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Correlated versus random behavior of dislocations in jerky flow of Al-Mg alloys

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The interest to jerky flow in dilute alloys or the Portevin-Le Chatelier (PLC) effect has not diminished since it was discovered a century ago. One reason for such sustaining interest is that the PLC effect is undesirable in practice since it impedes the formability of alloys. On the other hand, it is a striking example of dislocations self-organization that gives rise to a complex strain heterogeneity evolution and serrated deformation curves. The microscopic mechanism of plastic instability is understood rather well and is generally attributed to dynamical pinning of dislocations by solute atoms. Indeed, since this additional pinning is controlled by a balance between the solute diffusion rate and the plastic strain rate, it leads to a negative resistance of the material to loading: the stronger the strain rate, the lower the deforming stress. The feature of negative resistance is a well-known mobile of unstable behavior of dynamical systems. However, the knowledge of the microscopic mechanism is insufficient to model real behavior which requires understanding the instability development involving complex collective dynamics of dislocations. The observed behaviors depend on the strain rate, temperature, microstructure and even the scale of observation, but display some reproducible features that testify the existence of specific dynamical mechanisms. Uncovering these mechanisms has become one of important fields of research since two decades. In the present paper, the PLC effect is investigated using statistical analysis of plastic activity in Al-Mg alloys on distinct scales of observation, namely, the macroscopic scale of stress serrations and a mesoscopic scale pertaining to the accompanying acoustic emission, as well construction of spatiotemporal patterns characterizing the local strain field evolution. In particular, it is found that the extreme grain refinement by recently developed methods of severe plastic deformation strongly affects the dynamical mechanisms controlling the unstable plastic flow.

Biography

Mikhail Lebyodkin has completed his PhD at Moscow Institute of Physics and Technology in 1989. He started his career at Research Institute of Solid State Physics-Russian Academy of Sciences. He completed his Doctor of Science in 2002. He is a Research Director at French National Centre for Scientific Research (CNRS), appointed in Laboratory of Microstructures and Mechanics of Materials (LEM3), University of Lorraine. He is currently Head of LEM3. His main research interests include "Mechanical behavior of materials, self-organization of crystal defects, and relationships between mechanical and physical properties (magnetic, electric) of solids".

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