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NUMERICAL MODELLING OF PLASTIC DEFORMATION AND SUBSEQUENT PRIMARY RECRYSTALLIZATION IN A POLYCRYSTALLINE VOLUME ELEMENT, BASED ON A LEVEL SET FRAMEWORK.

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ABSTRACT

Recrystallization phenomena inevitably occur during thermal and mechanical processes and have a major impact on the final in-use properties of the material. Their accurate control is therefore of prime importance. Theories for recrystallization that provide quantitatively correct predictions of crystallographic orientation and grain size distributions have long been sought to fill a critical link to model material processing from start to finish. To date, no such theory exists. Grain growth or recrystallization mechanisms are not very well understood. Multiscale models are therefore in principle needed to fully describe recrystallization phenomena in a generic way [1,2,3]. Over the last decade, considerable progress has been made in the numerical simulation of primary recrystallization [4]. Common approaches include the Monte Carlo (MC) method [5], the Cellular Automaton (CA) methods [5], the phase field method [6] and the level set method [7].

Primary recrystallization is intrinsically dependent on the preceding processing step. Indeed, the energy stored during the deformation represents the driving force for recrystallization. Capturing the local energy gradients is of prime importance for the accurate modelling of the subsequent recrystallization phenomenon. Crystal plasticity has been extensively used to describe microstructural and mechanical heterogeneities that develop within and across grains during plastic deformation [8,9]. However few authors [10,11] have attempted to combine the modelling of plastic deformation and subsequent static recrystallization using digital discretized microstructures.

In this work, crystal plasticity finite element method is used to simulate the deformation of polycrystalline materials. Parallel processing as well as isotropic and anisotropic meshing and remeshing are intensively used to simulate large and finely discretized grain structures subjected to important strains. The final microstructure obtained and the computed bulk stored energies are used as starting conditions for the simulation of recrystallization. A level-set approach is used to follow the grain boundaries during the deformation stage and is cast into a novel framework that describes grain boundary

motion during the following recrystallization step. The development of vacuum and overlapping regions in 2D or in 3D is avoided. . Nucleation and growth phenomena can also be described accurately. It is shown that the proposed formulation, associated to adaptive anisotropic automatic remeshing, is an efficient and powerful tool for the simulation of recrystallization.

REFERENCES

[1] D., Rollett, Progress in Mat. Sci., 1997, 42, 77-99.

[2] G. Kugler, R. Turk, Comp. Mat. Sc., 2006, 37, (3), 284.

[3] M. Bernacki & al, Comp. Meth. in Mat. Sc., 2007, 7, 1, 141-149.

[4] M.A. Miodownik, J. of Light Metals, 2002, 2, 125-135.

[5] A.D. Rollett, D. Raabe, Comp. Mat. Sc., 2001, 21, 69.

[6] L.Q. Chen, Scripta Metall. Mater., 1995, 32, 115-120.

[7] H.-K. Zhao & al, J. Comp. Phys., 1996, 127, 179-195.

[8] Sarma & al, Comp. Mat. Sci, 1998, 12, 105-123.

[9] Diard & al, Int. J. Plast., 2005, 21, 691–722.

[10] D. Raabe, R.C. Decker, Model. Simul. Mater. Sci. Eng., 2000, 8, 445-462.

[11] T. Baudin & al, Mat. Sc. Forum, 2005, 495-497, 1291-1296.