Micromechanical methods for studying the mechanical durability of surface layers

Context:

The resistance to extreme surface fault initiation is a key issue for problems of component life for the mechanical and metallurgical industries. These damages appear in so-called surface layers whose thickness is usually limited to a few microns [Tum16]. The low thickness and the heterogeneity of these layers remained an obstacle to the mechanical analysis of their durability for many years [Dum21].
Over the past ten years, the various advancements in the development of FIB micromachining and micromechanical testing [Gui18, Bre20] now make it possible to envisage the deformation of these surface layers under conditions representative of the applied stresses (bending/ traction/fatigue).

The objective of this thesis work is to develop new methodologies for measuring the micromechanical response of surface layers by exploiting FIB micromachining for the manufacture of dedicated specimens.

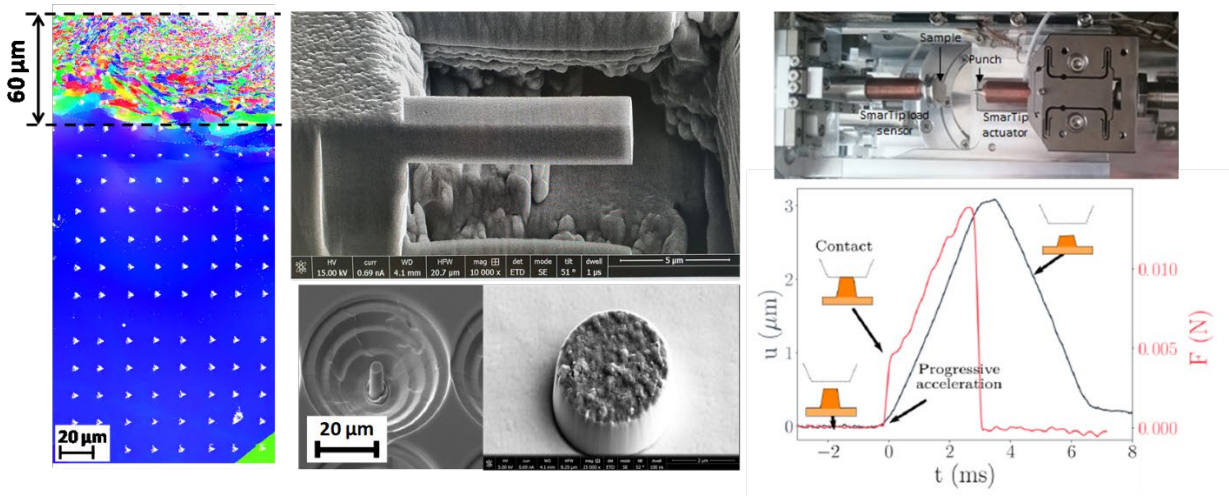

Figure 1 : On the left - surface layer induced by a mechanical surface treatment [Tum16]; Middle - FIB machining of micro-objects (cantilevers/pillars), Right: high-speed micromechanical loading device [Bre20].

Summary of work:

1. Development of residual stress measurements in surface layers. The principle of the method will consist of measuring the mechanical relaxation during FIB machining via digital image correlation inspired by the FIB-DIC method [Kor18].
2. Development of micromechanical tests of the alternating tension/compression and fatigue type on the scale of the surface layers. This work will require the micromechanical device of Mines Saint-Etienne, where current developments allow the deployment of high-frequency tests compatible with cyclic stresses of compression/traction/fatigue types.
3. Application to surface layers. The objective will be to apply all the developed methods on materials of interest to Manutech (white machining layers / materials irradiated by femtosecond laser / superficial tribological transformations). From an academic point of view, the objective will be to study the correlation between the state of residual stress, the microstructure and behavior of the material in compression, bending, traction and fatigue.

General informations :
Place: Saint-Étienne (Manutech USD and Mines Saint-Etienne)
Funding: CIFRE
Scientific manager: Guillaume Kermouche
Type of contract: Thesis
Duration: 36 months
Start date: Autumn 2022
Salary (gross): €23.484 / year

The coaching team:
The experimental and numerical developments will be carried out at the LGF Laboratory (Mines Saint Etienne) under the direction of Guillaume Kermouche, Szilvia Kalacska, Aurélien Villani and Gaylord Guillonneau (LTDS, Ecole Centrale de Lyon). The machining work by FIB will be carried out in the premises of Manutech-USD and in close collaboration with CETIM of Saint-Etienne.

The partners:
LGF and LTDS laboratories are experts in the fields of metallurgy, mechanics of materials and tribology. They are committed to designing the new generation of metallic materials in relation to the use of new manufacturing processes and surface treatments. The LGF laboratory and the LTDS laboratory are involved in the Manutech network, which aims to put the Lyon-St-Etienne region at the forefront of surface manufacturing and tribology.

CETIM is the 'Centre Technique Industriel', which aims to provide means and skills to mechanical companies to support them in their development and increase their competitiveness. For this, many R&D subjects are covered, particularly in the field of materials and surfaces. Strong development areas are surface engineering and advanced characterization.

GIE Manutech USD brings together, in Saint-Etienne, players from public research (Université Jean Monnet, Centrale Lyon, Ecole Nationale d'Ingénieurs Saint-Etienne, Mines Saint-Etienne) and industry (CETIM, HEF Group, WeAre Group) around an Equipex to explore and exploit the scientific and industrial possibilities offered by femtosecond lasers. As an expert in S&T, engineering and multi-scale functionalization of surfaces by ultra-short laser, it provides all the solutions for texturing and characterizing surfaces and defining the appropriate industrial and economic processes.

What we offer:
Cutting-edge training in mechanics and materials; a stimulating and enriching research and teaching program, a large international network with the best scientists in the field (EMPA-Thun, EPM and McGill University - Montreal, FAU-Erlangen, ...).

Requirements:
- Engineer and/or Master 2 in mechanics/materials
- Skills in mechanics of materials and mechanical testing
- Affinity for numerical simulation and programming
- Good level of English
- Ability to work in a team
- Spirit of synthesis / editorial quality

The candidate must provide a detailed CV, a cover letter, transcripts for the last two years and letters of recommendation.

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