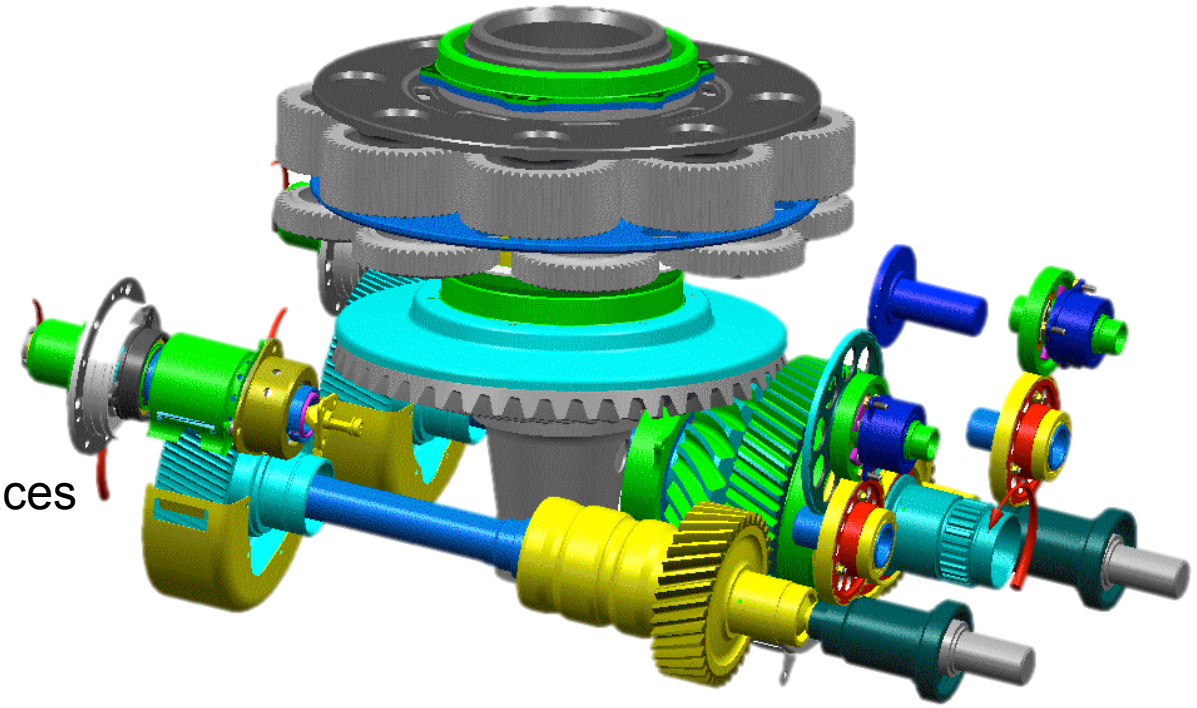
MSMP Mechanics, Surfaces and Materials Processing

Laser welding

From the surface to the durabilty

- Concepts of integrity and use of mechanical parts
  - Exemples
  - Principle
- Mechanical surface
  - Definition
  - Relationship with the mechanical processings
- Multiscale approaches
  - Exemples
  - Principle

