How do 3D microstructures and their digital representation help to understand microstructure formation in the micro, nano and atomic scale?

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ABSTRACT

The properties of many engineering materials are strongly influenced by their microstructures. The term microstructure refers to the complete internal structure of a material on the micro, nano and atomic scales. On one hand, it records the entire history of a material's production and structuring (casting, forming, heat treatments, but also crystal growth, etc.) through its phase composition, defect structure and morphology. On the other hand, all structural and functional properties e.g. toughness or conductivity are determined by the microstructure. Thus, the microstructure can be seen as an intrinsic multi-scale memory from which we can get information about all microstructure-building processes as well as predict the final material properties. However, it could not be fully exploited so far due to the lack of adequate 3D characterization techniques in some of the relevant scales. Recent progress in tomographic techniques has led to quantitative insights into the evolution of materials microstructures with gradual field of view sizes. We present hierarchical investigations for complex microstructure morphologies e.g. of an important lightweight material for automobiles – the Al-Si alloys. The interdendritic Al-Si eutectic network with its 3D shape and arrangement plays an essential role for stiffness, toughness and strain at fracture. The eutectic seeding controlled by clustering on the atomic scale [1]–[3], the microstructural growth mechanisms on the nano scale as well as their stochastic effect in the micro scale on the macroscopic properties are still under discussion and the materials are potentially far away from being optimal [4].

REFERENCES

[1] J. Barrirero, M. Engstler, N. Ghafoor, N. de Jonge, M. Odén, and F. Mücklich, "Comparison of segregations formed in unmodified and Sr-modified Al-Si alloys studied by atom probe tomography and transmission electron microscopy", *J. Alloys Compd.*, 611, 410–421 (2014)

[2] J. Barrirero, M. Engstler, and F. Mücklich, "Atom Probe analysis of Sr distribution in AlSi foundry alloys", in *Light Metals 2013 - TMS*, 291–296 (2013)

[3] J. H. Li, J. Barrirero, M. Engstler, H. Aboulfadl, F. Mücklich, and P. Schumacher, "Nucleation and Growth of Eutectic Si in Al-Si Alloys with Na Addition", *Metall. Mater. Trans. A*, 46 (3), 1300–1311 (2014)

[4] M. Roland, A. Kruglova, G. Gaiselmann, T. Brereton, V. Schmidt, F. Mücklich, S. Diebels, "Numerical simulation and comparison of a real Al–Si alloy with virtually generated alloys", *Archive of Applied Mechanics*, 85 (8),1161-1171 (2014)