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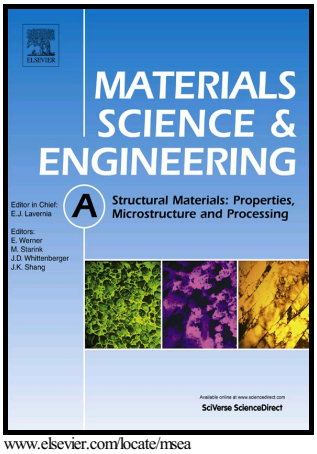

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Hard-yet-tough high-vanadium hierarchical composite coating: Microstructure and mechanical properties

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Abstract

In this work, we report a high-vanadium hierarchical coating prepared on the surface of nodular cast iron substrate by a low-cost plasma transferred arc (PTA) surface alloying process. The coating consists of a graded layer with an alloyed zone (AZ) rich in submicron sized granular (V-Ti-Nb-Cr-Mo) composite carbides on top of intermediate melted zone characterized by refined ledeburite and martensite. The dense spherical particles in the AZ are FCC structured MC-type (M = V, Ti and Nb) carbides which tend to aggregate while M_7C_3 and M_2C carbides nucleate on MC. The super-lattice V_8C_7 maintains its cube-on-cube orientation relationship with TiC. The hardness of the AZ is 9.6 ± 1.0 GPa, ~ 4 times that of the substrate. Nano- and micro-indentations point at a superior strength-toughness in the AZ, where cracks are deflected and bridged by the spherical MC carbides in a compressive residue stress state. The fracture mode appears to be rather ductile in the AZ whereas brittle failure appears in both the melted zone and substrate. TEM and EDS results confirm that such a microarchitecture design, assisted by the rapid solidification rate of the PTA process, concurrently activates various strengthening micromechanisms including the precipitation hardening and grain refinement.

Keywords: Plasma surface alloying; Vanadium; MC carbides; Hard-yet-tough; Fracture; Crack resistance