Chapter 5
Development of Functionally Graded Coating by Thermal Spray Deposition

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ABSTRACT

Functionally Gradient Coatings (FGCs) are emerging materials with an improved service life and have a promising future for the production of (a) tailored components for applications subjected to large thermal gradients, (b) smart coating with improved corrosion and wear resistance, (c) improved fatigue wear, and (d) improved material structures for energy applications like batteries, fuel cells, etc. FGCs may be developed by physical/chemical vapor deposition, electro/electroless deposition, thermal spray deposition technique, etc. Thermal spraying refers to the technique or a group of techniques whereby molten or semi-molten droplets of materials are sprayed onto a solid substrate to develop the coating. In this chapter, detailed overviews of the development of functionally graded coating by thermal spray deposition techniques are presented. In addition, a few research results on the development of functionally graded coating for tribological and thermal barrier applications are presented.

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INTRODUCTION

Surface composition and microstructures need to be optimized for an improved performance of engineering components (Budinski, 1988). Surface coating aims at tailoring the surface dependent engineering properties by applying another layer on the surface of substrate using physical, chemical/electrochemical, thermal and high energy surface modification routes. A functionally graded coating refers to the coating consisting of continuously changing composition from substrate to the surface to achieve combinations of toughness and bond strength (Kawasaki & Watanabe, 1997). The gradients may be continuous change in microstructure, microstructure and composition both or porosity distribution. These graded coatings are purposefully developed with an objective to improve the performance and are superior to homogeneous materials composed of similar constituents. The advantages of functionally graded coating over conventional monolithic coating system include a significant reduction in residual stress level, improved toughness, improved wear resistance and thermal properties. Functionally graded coatings are also well-known to enhance the thermal barrier properties due to smooth transition of the properties with depth leading to minimum probability of delaminating of coating from the surface.

Functionally graded coatings are used in many diverse areas and some examples include hydroxyapatite/titanium oxide graded coatings for bio-implant application (Kumar Roop, & Wang, 2002) graded polymer composites reinforced with ceramic particles (Krumova et al., 2001) Ti-Al$_2$O$_3$ artificial tooth roots (Iwasaki et al., 1997), reusable high-performance engines (Moro et al., 2002), coatings for tribological application, thermal barrier coating, coatings for cutting tool application and coating for thermal shock resistance application (Schulz et al., 2003; Koizumi & Niino, 1995).

Advantages associated with functionally graded coatings include (i) Reduction of the stress gradient between the coating and the coated component. (b) improvement of adhesion between the substrate and a protective coating, and thus reducing the probability of delamination during thermal or mechanical loading of the coating-substrate system, (iii) improved multi-functionality of composites and FGMs - stable abrasion response combined with a high temperature protection, iv) Improved damage tolerance for brittle ceramic coatings, during abrasive or impact loading and (v) tailored wear-frictional response over the coating lifetime, while the coating is partially removed by wear process (in joints of heavy machinery).

In the present review chapter, detailed overviews of the development of functionally graded coating by thermal spray deposition techniques are presented. In addition, the case studies on development of functionally graded coating for tribological and thermal barrier applications are presented. Finally, the future scope of research in the direction of functionally graded coatings is elaborately stated.
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