Gearwhell of gear box



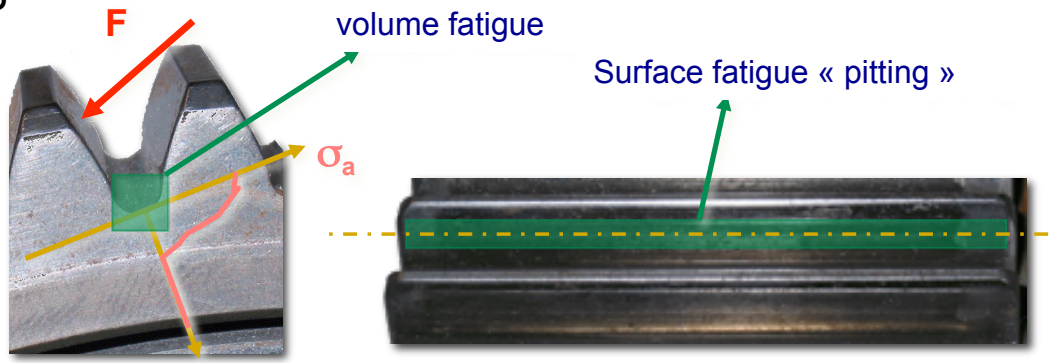
processing

surfaces/interfaces

materials

loading

durability



Example 2

Steam generator tubes

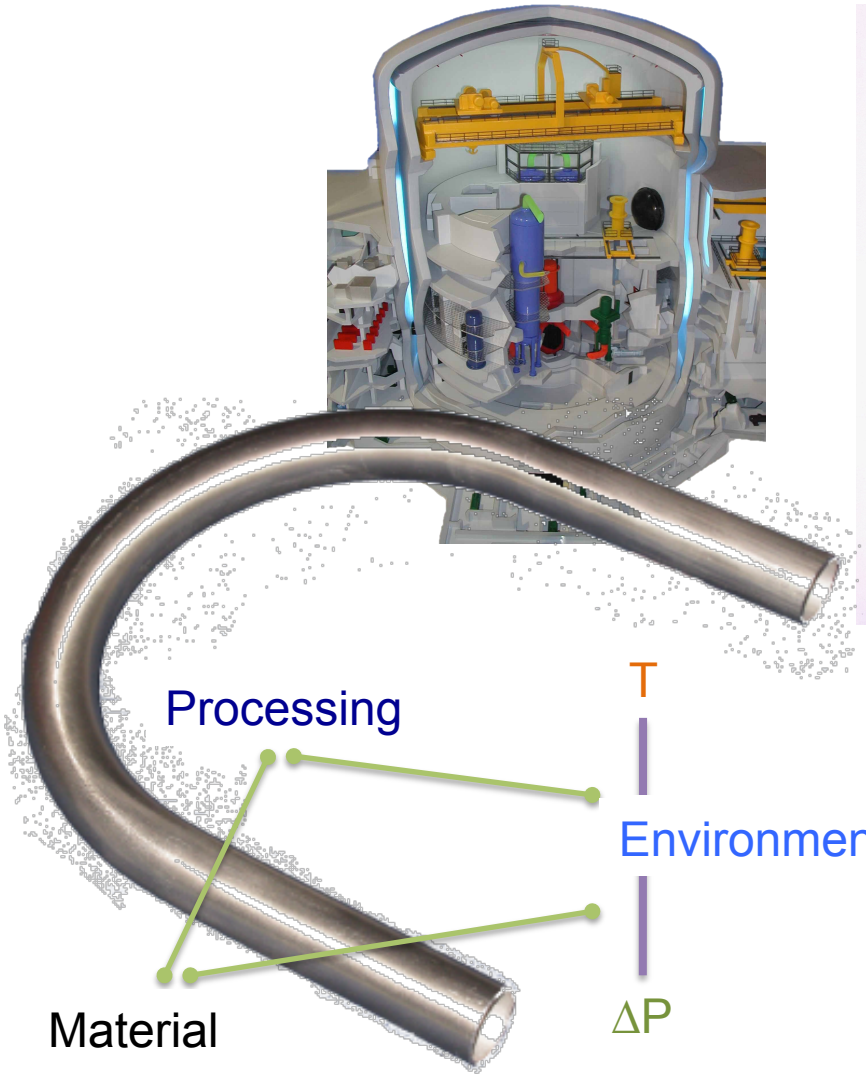
processing

surfaces/interfaces

materials

loading

durability



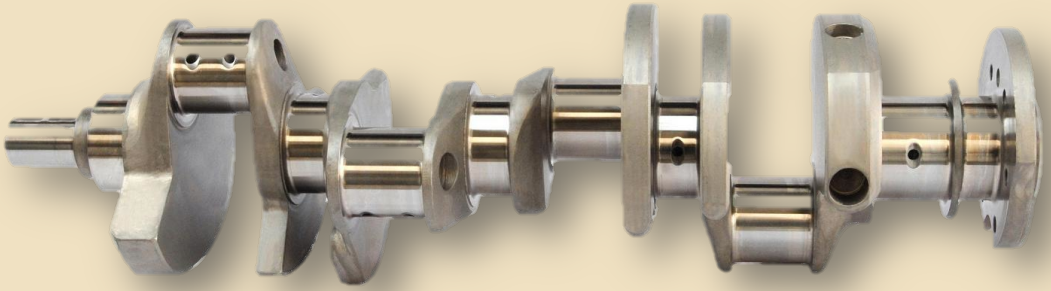
Principle

Dendritic microstructure

From the surface to the durabilty : a global approaches

Processings
- Metal elaboration
- Forming, casting, forging,…
- Direct manufacturing
- Machining, cutting,grinding,…
- Surface treatments
- Sequence

Loading
- Mechanical
- Chemical
- Thermal
- Radiation (neutron)



Generation
- Volume
- Surface
- Microstructures

Modification
- Microstructure
- Wear
- …

Constraints
- Price
- Environment
- Regulation

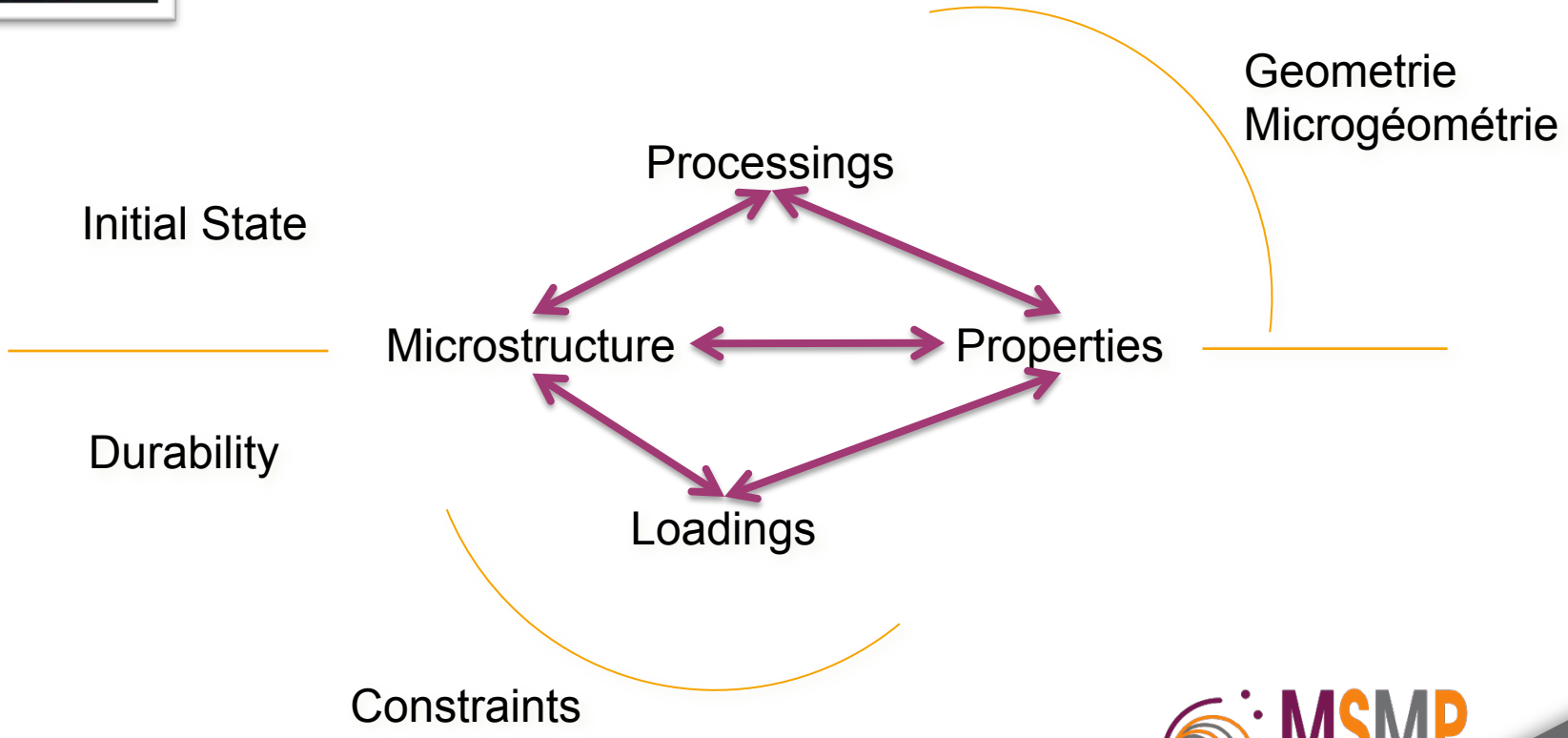
Use
- Functionality
- Service life
- Fiability
- …

