ITI HiFunMat Master Internship Proposal

☐ M 1 ☒ M 2

Title Coupling of Nanoindentation and Microsphere-Assisted Microscopy for the Characterization of Polymer Surfaces

Internship supervisor

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Laboratory	
Collaboration with a HiFunMat member (*please indicate their name*)	☐ No ☒ Yes : Sylvain Lecler , IPP / Icube

Student profile looked for

Master program (*more than one box can be ticked)*	☒ Material science and engineering ☐ Chemistry ☒ Physics
Other indications if necessary	

Internship description

Context and Background

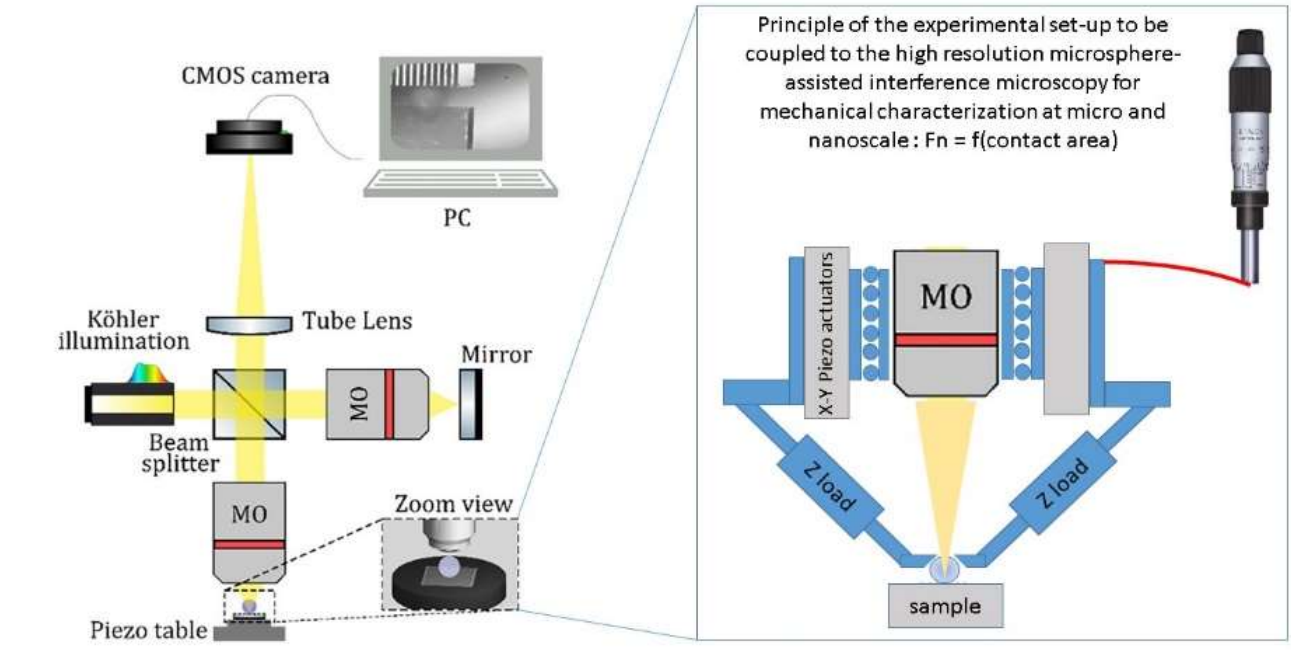
The instrumented indentation test is one of the few experimental techniques that allows for the local characterization of materials with heterogeneities, property gradients, or confinement in small regions, such as thin layers, coatings, and adhesives. Traditional indentation tests involve pressing a rigid indenter tip into the surface of a material and measuring the tip's displacement as a function of the applied force. The analysis of the force-displacement curve, often using the Oliver and Pharr method [1], enables the determination of key mechanical properties such as the elastic modulus and hardness. However, this method is less effective for polymers due to their viscoelastic and time-dependent behavior, complicating the analysis and interpretation of indentation data.

A recent collaborative project between two research teams—the Mechanics of Interfaces and Multiphase Systems team (MIM) at the Charles Sadron Institute (ICS) and the Photonics Instrumentation and Processes team (IPP) at the ICube laboratory—led to the development of a new instrumented indentation setup (see figure below). This device integrates microsphere-assisted microscopy [2] for in-situ observation of polymer surfaces during contact. It allows for the observation of non-transparent polymers with sub-micron resolution, overcoming the limitations of existing methods [3], such as low resolution and the restriction to transparent materials.

Objectives of the Internship

The newly developed device requires initial validation through testing on standard materials and comparison with results from commercial devices. The student will then focus on optimizing the optical setup and analyzing high-resolution images of the contact areas captured during indentation.

Once the setup is validated, the student will study time-dependent behaviors by performing a series of indentation experiments on various polymer substrates. These experiments will include creep tests, relaxation tests, recovery tests, and cyclic loading tests. The analysis and interpretation of the results will require a thorough literature review on instrumented indentation of polymer surfaces [4-6].



From A. Leong-Hoi et al. *Phys. Status Solidi A*, 215(6) : 1700858

Figure. Microsphere-assisted microscopy device [2] (left) and working principle of the new experimental set-up coupling microsphere-assisted microscopy and nanoindentation (right)

Skills and Profile

The ideal candidate should have a background in materials science, mechanical engineering, or physics, with a focus on polymer characterization, and a strong interest in experimental work.

Interested candidates can send their application (CV, motivation letter and recent grades) to Marina Pecora (marina.pecora@ics-cnrs.unistra.fr). and Christian Gauthier (christian.gauthier@ics-cnrs.unistra.fr)

[1] W.C. Oliver and G.M. Pharr. *J Mater Res*, 7(6):1564–1583, 1992.

[2] A. Leong-Hoi et al. Phys. Status Solidi A, 215(6) : 1700858.

[3] T. Chatel et al. *J Phys D Appl Phys*, 44 :1–10, 2011.

[4] M. Hardiman et al. *Polym Test,* 52:157–166, 2016.

[5] O. Smerdova et al. *J Mater Res,* 34(21): 3688-3689, 2019.

[6] S. Yang et al. *J Appl Phys*, 95(7):3655–3666, 2004.