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Characterization Of The Effects Of Particle Size On The Microstructure Of $MoSi_2/TiB_2$ Composites Produced By Elemental In-situ Reactions Using Scanning Electron Microscopy (SEM) And Electron Probe Microanalysis (EPMA)

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The effects of particle size on the sintering-densification process, phase formation sequences, and microstructural scale of both the matrix and reinforcement phases in composites have been evaluated to some extent in recent years. The proper selection of particle size and particle size distribution has been found to be determinant factors in the densification of the composites. In addition, particle size is one of the most important controlling parameters for the reaction rate in these reaction-sintering processes. As expected, faster formation rates are observed when the particle size of the reactants is smaller, however, the introduction of impurities such as oxides formed at the surface of the particles is more significant. The size and characteristics of the final microstructures obtained through solid-state reactions depend significantly on the size and distribution of the particulate reactants. Many studies on molybdenum disilicide composites have demonstrated that particle size affects significantly the grain size of the $MoSi_2$ that is formed during processing. Thus, the mechanical properties of the composite are affected since properties like the fracture toughness of the composite are strongly influenced by the grain size of the $MoSi_2$ matrix. The evolution of phases is also significantly affected and sometimes leads to the formation of intermediate phases that substantially affect the microstructural characteristics of the composites.

In this study, reactions using "small" vs. "large" elemental reactant powders were assessed. The "small" elemental reactant powders led to greater densification in the final composite although the amount of oxides introduced into the system from the surface of the powders was higher. The dissolution and further segregation of the oxygen introduced into the system led to the formation of silica pockets, as the most distinctive characteristic of the resulting microstructures. It was also found that the shape of the TiB_2 grains is initially strongly influenced by the size of the reactant particles. Smaller powders led to highly compacted pellets and initially elongated TiB_2 grains due to the simultaneous growth of a large number of fine grains. Larger powders produced more regular equiaxed TiB_2 grains. The effect of the initial powder size of the metallic components on the microstructure was evaluated specifically; the initial size of the molybdenum powders led to $MoSi_2$ regions of similar size. Likewise, the size of the initial titanium powder particles resulted in partially reacted final microstructures. This is related to the fact that the formation of TiB_2 is the slowest reaction of all the sub-reactions that occur to produce the final $MoSi_2$-TiB_2 composites.

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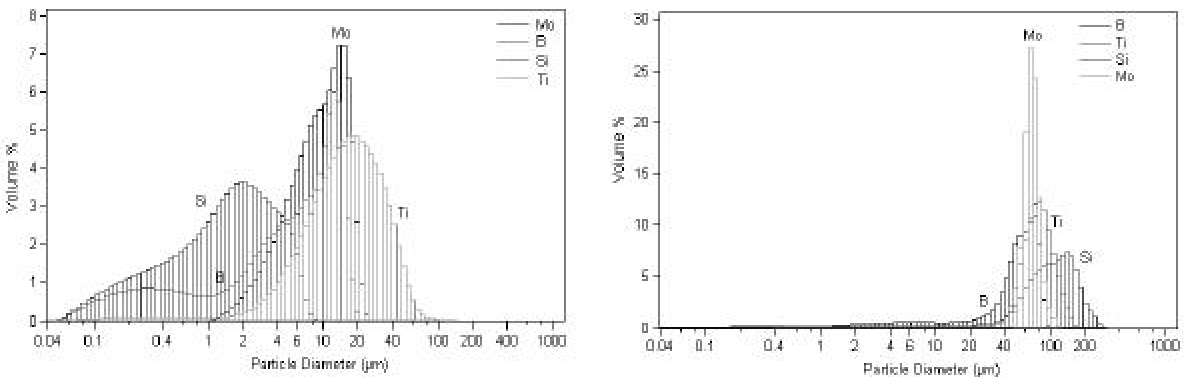
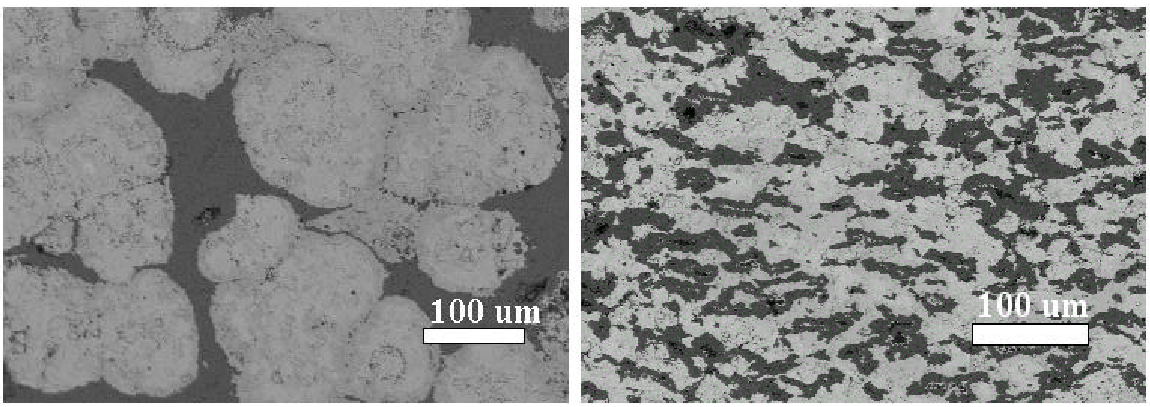


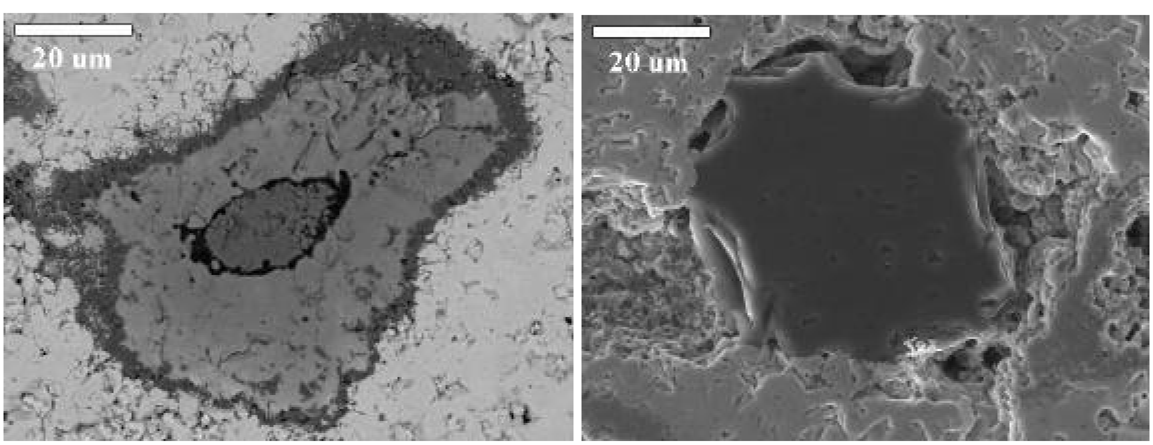
(a) (b)

FIG. 1. Distribution of particle sizes of elemental powders a) "small" size range 0.04 - ≈40 μm b) "large" size range 40 - ≈200μm.



(a) (b)

FIG. 2. Backscattered electron images of the microstructures of samples a) having a larger size of molybdenum powders and "small" Ti, B and Si reactant powders and b) using all "small" elemental reactant powders.



(a) (b)

FIG. 3. Backscattered electron images of samples having a larger size of titanium powders a) partially reacted titanium particle and b) unreacted boron particle.

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