Proceedings of the 9th International Conference on Fluid Flow, Heat and Mass Transfer (FFHMT'22)
Niagara Falls, Canada – June 08-10, 2022
DOI: 10.11159/ffhmt22.001

Transport Phenomena in Advanced Materials Processing

Yogesh Jaluria
Board of Governors Professor & Distinguished Professor
Mechanical and Aerospace Engineering Department
Rutgers University, Piscataway, NJ, USA

Abstract

There has been a major revolution in the development of new and advanced materials in recent years, particularly in optical and electronic materials and devices. These materials have changed the very spectrum of technology today. Transport mechanisms play a critical role in the thermal processing of materials because they determine changes in the structure and characteristics of the material and thus in the final product, such as in a crystal drawn from silicon melt or a gel from the chemical conversion of a biopolymer. This presentation focuses on the fluid flow and associated transport phenomena that arise in many relevant processes and are critical to the quality and characteristics of the final product, as well as to the operation and optimization of the system. A wide variety of material fabrication processes, such as the manufacture of optical glass fiber for telecommunications, fabrication of thin films by chemical vapor deposition and surface coating, involve microscale length scales due to the requirements on the devices and applications for which they are intended. For example, hollow fibers, which are used for sensors and power delivery, typically need fairly precise micro-scale wall thicknesses and hole diameters for satisfactory operation. The basic transport mechanisms underlying these processes are discussed. The importance of material characterization in accu-rate modeling and experimentation is brought out, along with the coupling between the process and the resulting properties such as uniformity, concentricity, porosity, and dimensions. Of particular interest are defects and other imperfections that may arise due to the transport phenomena. Additional aspects such as surface tension, stability, and free surface characteristics are also discussed. Some of the important methods to treat these problems and challenges are presented. Characteristic numerical and experimental results are discussed for some new and emerging areas. The talk also discusses current trends in materials processing and outlines future research needs. Of particular importance are experiments that would provide data for model validation and for better understanding of the underlying fluid flow mechanisms. Innovative modeling and numerical approaches needed to study the complex flows that commonly arise in materials processing are outlined.