Miniaturized mechanical testing of polymers

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Miniaturized mechanical testing of polymers

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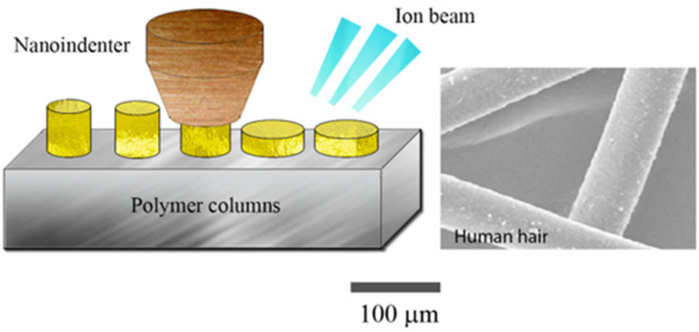
Objectives and goals

Polymers are an interesting class of materials due to their ease of processability, high toughness, and low cost. These materials are widely used in many areas of our life, starting from commodity products to state of the art devices for biomedical engineering. Usually, samples of macroscopic size are used to study the mechanical behavior of polymers in the solid state, e.g. elasticity, yielding, and strain hardening [1].



While this is a viable route for commodity polymers, the more special the polymers under consideration are, the availability of material becomes increasingly limited. By virtue of the recent rapid development of ion beams, the preparation of various 3D objects at smaller scales becomes possible and well controllable. Polymer samples with a desired shape can thus be produced, tested and analyzed at microscale [2].

Future work and perspectives

On the one hand, we strive to perform small-sample tests that are representative of the behavior of macroscopic samples. On the other hand, we also consider aspects in the mechanical behavior that is characteristic for small scales, but absent on macroscopic scales.

Literature

[1]. Tom A.P. Engels, Leon E. Govaert, & Han E.H. Meijer, Polymer science: A comprehensive reference (2), (Elsevier, 2012), p.p. 723-747

[2]. Oleksii V. Kuzmin, Yutao T. Pei and Jeff T.M. De Hosson, Microscopy and Microanalysis, 20 (05), 1581-1584 (2014)

Methods and results

• Sample preparation by focused ion beam (FIB) milling of polymer microbeams with FEI Nova600i NanoLab

• Microcompression tests of 20–40 µm sized microbeams with a tungsten flat punch of 40 µm in diameter by the Nanoidenter XP (MTS Instruments)

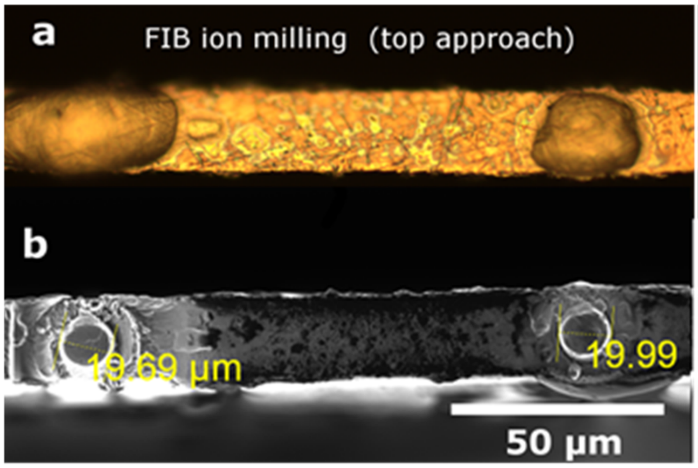


Fig. 1. Top view of polystyrene (PS) bubble-like drops on well-polished metallic substrate ribbon before FIB milling (a), and FIB top-milled polymer beams with Ø 20 µm and aspect ratios about unity (b).

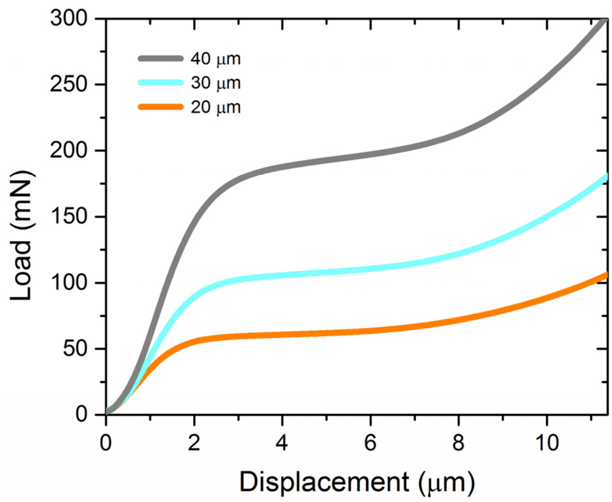


Fig. 2. Load-displacement curves of 20 µm, 30 µm and 40 µm cylinder-shape SU-8 polymer microbeams after microcompression under load-rate controlled mode at 10^{-2} s^{-1}.