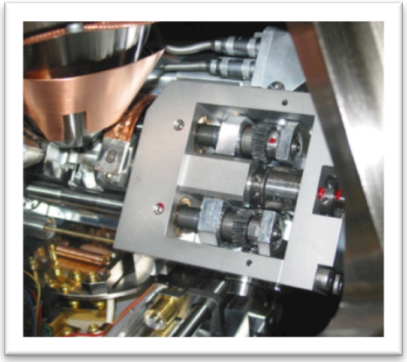
Schematic approach

Power train

From the surface to the durabilty

- Durability is a function of the initial state
- Depending of (μ)geometry and external constraints
- Multiscale approaches



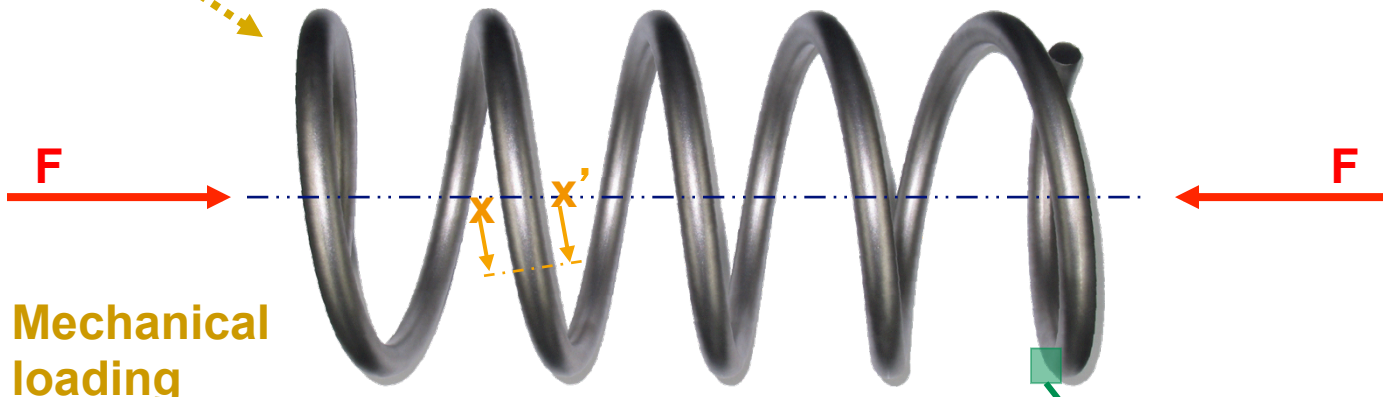


From the surface to the durabilty

- Material close to the surface is generaly the more loaded

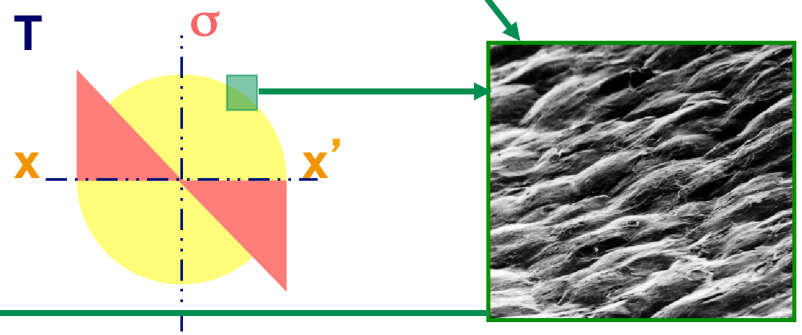
Environment

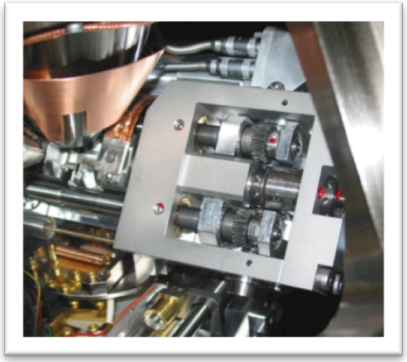
Surface: materials do not always call!



Mechanical loading

- Maximum surface stress
- Surface corrosion
- Cyclic effets
- µgeometrical effects
- Contacts





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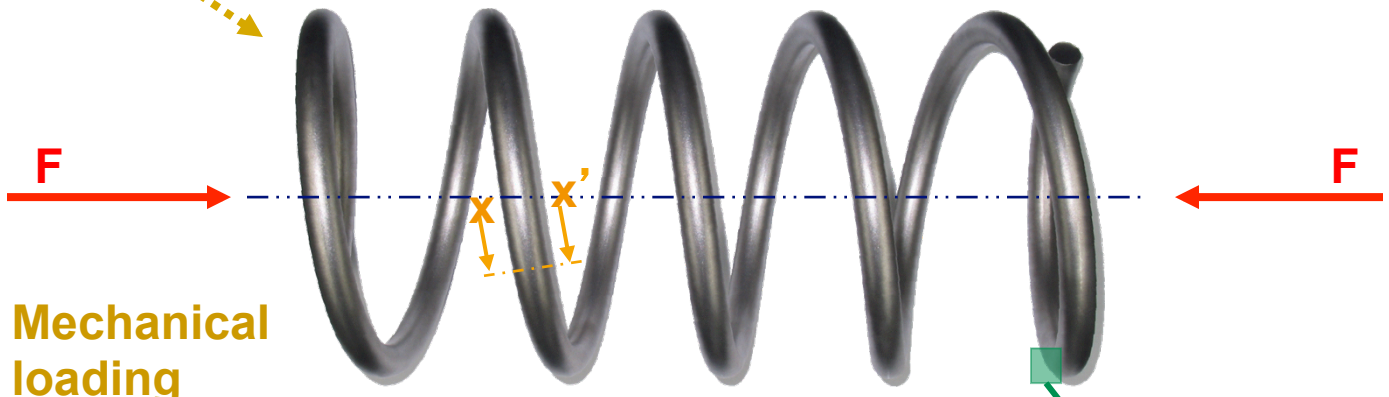

