Foreword

Multi-Scale Modeling of Microstructure Deformation in Materials Processing

Multi-scale modeling techniques are already widely used in various research areas including biology, chemistry, physics, and mechanics as well as materials science. In the case of material science, the search for models that account more accurately for micro scale and even nano scale phenomena has been the objective of research during the last two or even three decades.

The improvements in experimental techniques were major factors stimulating this research. New experimental techniques have made it possible to visualize physical processes and to measure relevant parameters at fine scales. Examples connected with new experimental equipment allowing research on mechanics of deformation are atomic force microscopy (AFM), nano indentation tests, computer tomography, and electron back scattered diffraction (EBSD) *etc.* These techniques are supported by the established approaches such as scanning and transmission electron microscopy.

The knowledge obtained about mechanisms of deformation from these experiments has been recently combined with the idea of multiscale modelling of materials to develop models with new predictive capabilities at various length and time scales. For the macro scale analysis, a conventional set of numerical methods is usually used, *e.g.* finite element (FEM) and alternative methods. For the micro scale models, both discrete and continuous methods can be used: Monte Carlo (MC), Cellular Automata (CA), Molecular Dynamics (MD), Molecular Statics (MS), Level set methods, Crystal plasticity models, Crystal plasticity Fast Fourier models, Homogenization methods, FEM, finite volume method (FVM), boundary element method (BEM), Multi grid methods, artificial neural networks (ANN), and Extended Finite Element Method X-FEM.

Recent developments in the aforementioned numerical techniques were presented during the “Multi-Scale Modeling of Microstructure Deformation in Materials Processing” mini-symposium cyclically organized during Material Science & Technology (MS&T) conferences. This mini-symposium became a forum for wide discussions and dissemination of results among scientific multi scale community from around the world.

To highlight immense capabilities of multi-scale methodology, we have decided to present to the broader audience, *via Metallurgical and Materials Transactions*, two carefully selected papers from that symposium. Those papers show fundamentally different applications of the modern numerical techniques. That way various possible applications of multi-scale approaches can be appreciated.

Maciej Pietrzyk, Professor and Łukasz Madej, Assistant Professor
AGH University of Science and Technology
Kraków, Poland
e-mail: lmadej@agh.edu.pl