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| Fiscal Year: | FY 2021 | Task Last Updated: | FY 08/31/2021 |
| PI Name: | Ankit, Kumar Ph.D. | | |
| Project Title: | Advanced Modeling and Simulation of Crystal Growth Dynamics | | |
| Division Name: | Physical Sciences | | |
| Program/Discipline: | | | |
| Program/Discipline--Element/Subdiscipline: | MATERIALS SCIENCE--Materials science | | |
| Joint Agency Name: | TechPort: | No | |
| Human Research Program Elements: | None | | |
| Human Research Program Risks: | None | | |
| Space Biology Element: | None | | |
| Space Biology Cross-Element Discipline: | None | | |
| Space Biology Special Category: | None | | |
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| Zip Code: | 85287 | Congressional District: | 9 |
| Comments: | | | |
| Project Type: | GROUND,Physical Sciences Informatics (PSI) | Solicitation / Funding Source: | 2017 Physical Sciences NNN17ZTT001N-17PSI-D: Use of the NASA Physical Sciences Informatics System – Appendix D |
| Start Date: | 08/01/2018 | End Date: | 07/31/2022 |
| No. of Post Docs: | 0 | No. of PhD Degrees: | 0 |
| No. of PhD Candidates: | 1 | No. of Master' Degrees: | 0 |
| No. of Master's Candidates: | 0 | No. of Bachelor's Degrees: | 0 |
| No. of Bachelor's Candidates: | 0 | Monitoring Center: | NASA MSFC |
| Contact Monitor: | Su, Ching-Hua | Contact Phone: | 256-544-7776 |
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| Flight Program: | | | |
| Flight Assignment: | NOTE: End date changed to 7/31/2022 per NSSC information (Ed., 11/8/21) NOTE: End date changed to 7/31/2021 per NSSC information (Ed., 9/9/2020) NOTE: End date changed to 7/31/2020 per NSSC information (Ed., 5/4/2020) | | |
| Key Personnel Changes/Previous PI: | None | | |
| COI Name (Institution): | Glicksman, Martin Ph.D. (Florida Institute of Technology) | | |
| Grant/Contract No.: | 80NSSC18K1440 | | |
| Performance Goal No.: | | | |
| Performance Goal Text: | | | |

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| Task Description: | <p>Recent theoretical analyses of the Isothermal Dendritic Growth Experiment (IDGE) archived in the NASA Physical Sciences Informatics (PSI) system reveals the presence of a fourth-order interfacial scalar field, termed the bias field, that works in the background and dynamically couples with interface normal motion. Solid-liquid interfaces support such scalar perturbation fields by adding or withdrawing small amounts of thermal energy. Preliminary insights suggest that perturbation fields modulate interface motion and can stimulate pattern formation depending upon the interface's curvature distribution. However, our current understanding of the factors that govern the intensity of capillary-mediated fields is limited to pure melts and to two spatial dimensions. Moreover, any quantitative understanding of the intensity threshold beyond which such capillary-mediated fields can potentially modulate pattern formation is all together, absent. The goal of the PSI project is to explore this fascinating autogenous mechanism of pattern formation by leveraging the IDGE data.</p> <p>Surface curvature and crystal-melt anisotropy strongly influence bias fields. Motivated by our recent detection of perturbation fields on grain boundary grooves (GBGs), which also appear to explain the anomaly reported in the microgravity data, the underlying hypotheses which we intend to test are: (a) weak capillary fields that are resident on solid-liquid interfaces modulate the shapes of melting crystalline fragments, and (b) shape perturbations from capillary fields amplify on unstable interfaces, and instigate instabilities on interfacial regions of equilibrated GBGs. Our 3D phase-field simulations on grooving will provide unprecedented insights into this fascinating autogenous mechanism of pattern formation and might also enable us to develop novel processing methods to improve microstructure-level control in alloy castings. The associated issue of comparing the efficacy of noise amplitude to the bias field intensity--fundamental issue in understanding pattern formation--will also be investigated theoretically and via the phase-field techniques.</p> |
| Rationale for HRP Directed Research: | |
| Research Impact/Earth Benefits: | <p>The physical interface mechanism explored in this study shows that capillary-mediated fields provide perturbations capable of initiating diffusion-limited patterns. These include patterns in nature exhibited by snowflakes and crystallized mineral forms, as well as microstructures of cast alloys. Capillary-mediated interface fields might provide new approaches toward achieving improvements in solidification processing, welding, and crystal growth by control of microstructure at mesoscopic scales.</p> |
| Task Progress: | <p>As proposed earlier, we continued our analysis of periodic grain boundary grooves in the project period 2020-2021. The research activities resulted in a paper that has recently been accepted to the special issue of Nature Microgravity journal, which is dedicated to topics in interfacial transport phenomena in memory of the late Professor Paul Steen. Full citation: M. Glicksman, P. Wu, and K. Ankit (2021). Surface Laplacian of Interfacial Thermochemical Potential: its role in solid-liquid pattern formation, npjMicrogravity, Accepted, In press.</p> |
| Bibliography Type: | Description: (Last Updated: 11/17/2022) |
| Articles in Peer-reviewed Journals | <p>Glicksman M, Wu P, Ankit K. "Surface Laplacian of interfacial thermochemical potential: its role in solid-liquid pattern formation." npjMicrogravity. 2021 Nov 2;7(1):41. Accepted 30 September 2021. https://doi.org/10.1038/s41526-021-00168-2 ; PMID: 34728630 , Nov-2021</p> |