Functionality
Energy storage
Number of cycles to failure
Fiability
Service time

Mechanical loading

Maximum surface stress
Surface corrosion

Shot Peening
Painting

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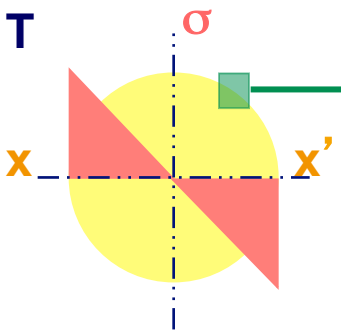
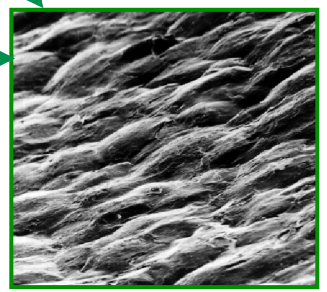




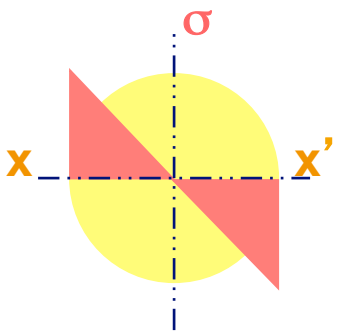
Cyclic effets

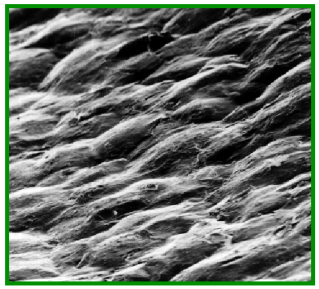
High elastic limit carbon steel

Constraints
Low price

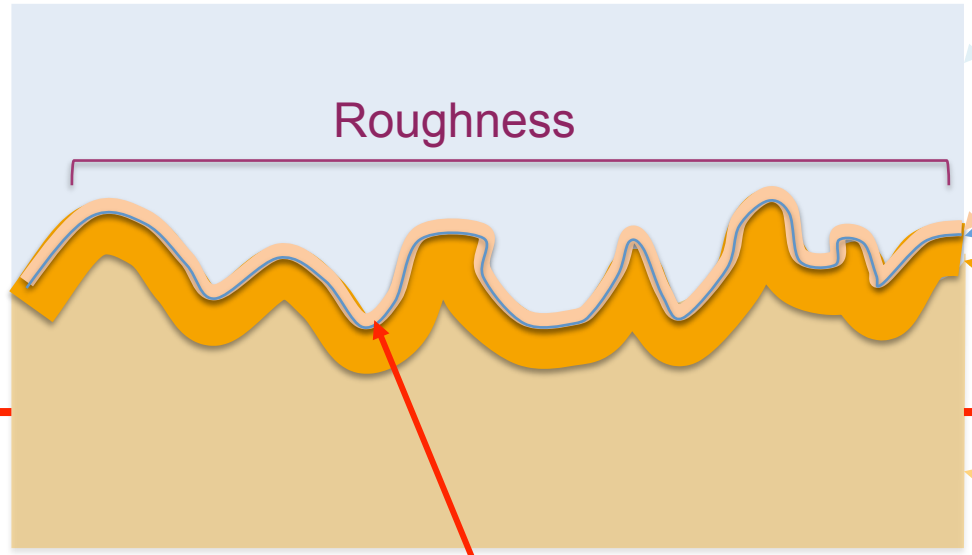
From the surface to the durabilty

- Material close to the surface is generaly the more loaded





Functionality
Energy storage
Number of cycles to failure
Fiability
Service time



Shot Peening
Painting

High elastic limit carbon steel

From the surface to the durabilty

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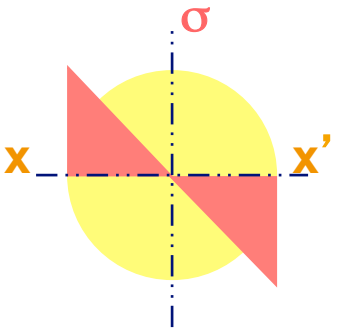
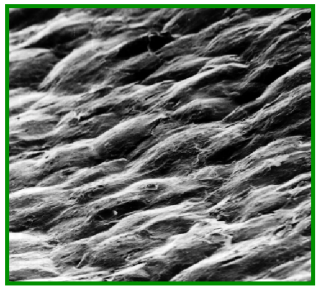
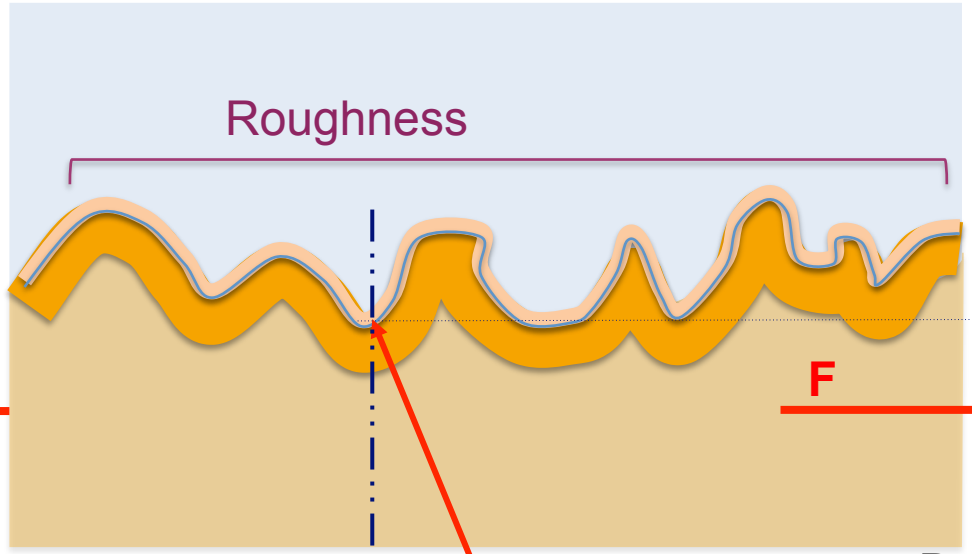




