ADDITIVE MANUFACTURING: INTEGRATED COMPUTATIONAL AND EXPERIMENTAL METHODS

Integrated Computational and Experimental Methods for Additive Manufacturing

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Additive manufacturing (AM) holds the promise of revolutionizing current paradigms in engineering design, manufacturing, and material and structural performance.^{1–3} However, full realization of the possibilities of metal-based AM will require significant advances in both the process and performance modeling of additively manufactured materials and structures.^{4–8} Modeling and simulation of AM processes is particularly challenging, since it involves multiple time and space scales.⁹ Furthermore, metal-based AM involves multiple physics, and is thus multidisciplinary in nature, requiring interdisciplinary research efforts. Fortunately, the unique manufacturing process of AM affords the possibility of tight integration of in situ measurements and computational modeling.^{10–12} Significant challenges remain, however, in material/structural qualification and development of process–structure–properties–performance linkages.^{13–17} The recent 3rd Sandia Fracture Challenge focused on metal AM is an interesting example of the challenges involved in predicting the performance of AM components, even provided with significant a priori information of the as-built structure.¹⁸

With the goal of fostering communication and collaborations between the AM computational and experimental communities, a conference was recently held at the Colorado School of Mines, on September 6–8, 2017.¹⁹ The conference brought together researchers from both the computational mechanics and materials science research communities involved in advancing the state of the art in process and performance modeling of additively manufactured (AM) materials and structures. There were over 31 invited speakers from academia, industry, and national laboratories, organized in a

single-track session to foster communication. A central theme of the conference was integration of computational modeling and experiments, leveraging the unique manufacturing aspects of AM, to improve overall modeling predictivity and enable process optimization. This conference was jointly sponsored by the U.S. Association of Computational Mechanics (USACM) through the Technical Thrust Area on Manufacturing and Materials Processing and The Mineral, Metals & Materials Society (TMS) through the Committee on Additive Manufacturing. Funding support was provided by the National Science Foundation and Sandia National Laboratories.

While the conference did not have published proceedings, presenters were invited to submit articles for a special topic in *JOM*. The following three articles have been assembled from this process. The first article by Roehling et al. describes the use of single-track laser-melting experiments to explore process parameters and their effects on microstructure. Experimental results were used to benchmark a phase-field model that simulated the rapid solidification in conditions relevant for AM. The second paper by Lindwall et al. models the creation of bulk metallic glasses using a powder-bed fusion process. The study evaluates computational approaches that can be used to increase the computational speed while maintaining accurate temperatures in critical regions. The accurate prediction of temperature history is particularly important in ensuring that reheated material does not become devitrified. The third paper by Donoso and Peters uses a combined discrete-continuous concept to model the physical phenomena in a powder-bed fusion process. The computational approach models the powder using the eXtended Discrete Element Method, which predicts the thermodynamic state and phase change for each

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particle, while the surrounding fluid is solved with a multiphase computational fluid dynamics technique.

The following papers are published under the topic “Additive Manufacturing: Integrated Computational and Experimental Methods” in the August 2018 issue (vol. 70, no. 8) of *JOM* and can be accessed via the *JOM* page at <http://link.springer.com/journal/11837/70/8/page/1>.

- “Rapid Solidification in Bulk Ti-Nb Alloys by Single-Track Laser Melting” by John D. Roehling, Aurélien Perron, Jean-Luc Fattebert, Tomorr Haxhimali, Gabe Guss, Tian T. Li, David Bober, Adam W. Stokes, Amy J. Clarke, Patrice E.A. Turchi, Manyalibo J. Matthews, and Joseph T. McKeown
- “Efficiency and Accuracy in Thermal Simulation of PBF of Amorphous Alloy” by Johan Lindwall, Andreas Malmelöv, Andreas Lundbäck, and Lars-Erik Lindgren
- “A Multiphysics Resolution Approach for Additive Manufacturing” by Alvaro Antonio Estupinan Donoso and Bernhard Peters

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