The full constraints Taylor model as a transfer function for texture evolution during plastic deformation

Rafael Schouwenaars*[1,2], Tuan Nguyen-Minh[2], and Leo A.i. Kestens[2,3]

[1]Departamento de Materiales y Manufactura, Universidad Nacional Autónoma de México – Mexico
[2]Department of Electromechanical, Systems and Metals Engineering, Ghent university – Belgium
[3]Delft University of Technology, Department of Materials Science and Engineering – Netherlands

Abstract

Modern microtexture measurements provide a statistical sample of crystal orientations which can be processed to provide a wealth of information related to the microstructure and substructure of a polycrystal. These data can be studied microscopically to elucidate the details of microstructure and texture evolution or can be analysed statistically to provide through-process information about the bulk properties of a material along its production history. From a theoretical viewpoint, the statistical description of a well-defined set of microstructural variables defines a Continuous Microstructure Function (CMF). The Orientation Distribution Function (ODF) is a three-dimensional marginal distribution of the CMF. It can be postulated that externally imposed temperature changes or applied deformations define a transfer operator which acts on the CMF. This work shows how the full constraints Taylor theory can be reformulated as a transfer function (TF) which depends on the strain increment alone. The TF is calculated by interpolating the lattice rotation of a finite set of crystal orientations for a given strain mode and equivalent strain increment. Texture evolution is simulated by running a representative set of orientations through the predefined TF repeatedly, up to the required total strain. This is significantly more efficient than a stepwise calculation of the rotation of each individual orientation. To define the method for any strain mode on a 4-dimensional hypersphere in 5-dimensional plastic strain mode space, the challenge is to describe the TF in a form that can be conveniently stored in computer memory. This requires a sufficiently precise interpolation of the individual points calculated for the 7-dimensional parameter space (orientations + strain modes). From a theoretical viewpoint, the method can be expanded to grain interaction or self-consistent models for crystal plasticity, although the curse of dimensionality looms at the horizon.

Keywords: Taylor model, transfer function, ODF, Deformation texture

*Speaker