PREFACE: THERMAL TRANSPORT IN ADVANCED MATERIALS MANUFACTURING

In advanced materials manufacturing, energy is required to transform materials from one form to another. Often, heat is involved in the process. Heat may be an energy input and may also be either released or consumed during the transformation of material from one form to another. Understanding heat, mass, and momentum transport in the manufacturing processes is critical for the quality control of the final products. This volume highlights some of the exciting areas of manufacturing of advanced materials in which thermal processes play a dominant role.

The first two chapters focus on manufacturing of nanomaterials. Chapter 1, by Grigoropoulos, discusses the use of lasers in the formation of semiconductor nanomaterials, including recrystallization of amorphous materials in confined space and laser-directed growth of nanowires and two-dimensional materials. Lasers provide the versatility and precision in controlling nucleation sites for the growth of semiconductor nanomaterials. Chapter 2 by Tse et al. focuses on flame synthesis of nanomaterials deposited on different substrates. Flame synthesis can produce different nanomaterials, such as nanoparticles, nanowires, graphene, and other layered materials, at large scale. Chapter 3, by Chandra, discusses coatings via thermal spray, which deposits molten materials onto a substrate. The impingement of the molten droplets onto the substrate, and subsequent flow and heat transfer processes, determine the quality of the deposited film. Chapter 4, by Sun, reviews the transport phenomena in printed electronics. Electronic materials in a carrying liquid are deposited onto a substrate, and the subsequent spreading and drying process determines the performance of the printed devices.

The next three chapters bring the manufacturing to higher dimension. Chapter 5, by Jaluria, summarizes heat and mass transfer processes in optical fiber drawing. Chapter 6, by Meier et al., discusses fundamental thermophysical phenomena in 3D printing of metallic structures based on laser heating of the materials. The final chapter, by Bianco et al., reviews manufacturing and heat transfer processes in foam structures, which are used in heat exchangers and solar receivers.

Topics covered in this volume serve as examples to illustrate the richness of thermal transport phenomena involved in manufacturing processes, from the nanoscale to macroscale. An interesting observation is that all topics covered focus on additive manufacturing processes: from forming new materials through a chemical reaction to coatings. Of course, lasers and other thermal sources can be used for cutting purposes, but one could argue that thermal processes are more widely used for the addition of materials. The great attention to freeform additive manufacturing calls for further understanding of the thermal processes involved. This enhanced understanding can lead to innovation to further expand the reach of 3D printing technologies.

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ISSN: 1049–0787; ISBN: 978–1–56700–465–6/17/$35.00 + $00.00