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Cu-NbC Nanocomposite Coatings Developed by Laser Cladding

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Abstract - Cu-NbC nanocomposite coatings were produced by laser cladding, from nanocrystaline powder synthesised by mechanical alloying from elemental mixtures of Cu, Nb and graphite (Fig. 1). The coatings microstructure consists of nanocrystaline NbC particles uniformly distributed in the Cu matrix (Fig. 2). Though some coalescence and agglomeration of NbC particles occurred during laser cladding they remain nanocrystaline with average sizes in the range 20-200 nm. The coatings present an average microhardness of 180 HV. Their wear behaviour was investigated through microscale wear tests performed under dry sliding conditions against a steel counterbody. Wear occurs in the moderate regime mainly by abrasion, adhesion and material transfer.

The authors have previously shown the possibility of in-situ synthesis of nanocrystaline NbC particles in a copper matrix, (up to 20 vol.% NbC) during high-energy milling of elemental mixtures of Cu, Nb and graphite, powders at room temperature, without additional heat-treatment [1]. A two-step milling process was developed that allows the synthesis of NbC phase to start in the early stages of milling (after 1 hour) and the maximum volume fraction to be achieved after 8 h of milling. Further milling leads to an increase of Fe contamination [2]. The result is a nanocomposite powder formed of 10 nm NbC and 20 nm Cu crystallites (Fig. 1). The powder is thermally stable up to 600 °C, without major coarsening of both Cu and NbC grain sizes.

The powders synthesised by mechanical alloying were used to produce Cu-NbC nanocomposite coatings by laser cladding with improved hardness and wear resistance, while avoiding considerable particle coarsening during deposition. The coatings have an average thickness of 800 μm and their microstructure was characterized by SEM, EDS, XRD and TEM analyses. It consists of nanocrystaline NbC particles uniformly distributed in the Cu matrix (Fig. 2). Though some coalescence and agglomeration of NbC particles occurred during laser cladding, they remain nanocrystaline with average sizes in the range 20-200 nm. The coatings present an average microhardness of 180 HV. Their wear behaviour was investigated through microscale wear tests performed under dry sliding conditions against a steel counterbody. The influence of load on the prevailing wear mechanisms was analyzed and related to the microstructure of the coatings. Two wear regimes were identified. At low loads the predominant wear mechanism is abrasion, while at high loads adhesion and material transfer are the main mechanisms. However, the wear coefficients are relatively low (10^{-13} m^2/N) and wear remains in the moderate regime.

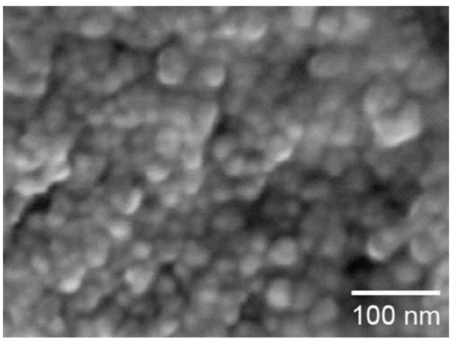

Figure 1: SEM image of as-milled Cu–10 vol.% NbC powder.

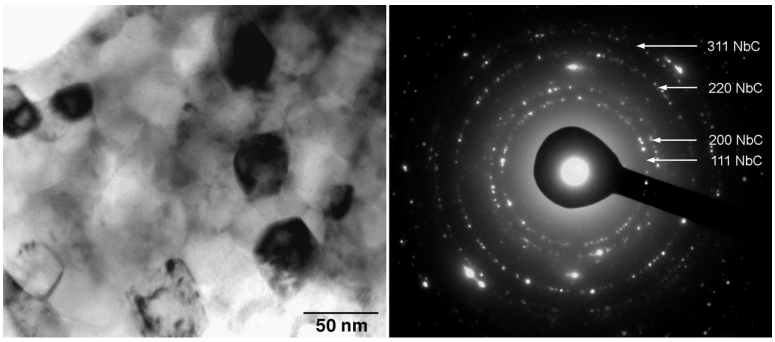

Figure 2: TEM image of the coating microstructure showing NbC particles dispersed in the Cu matrix and the diffraction pattern of NbC articles.

[1] M.T. Marques, V. Livramento, J.B. Correia, A. Almeida and R. Vilar. Materials Science and Engineering A399, (2005) 382-386.
[2] M.T. Marques, V. Livramento, J.B. Correia, A. Almeida and R. Vilar. Journal of Alloys and Compounds 434-435, (2007) 481-484.