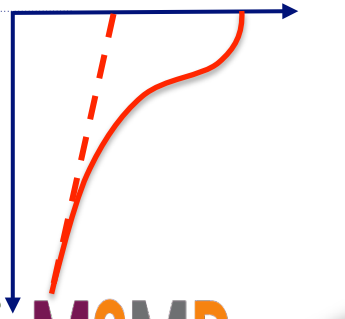
Functionality
Energy storage
Number of cycles to failure
Fiability
Service time

Scale effect



Shot Peening
Painting

High elastic limit carbon steel

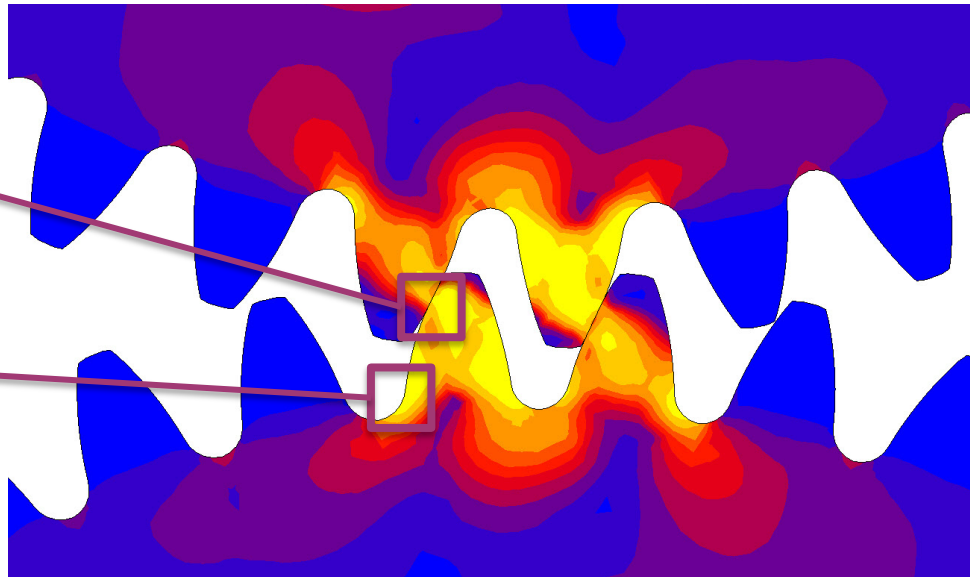


Surface for mechanical parts

- Material close to the surface is generaly the more loaded

Surface loading
- Superficial fatigue
- Pitting (high loading)
- Wear

Volume loading
- Volume fatigue

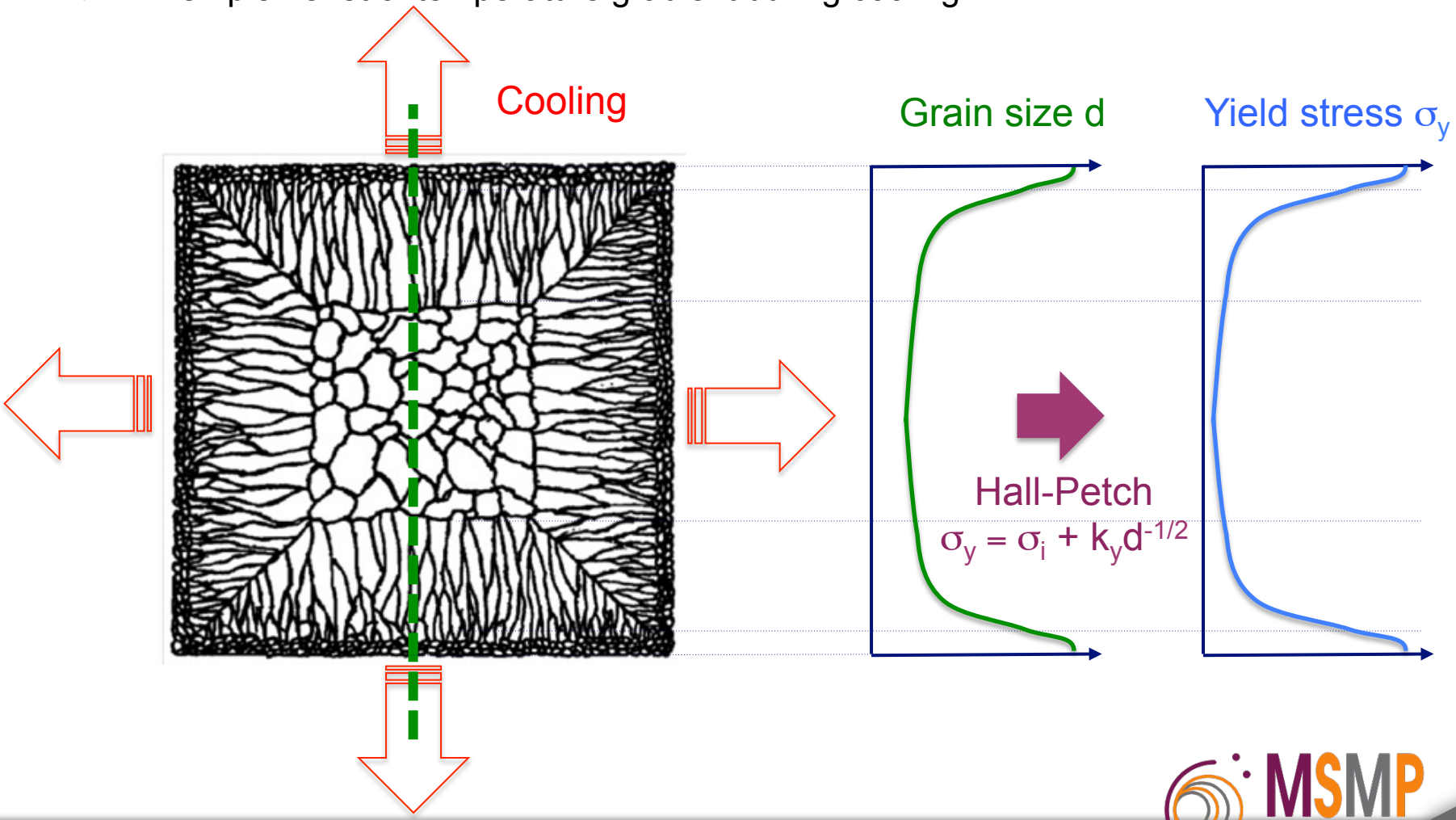


Improvment of mechanical properties of superficial material
- Superficial treatments
- Surface processings

Proccessings optimisation
