Abstract

Multi-phase ceramic composite coatings of Al_2O_3-TiC-TiB_2 and Al_2O_3-TiC-TiB_2-SiC with some intermetallic phases have been developed by laser cladding of pre-placed powder mixtures (TiO_2, B_4C, Al) or (TiO_2, SiO_2 B_4C, Al, C) on steel substrates. The pre-placed powders undergo self-propagating high temperature synthesis (SHS) and the products of SHS are laser clad onto the substrate surface to form the coating. Sol-gel technology has been used to synthesize nano-sized TiO_2 and SiO_2 which are beneficial for SHS reaction, leading to improvements in the properties of the coating. Two substrate materials, *viz.*, AISI 1020 steel and AISI 304 stainless steel, have been used to develop the coatings.

Characterization of the coating has been carried out by X-ray diffraction (XRD), field emission scanning electron microscope (FESEM), energy dispersive spectroscopy (EDS), micro-hardness measurement and high resolution transmission electron microscope (HRTEM) analysis. Evaluation of the tribological behaviour of the coating has been performed by ball-on-disc type tribometer. The effects of laser processing parameter mainly laser scanning speed on the microstructure, phase-composition, micro-hardness, wear rate, coefficient of friction, modulus of elasticity (E) and fracture toughness of the composite coatings have been investigated. Effect of substrate material on the performance of the coating has also investigated.

The developed coatings possess high hardness and fracture toughness and exhibit high wear resistance over a wide range of normal loads and sliding speeds. The hardness and wear resistance increase with the increase in laser scan speed due to refinement in microstructure of the coating. The wear rate of the developed coatings increase with increase in normal load.The wear mechanism of the developed composite coatings changes from adhesive and abrasive wear to brittle fracture with increase in normal load, especially at high sliding speeds. Fracture toughness of the coating is found to be higher than those of the individual ceramic phases present in the coating. This is because the multi-composite ceramic coating possesses higher fracture toughness compared to monolithic ceramic coatings. With the increase in the proportion of (SiO_2+C) in precursor powder mixture, micro-hardness, wear resistance as well as the coefficient of friction (against WC-Co counter-body) is found to increase, due to formation of silicon carbide in the matrix contributing to higher hardness and wear resistance. The developed composites have high potentials as prospective materials for wear resistant coatings in various engineering applications.