Novel W-B-Fe-based borides as candidate compact radiation shielding materials

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Dense tungsten-iron-borocarbide (W-B-FeCr) materials were synthesized at as an off-shoot of the WC-FeCr cemented tungsten carbide (cWC) shielding concept using conventional powder metallurgy techniques and starting materials. A variety of tractable compositions were synthesized from boron carbide (B_4C), pre-alloyed Fe-8Cr powder and W metal powder. This work follows on from the first investigations of the cWC-RSB radiation shielding concept[1,2,3] where neutronics simulations indicated that a combined cWC-boride shield in combination with a water coolant/moderator could have better radiation attenuation characteristics than W metal shields alone[1].

Recent research using XRD and microscopy on sintered RSBs have enabled the quantitative determination of the phase abundance and theoretical density of sintered RSB bodies. Quantitative determination of boron and carbon content in sintered bodies by ICP found that in compositions with starting B_4C content 5.5% < x < 9% had sintered compositions with W : Fe : B atomic ratios closer to 1 : 1 : 1 than at weigh-in. Theoretical densities from RSBs showed that their sintered densities were generally >95% of theoretical density for the stated composition when carbon and boron corrections were applied. All RSBs showed significant differences in their microstructures with iron tungsten borides as the dominant phase, followed by FeWCr carbides, iron borides and mixed tungsten borides. Carbon lacunae were observed in all samples, usually at WB_x – FeB_y interfaces in structures resembling blisters which incorporated most of the observed porosity.

Sample heterogeneity between edge and centre along with features associated with sample delamination indicate that although current processing parameters for RSBs are not optimized with respect to organic binder and current sintering parameters, optimization of processing parameters within existing powder metallurgy is possible.

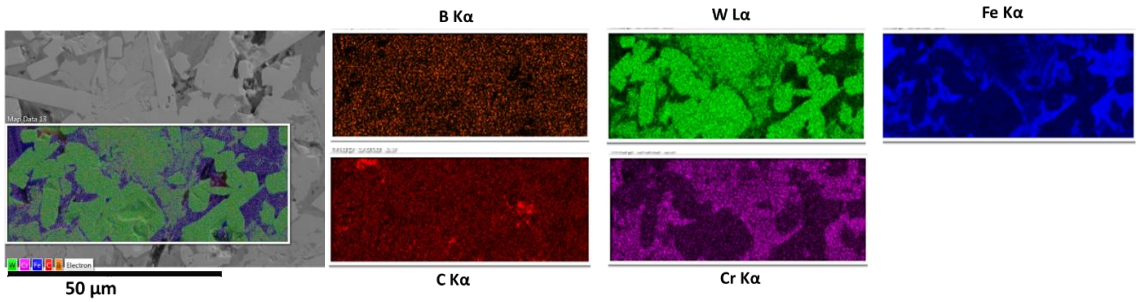

Figure 1: EDX element map for central B5T522W RSB.

1. Humphry-Baker, S. A. *et al. Scr. Mater.* **155,** 129–133 (2018).
2. Windsor, C. G. *et al. Nucl. Fusion* **57,** 036001 (2017).
3. Windsor, C. G. *et al. Nucl. Fusion* **58,** 076014 (2018).