- Use of parts
- Constraints

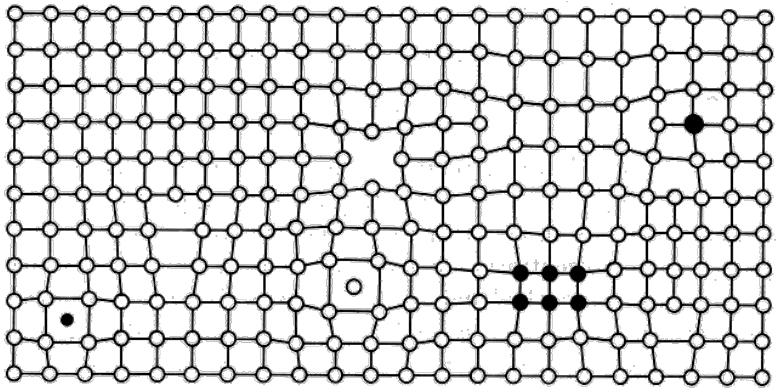
From microscopical to macroscopical scale

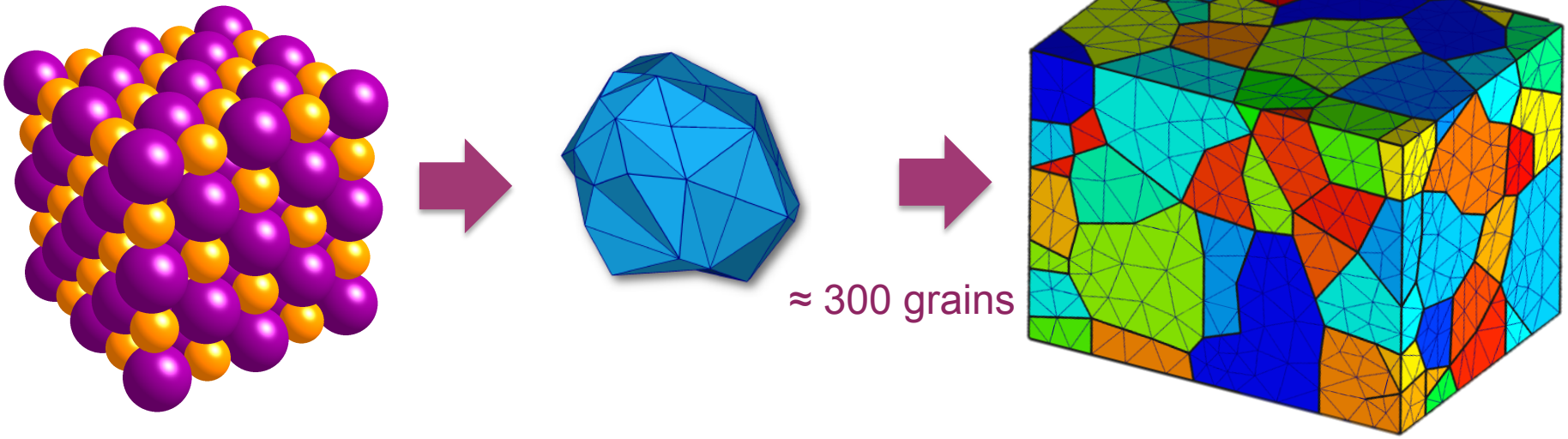
- Macroscopical properties are function of microscopical properties
- Exemple : effet of temperature gradient during cooling



From microscopical to macroscopical scale

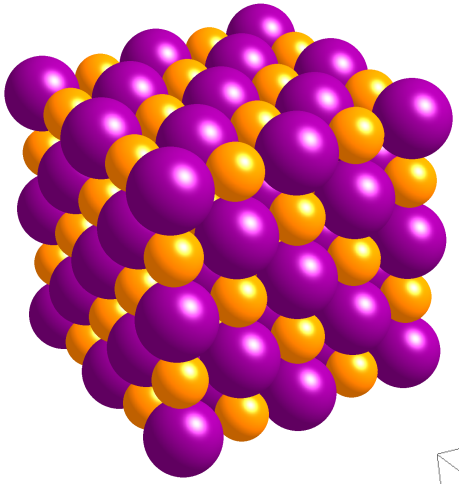
- Mechanical grain properties are function
  - of the inner defects
    - Crystal structure
    - Point defects : interstitial substitution atoms, vacancies
    - Dislocations density, twins
    - Grain boundaries
    - Precipitations
  - orientation

