VIDEO ARTICLE

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Self-Organized Behavior of Deforming Polycrystals

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Abstract

The microstructure and the crystallographic texture is changing profoundly during large plastic deformation of polycrystalline materials. The understanding and modeling of their behavior has been challenging the scientific community since the pioneering work of Taylor (1937). Taylor assumed uniform deformation mode for all grains of the polycrystal; identical to the macroscopic one. As experimental observations could not fully confirm the Taylor deformation mode, new modeling were developed, about 50 years later, allowing for strain heterogeneities and grain shape effects: the self-consistent polycrystal models. They were followed by the powerful finite element crystal plasticity simulations showing large strain gradients within the grains.

On the experimental side, since about 25 years, orientation mapping at very fine scales by electron back scattering diffraction provided rich information on the evolution of the microstructure. At the same time, the research work of the Noble prize winner Bridgeman (1947) was resumed by establishing new Severe Plastic Deformation (SPD) processes and attracting the attention of a large materials science community. During SPD, there is a dramatic grain size refinement, producing even nano-size grain structures, so augmenting tremendously material strength.

In recent years, modelling efforts on SPD of polycrystalline materials permitted to gain new insights into the behavior of polycrystals. They showed that the initially large deformation heterogeneities are replaced by the Taylor deformation mode at extreme large strains (Toth et al. see Refs. below). The grain subdivision process begins with correlated behavior of the new grains and continued by uncorrelated orientation relationships between the neighboring grains. This leads to a large decrease in the amount of geometrically necessary dislocations that are needed to maintain strain gradients. One can say that the new grain structure - that is composed of submicron or nano-size grains – develops in a self-organized manner.

The above presented aspects of the microstructure evolution during large strains of polycrystals will be examined in the proposed lecture.

References

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Biography of Presenting Author

Laszlo S. Toth is an internationally known personality of the mechanics and materials scientific community since about 1990. He earned his high recognition through his broad knowledge in both mechanics and materials which permits him to make the bridge between these two disciplines. His high standard interdisciplinary activity made him an ideal collaborator in the best laboratories of several countries where he spent long periods. Established now in France, his original scientific activity attracts many excellent foreign scientists for joint research. The recent expertise of Prof. Toth is in the field of experiments and mechanical modeling of textures and microstructures of SPD materials, especially on quantitative modeling of grain refinement. Prof. Toth published 220 refereed papers, his h factor is 45. He founded two laboratories, the laboratory 'LEM3' in 2010 counting 160 persons, then the Laboratory of Excellence on Design of Alloy Metals for low-mAss Structures ('DAMAS' – 82 researchers) in 2012 of which he is currently the director. Prof. Toth is the Chairman of the next ICSMA Conference (Int. Conf. on Strength of Materials), June 27 – July 2, 2021, Metz, France.

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