Materials Research in Reduced Gravity

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Reducing gravitational effects such as thermal and solutal buoyancy enables investigation of a large range of different phenomena in materials science. Reduced-gravity experiments can isolate phenomena otherwise obscured in ground-based experiments leading to new discoveries that can improve materials and processes here on Earth. In addition to ground-based and short term drop tower, reduced gravity aircraft or sounding rocket facilities, long-term experiments in microgravity have a long history – from the early days of spaceflight to current experiments on the International Space Station (ISS). The *Materials Research in Reduced Gravity Symposium* was conducted as part of the 149th Annual Meeting in San Diego – TMS 2020. It involved four sessions composed of 30 presentations with contributions from more than 12 countries. The sessions concentrated on three different categories of topics related to ongoing reduced-gravity research: (1) Programmatic and Facility Status, (2) Solidification, and, (3) Thermophysical Properties. These papers represent a snapshot of some of the exciting new solidification processing activities currently underway on ground and in space to support reduced-gravity experiments. The sessions concluded with a panel discussion on how to support upcoming activities related to the National Academies Decadal Survey. The symposium was sponsored by the TMS Extraction and Processing Division, the TMS Materials Processing and Manufacturing Division and the TMS Process Technology and Modeling Committee. TMS commissioned the organizers to produce this special issue for JOM to highlight the accomplishments from the meeting.

SPECIAL ISSUE CONTENTS

Kao et al. present an analytical study of how forced convection influences dendrite growth for undercooled pure nickel melts. They present an enthalpy-based technique coupled to a lattice Boltzmann method linked by convective thermal transport to obtain a simulation of anisotropic dendrite growth using a sharp-interface model. In practice, this involves iterative evaluation using an adaptive cell size approach to demonstrate convergence. The results show promise in explaining how ground-based terrestrial rapid solidification experiments differ from space-based tests.

Thermodynamic modeling of the activity of each element in solution is used to quantify evaporation in multi-component commercial nickel-based superalloys during ISS-testing in microgravity in an article by Nawer, et al. Tracking of evaporation impacts the accuracy and precision for thermophysical property measurements, ensures that differential loss of volatile species does not change the chemistry of the alloy during testing, and ensures that astronaut health and safety mitigation procedures are in place to eliminate the potential for exceeding station dust exposure limits.

Flow-induced anomalous nucleation during space testing is investigated in an article by Bracker et al. The model explores how the shock waves associated with the collapse of flow-induced voids create localized regions of high pressure. Within these regions the fluid becomes highly supercooled and the enhanced driving force leads to dynamic nucleation.

UPCOMING MICROGRAVITY DECADAL SURVEY

2020 represents a significant milestone in space research. For the past twenty years, man has had a continuous presence of humans living, working and conducting research in space aboard the International Space Station. NASA is in the process of critically evaluating how to prioritize activities over the next decade and is tasking the

National Academies of Sciences, Engineering and Medicine to develop a comprehensive research strategy for the next decade of life and physical sciences research in space. Survey tasks are expected to include the review of current and emerging areas of space-related biological and physical sciences research, identifying the most compelling science priorities and outlining future facility and platform requirements, recommending approaches to development of a robust, resilient and balanced program of space research, and assembling proof-of-concept research campaigns over a broad set of cost categories.

Readers are encouraged to support the activities of the National Academies during the ongoing fact-finding mission by contributing to the upcoming Decadal Survey 2023. NASA desires assistance in developing plans to meet the needs of exploration missions, provide concomitant terrestrial benefit, and uniquely advance scientific knowledge. Solicitation of input from the greater scientific community is essential in order to make this effort a success. Research scientists, and the general public, are encouraged to submit *White Papers* directly to the National Academies. These documents are anticipated to be stand-alone descriptions of critical activities, projects, or professional topical studies that can support the NASA research mission in the coming decade. These papers will provide the basis for discussions by various Decadal Survey Committees as they assess how NASA's mission will evolve over the next ten years and in prioritizing recommendations for future research opportunities.

For additional information about the *White Paper* solicitation, readers are encouraged to contact the corresponding author, Dr. Douglas Matson, who currently serves as the 2020 President of the American Society for Gravitational and Space Research and as a member of the National Academies Committee on Biological and Physical Sciences in Space.