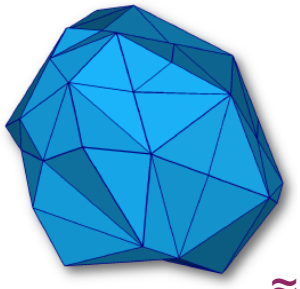




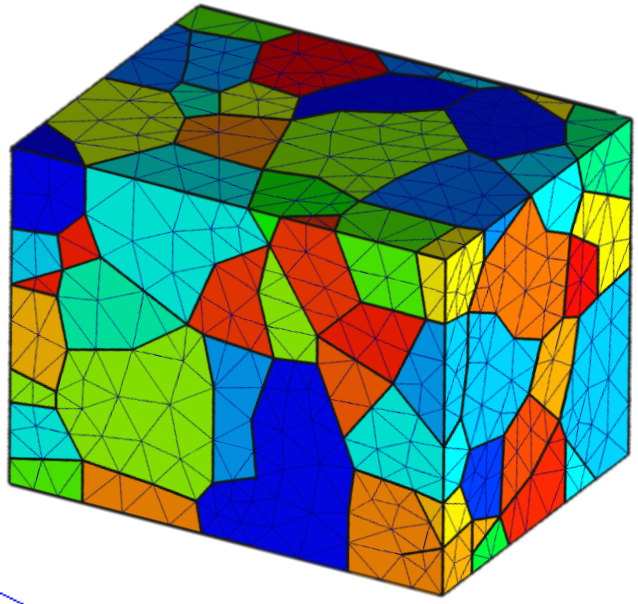
From microscopical to macroscopical scale

