ICSMA19 Metz, France, June 26 - July 1, 2022
International Conference on Strength of Materials

Phase transformation assisted by dislocation-solute interactions

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Dislocations, in addition to causing plastic deformation, can also influence the energetics and kinetics of phase transformation. Recent APT experiments in systems with miscibility gap have shown that segregation of solutes to dislocations can result in localized phase separation along the dislocation line [1]. In our phase field model, we account for the stress associated with dislocations and solutes as well as the pipe diffusion of solutes along dislocations. We show that depending on the ratio of pipe mobility to bulk mobility, even in a system with nominal compositions outside the spinodal limit, spinodal phase separation is possible. Surprisingly, phase separation through both nucleation and growth, and spinodal decomposition, can occur concurrently for certain dislocation structures. We map the phase separation mechanisms for different choice of system parameters and also discuss the effect of dislocations on precipitate morphologies and their coarsening.

Keywords: phase separation, spinodal, pipe diffusion, phase-field, nucleation

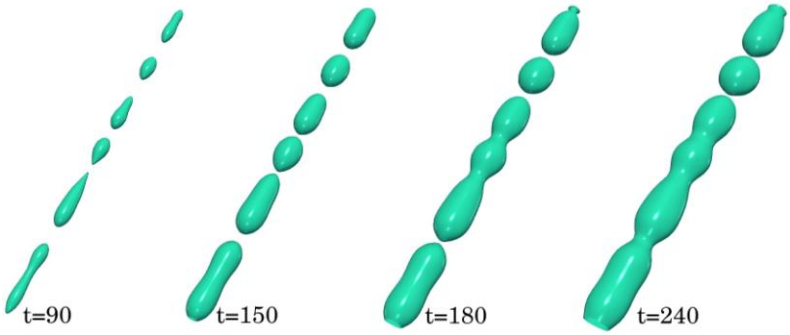

Fig.1 c=0.5 iso-surfaces showing phase separation by localized spinodal decomposition along the dislocation line shown at different time steps

Acknowledgment: We thank SERB, DST, Govt. of India for funding this project. We also thank (i) Spacetime, Dendrite and Spinode (DST-FIST HPC Facility, MEMS Dept.) at IIT Bombay, and (ii) CDAC, Pune for the computing facilities.

References

[1] A. K. Da Silva, D. Ponge, Z. Peng, G. Inden, Y. Lu, A. Breen, B. Gault, and D. Raabe, Phase nucleation through confined spinodal fluctuations at crystal defects evidenced in Fe-Mn alloys, Nature Communications, 9(1), 2018, 1-11.