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Boron Carbide-aluminum Composites Fabricated by Pressureless Infiltration at Low Temperature

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Extended Abstract

Two main problems are associated with the fabrication of boron carbide-aluminum composites. Firstly, pressure-less infiltration may be achieved only above 1150^{o}C, because of the unavoidable aluminum oxide layer that is ubiquitously present at the metal interface and prevents wetting and infiltration. Second, at this infiltration temperature the Al_4C_3 phase is formed and its presence (even as a very low fraction) is highly detrimental. This carbide is hydrophilic, absorbs environmental humidity to form aluminum hydroxide which involves a twofold volume increase and causes over time the disintegration of the solid. Full infiltration can be achieved at 750^{o}C under 8 to 40MPa external pressure. In this case, no evidence of Al_4C_3 formation was detected. Taking advantage of the experience gained by infiltrating with Mg containing alloys under Mg vapor (Cafri et al., 2012; Cafri et al., 2014), we retried the infiltrating porous boron carbide preforms with molten Al at 850^{o}C. We report herewith for the first time our results regarding the fabrication of B_4C–Al composites by pressure-less infiltration at a temperature as low as 850^{o}C. The contact angle of pure aluminum on a boron carbide substrate at 850^{o}C under vacuum (10^{-5}mbar) is about 150º, while under magnesium vapor atmosphere it is significantly lower ~ 25º. These observations confirm that the magnesium vapor reduces the aluminum oxide layer on the aluminum drop and provide the adequate conditions for free infiltration. It has to be pointed out that the presence of magnesium vapor in the chamber leads to the enrichment of the aluminum drop with Mg up to 15 wt.%. B_4C-Al composites fabricated at 850°C exhibit similar mechanical properties (Young's modulus 340 ± 5 GPa, flexural strength of about 240 MPa and hardness of 1600 ± 250 HV) as those of the B_4C- Mg,Si composites fabricated at 1000 °C (Cafri et al., 2014).

The environmental behavior of infiltrated composites was investigated in a special humidity chamber with a water vapor atmosphere at room temperature. The samples fabricated at 850^{o}C display excellence corrosion resistance, while at the surface of B_4C-Al composites infiltrated at 1200°C pitting regions were observed after one month of the treatment. After 8 months these samples were completely disintegrated.

References

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