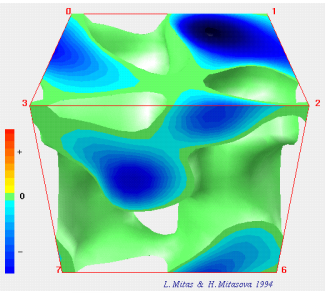
- Exemple : elastic properties

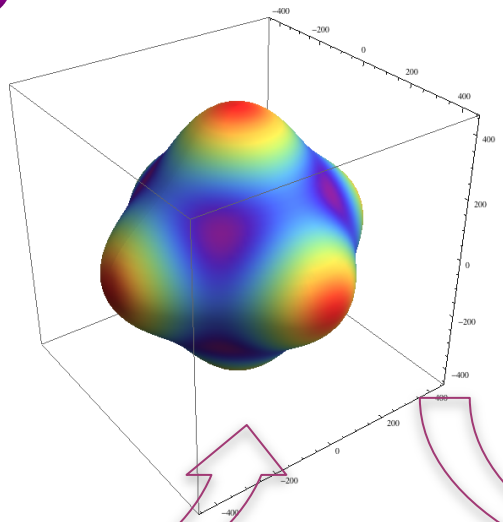


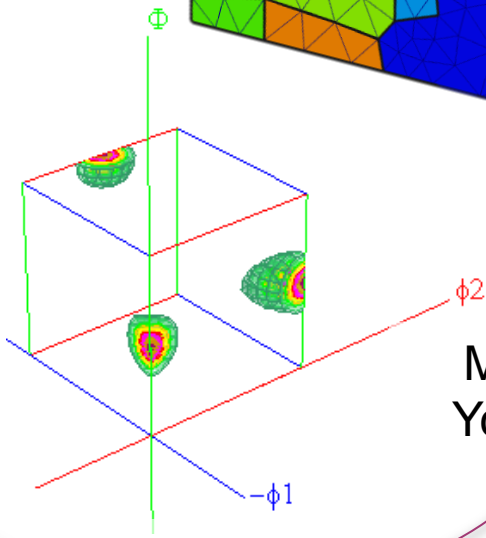


≈ 300 grains









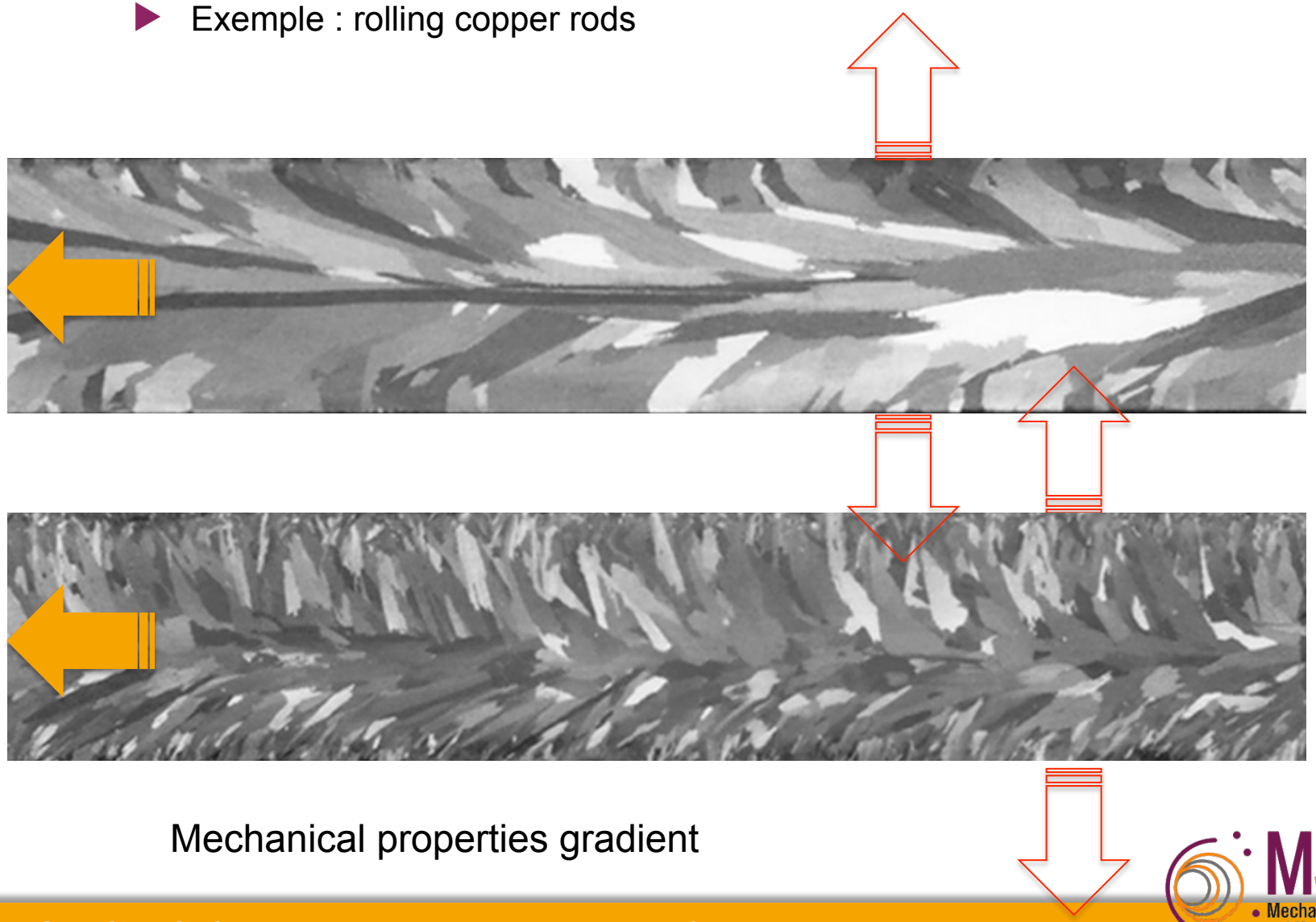
Macroscopical
Young modulus

Wave function
Quantum mechanic

Orientation
distribution function

From microscopical to macroscopical scale

- Exemple : rolling copper rods

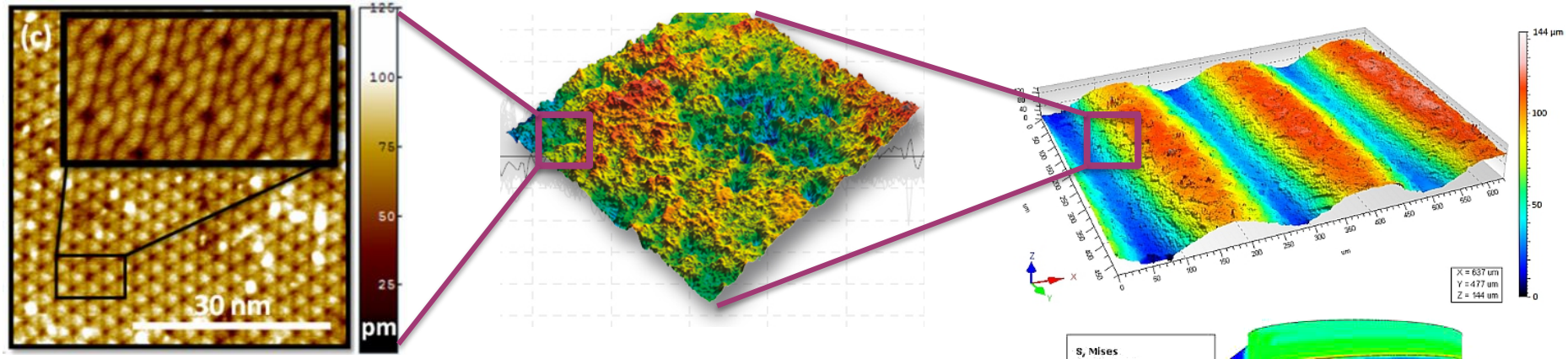


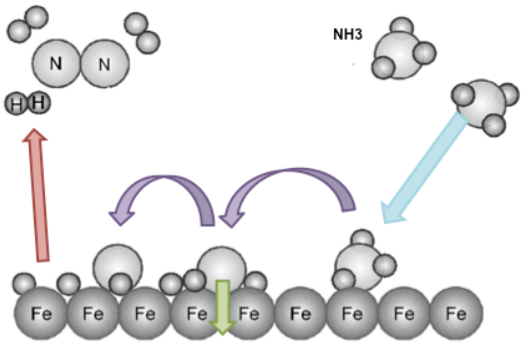
Mechanical properties gradient

From microscopical to macroscopical scale

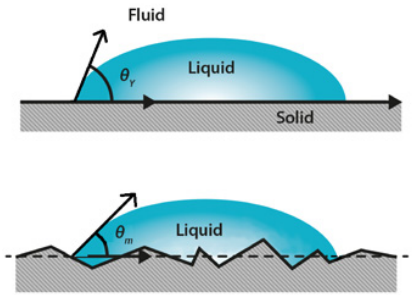
- Exemple : multiscale geometry

Atoms (nano) | Roughness (micro) | Geometry (macro)

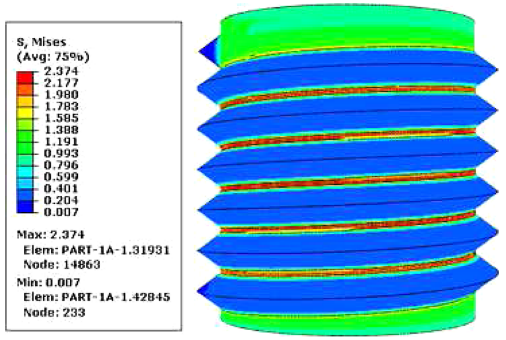




Adsorption



Superficial tension



Stress concentration

From (nano) microscopical to macroscopical scale and parts

- Nanoscale (< 100 nm)
  - Surface : adsorption
  - Volume : defects, atom mouvement
- Microscale (100 nm – 100 µm)
  - Surface : roughness
  - Volume : diffusion, grains
- Macroscale (100 µm – 1 mm)
  - Surface : form
  - Volume : thermodynamic, polycrystal, engineering
- Part (1 mm - …)
  - Surface : functionnalisation
  - Volume :