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Preparation of (Ti,Ta)(C,N) by mechanical alloying

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Abstract

The research described in this dissertation concerns an investigation into the development of new/modified Ti(C,N)-based cermet materials for applications relating to the metal machining industry.

Ti(C,N)-based cermets are widely employed for high speed machining owing to their attractive properties such as high hot hardness, chemical stability and excellent wear resistance. However, the increasing demand for high performance, advanced materials has steered research towards the development of novel tooling materials using unconventional processing methodologies. The mechanical alloying technique has shown promising results in this regard. The technique has been identified as a powerful tool for the development of advanced engineering materials including equilibrium, non-equilibrium and composite materials. By understanding the composition-microstructure-property relationship, guidelines can be provided with regard to producing materials possessing desirable mechanical properties. As such, the synthesis of the (Ti,Ta)-carbonitride solid solution was investigated by mechanically alloying brittle-ductile and brittle-brittle components.

When brittle-ductile Ti(C,N) and Ta powders were mechanically alloyed, the (Ti,Ta)-carbonitride solid solution was successfully obtained. Mechanical alloying greatly improved the sinterability of the Ti(C,N)-Ta powders and full densification was obtained in solid state. As a result of high energy milling, nanocrystalline Ti(C,N) was obtained. Consequently, cermets produced with these mechanically alloyed powders showed a fine microstructure and possessed superior mechanical properties, as compared to conventional ball milled sintered cermets.

Conversely, formation of the (Ti,Ta)(C,N) solid solution phase was unsuccessful by the mechanical alloying of brittle-brittle Ti(C,N) and TaC powders. Owing to the brittleness of the powders and the low diffusion coefficients in the carbide lattices, the mechanical alloying process served only to refine the grain size of the Ti(C,N) and TaC phases, whilst both phases remained unreacted by the end of milling. Consequently, only partial dissolution was achieved during sintering of the mechanically alloyed Ti(C,N)-TaC powders. As such, poor densification was obtained in these samples which served to lower their mechanical properties.