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Microgravity Experiments from Sub-Orbital to Orbital Platforms (3)

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QUANTIFICATION OF THE IMPACT OF GRAVITY ON ISOTHERMAL EQUIAXED ALLOY SOLIDIFICATION USING MACHINE LEARNING

Abstract

While external forces can have a significant impact on alloy solidification, the specific role that gravity may play is not yet fully understood. In 2015, as part of a long running interest in this research area, the European Space Agency launched the MASER 13 sounding rocket in order to conduct a series of microgravity experiments. Included on board was the isothermal furnace XRMON-SOL and an X-Ray camera. This allowed for the acquisition of in-situ data and videos of a thin Al-20wt%Cu alloy experiencing spatially isothermal, equiaxed solidification. Alongside this launch, a terrestrial control sample was also solidified within XRMON-SOL, with similar in-situ data recorded. We have developed an automated image analysis approach, involving machine learning and multi-stage thresholding, to analyse and measure the dendrites visible within both the microgravity and terrestrial in-situ videos. By comparing and contrasting aspects such as nucleation behaviour, growth rate, rotation and movement throughout the solidification process, a relative assessment has been made between the two acquired videos, and the dendrites they depict. This resulting comparison not only demonstrates the digital measurements and observations that can be made for this specific experiment and alloy but also show the effects of gravity on equiaxed alloy solidification more broadly. Similar experiments are proposed for the International Space Station and may be relevant to manufacturing in space.