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MATERIALS GENOME INITIATIVE SEMINAR SERIES

Multi-scale Finite Element Modeling in Structural Metals

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ABSTRACT Two-scale finite element analysis based on mathematical homogenization method is one of scale-coupling approaches between macro-scale and micro-scale. In this approach, the micro-scale finite element analyses behave as the macroscopic constitutive model at macro-scale. Currently it is difficult to apply this approach to practical nonlinear problems due to the high computational efforts. To overcome this practical obstacle, we proposed the micro-macro decoupled scheme using Numerical Material Testing [1]. Finite element modeling of microstructure is namely the key element in this framework and also challenging especially in structural metals. We have developed techniques and models to define the objective microstructure; e.g. An anisotropic constitutive model was proposed on the basis of Numerical Material Testing couping with DFT calculation [2]. Here one of major difficulties to apply the framework to materials R&D is the determination of material constants in nonlinear constitutive models on a finite element model of microstructure. For this subject, some attempts have been conducted to characterize the microscopic material behaviors using material database, microscopic experimental testing and atomistic computations.

Dr. Ikumu Watanabe *is a senior researcher in National Institute for Materials Science (NIMS), Japan. He studies multi-scale modeling based on continuum mechanics and its applications to material R&D. He has participated numerous projects in Japan. He received his Ph.D from Tohoku University in 2006. After staying at Swansea University as JSPS (Japan Society for the Promotion of Science) research fellow, he worked for TOYOTA Central R&D Labs. Then he moved to NIMS in 2010. He has been at Northwestern University (NU) since September 2013 until August 2015 to strengthen relationships between NU and NIMS at NU-NIMS Center for Materials Innovation. He won young researchers awards from JSCES (Japan Society for Computational Engineering and Science) and ISIJ (Iron and Steel Institute of Japan).*

[1] I. Watanabe and K. Terada, A method of predicting macroscopic yield strength of polycrystalline metals subjected to plastic forming by micro-macro de-coupling scheme, *Inter. Jour. Mech. Sci.*, pp.343-355, Vol.52, 2010.
[2] I. Watanabe *et al.,* Multiscale prediction of mechanical behavior of Ferrite-Pearlite steel with Numerical Material Testing , *Inter. Jour. Numer. Meth. Engrg.*, pp.829-845, Vol.89, 2012.