Toward novel nanostructured materials with advanced micro- & nanoscale mechanical/electrical properties

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Novel high-performance nanostructured materials with superior mechanical and functional properties are required for advanced applications such as micro-/nanoelectronics, energy production, sensors and wear protection. Especially, mutually excluding structural properties such as high strength and ductility need to be combined but also resistance to harsh environments such as wear and high temperature must be improved. In order to trigger microstructure-induced material properties, control of the micro-scale porosity, atomic composition, average grain size, and layer/film thickness must be optimized.

In addition, the need of probing locally the properties of bulk materials combined with the ongoing trend for miniaturization of micro electro mechanical systems (MEMS), microelectronic components and thin films require the development of novel techniques in order to acquire information about the local mechanical/electrical behavior.

Here, I will review several cutting-edge techniques used to extract the mechanical behavior of advanced materials at the micro- and nanometer length scale, involving i.e. micro-scale tensile tests, micro-pillar compression/splitting [1] and tensile test *in-situ* TEM, while focusing on local measurement of the electrical properties. I will present novel results for several class of advanced materials including nanostructured metallic glasses [2] and multilayer high entropy alloys, while discussing the local electrical properties across grain boundaries for bulk materials and thin films.

Finally, I will show how these materials can be used in daily-life applications with the development of a wirelessly rechargeable transparent heater for thermotherapy patch based on metallic glass films reporting excellent stretchability (70%) and low sheet resistance (~3 Ω/sq), demonstrating their potential for novel stretchable electronic devices [3].

[1] J. Ast, M. Ghidelli, K. Durst, M. Göken, M. Sebastiani, A.M. Korsunsky, *A review of experimental approaches to fracture toughness evaluation at the micro-scale*, Materials & Design, 173, 107762 (2019).

[2] M. Ghidelli, H. Idrissi, S. Gravier, J.-J. Blandin, J.-P. Raskin, D. Schryvers, T. Pardoen, *Homogeneous flow and size dependent mechanical behavior in highly ductile Zr65Ni35 metallic glass films*, Acta Materialia, 131, 246-259 (2017).

[3] S. Lee, H. S. An, S.-W. Kim, M. Ghidelli, A. Li Bassi, S.-Y. Lee, J.-U. Park, *Transparent Supercapacitors and Electrodes Using Nanostructured Metallic Glass Films for Wirelessly Rechargeable Heat Patches*, Submitted to Nanoletters, (2020).