NANYANG TECHNOLOGICAL UNIVERSITY
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MSE's 30th Anniversary Colloquium Series

Exploiting In situ Chemical Reactions During Laser Additive Manufacturing for Developing Hierarchical Metal-Ceramic Composites

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Abstract

3D printing or additive manufacturing (AM) of metals is rapidly increasing in its impact, as evidenced by the multiple worldwide research groups involved in this activity. However, the overwhelming majority are focusing on maturing the metals AM technology for fabricating components of well-established metals/alloys, which have traditionally been processed via conventional manufacturing. While these efforts are noteworthy, metals AM also has also opened a completely new domain of novel materials, such as in situ metal-ceramic composites and compositionally and functionally graded materials, which cannot be processed via conventional means. The present talk focuses on employing the specific processing technique, the laser engineered net shaping (LENS) process, which is a directed laser deposition (DED) technique capable of 3D printing/additive manufacturing (AM) of metallic parts of a specific geometry onto an appropriate substrate. This presentation will focus on using this LENS/DED technique to process such in situ composites. The concept will be demonstrated by discussing two examples:

1. A novel in situ Ni-Ti-C based composite for surface engineering applications, e.g. in the aerospace industry, exhibiting high hardness, wear resistance, while maintaining an exceptionally low coefficient of friction.
2. A novel in situ Ti-B4C based composite with a hierarchical multi-phase microstructure exhibiting very high hardness and promising tribological properties.

The evolution of different phases in the composites resulting from the in situ reactions within the microscopic scale melt pool of the AM process, will be discussed. These novel metal-ceramic composites comprise a novel category of materials enabled via AM and are not enable for conventional melt processing or solid-state processing.

Biography

Dr. Rajarshi Banerjee is a University Presidential Professor and Regents Professor in the department of materials science and engineering at the University of North Texas (UNT). He is also the Director of UNT's advanced characterization and analysis facility, the Materials Research Facility. His primary research focus is on advanced metallic and functionally graded composite (or hybrid) materials for aerospace, energy, and biomedical applications. Materials of focus include titanium base alloys, nickel (and cobalt) base superalloys, magnetic alloys, and high entropy alloys, processed using fusion-based additive manufacturing (AM) technologies such as directed energy deposition (DED) and laser powder bed fusion (LPBF). The use of advanced characterization techniques, spanning over a range of length scales, including scanning and transmission electron microscopy, electron backscatter diffraction (EBSD), focused ion beam based serial sectioning and tomography, and atom probe tomography (APT), constitute a common thread tying his multiple research activities. These techniques are used to identify the underlying mechanisms and phase transformations governing microstructural evolution and microstructure-property relationships in these complex multi-phase, multi-component materials systems. He has over 300 publications in peer-reviewed journals, total citations exceeding 15,000, and an H-index of 69 (Google Scholar). Dr. Banerjee also holds appointments as an adjunct professor in materials science and engineering at the Ohio State University in Columbus, Ohio, and as a visiting professor at Nanyang Technological University, Singapore.

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Lecture Theatre 3 (NS4-02-32) Map
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