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Length-Scale Selection and Microstructural Patterning During Phase Transformations

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A recent TMS2014 (San Diego, California) symposium highlighted many of the fundamental questions surrounding length-scale selection in materials. Distinct, nonrandom pattern formation during phase transformations and microstructure development is the outcome of a complex interplay among many contributing factors (thermodynamics, growth anisotropy, disparity in species transport speed, etc.) that will ultimately influence properties. These properties can range from tensile strength to magnetic hysteresis. Some of the more recent classes of materials and applications depend on the ability of a system to self-assemble into a defect-free coherent pattern, exemplifying the need for a deeper understanding of the underlying pattern-generating mechanisms. As different scientific fields encounter selection mechanisms in different manifestations, it is important to keep an open dialogue between materials-oriented fields concerning length-scale and pattern formation.

Many important insights have been gained by examining diffusional transformations in steels and superalloys because there are relatively large empirical datasets connecting the kinetics, driving force, and resultant microstructure. One of the best studied, but still elusive, reactions is the coupled growth of multiple phases into a matrix that need not be homogeneous. Two of the articles within the current *JOM* issue help to bring more subtle details of this type of transformation to light. Rojhirunsakool et al.[1] ("Discontinuous Precipitation of γ' Phase in Ni-Co-Al Alloys") examine the interesting and difficult case where the matrix is inhomogeneous. Miller and De Moor[2] ("Influence of Nb Additions on Microstructural Evolution of a V-Microalloyed High Carbon Wire Steel During Patenting") examine the effect of alloying and industrial-style heat treatment on the development of pearlite.

Outside of metals, Aytimur et al.[3] ("Boron Undoped and Doped Europium-Bismuth Oxide Nanocomposites via the Polymeric Precursor Technique") have studied changes in morphology of Eu-Bi oxides with boron doping. During processing, these materials undergo multiple reactions where the initial grain size, phase selection, and morphology influence the next step of the reaction. Gibbs et al.[4] ("Multiscale X-ray and Proton Imaging of Bismuth-Tin Solidification") have taken a different tack in their approach to length-scale selection by using time-resolved multiscale imaging techniques to highlight changes in size and spatial distribution during tin-bismuth solidification.

Certainly, the challenges inherent to pattern formation and length-scale selection during phase transformations will remain, but a combination of new data, new techniques, and creative theory development will continue to pave the way for tomorrow's technologies.

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