2025-2026

Master thesis proposal

Title: Melting patterns of eutectic composites

Keywords: solidification, melting, in situ experiments, microgravity, pattern formation

Scientific description:

Melting is merely the reverse of solidification, but the two processes give rise to contrasting pattern formation phenomena. This stems, in particular, from the fact that the melting dynamics of a material is strongly sensitive to the microstructures that were previously frozen during solidification. This largely unexplored problem is attracting new attention in relationship to the development of additive manufacturing techniques that involves partial melting and solidification stages during the elaboration of complex metal alloy pieces. To this respect, eutectic composite alloys with two-phase microstructures are especially interesting. For a deeper understanding of the physical mechanisms, in situ experiments in well-controlled conditions with real-time optical imaging of the melting front are needed. We propose an investigation of the directional melting in a fixed temperature gradient of a model transparent alloy in thin (10-µm thick) samples. In that geometry, the dynamics of the system in essentially 2D, thus facilitating the acquisition and the analysis of the images during both steady-state and transient regimes. The observations can then be compared to the available theory, based on the coupling of the motion of the solid-liquid interface with the diffusion of chemical species. Challenging questions relative to the relevant scaling quantities should be addressed. This study is part of the preparation of an upcoming science-in-microgravity experimental program (ESA) onboard the ISS.

Techniques/methods in use: optical microscopy, solidification, image analysis
Applicant skills: materials science
Industrial partnership: N

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Possibility for a Doctoral thesis: Y (possibly ½ grant CNES) ; codir. M. Plapp, Ec. Polytechnique (phase-field simulations).