Ceramics International
Volume 46, Issue 14, 1 October 2020, Pages 23049-23058

Mechanosynthesis of metastable cubic δ-$Ta_{1-x}N$

T. Garcia-Mendoza [a], A. Martinez-Garcia [b c], I.G. Becerril-Juarez [d], E. Lopez-Vazquez [c], M. Avalos-Borja [d], M. Valera-Zaragoza [b], E.A. Juarez-Arellano [b]

Show more

Share Cite

https://doi.org/10.1016/j.ceramint.2020.06.082

Abstract

The formation of the cubic δ-$Ta_{1-x}N$ phase by high-energy ball-milling from tantalum and boron nitride (h-BN) is explored. Two different molar ratios Ta:BN, 1:1 and 2:1, were used. X-ray diffraction, scanning electron microscopy, surface area analysis by the Brunauer-Emmett-Teller method, and thermogravimetric analysis were used to characterize the products obtained. In both molar ratios and after a few minutes of milling, the mechanosynthesis of δ-$Ta_{1-x}N$ was observed. Increasing the entropy of the system by introducing vacancies and point defects by the high-energy ball-milling process seems to stabilize the cubic δ-$Ta_{1-x}N$ phase, as previous theoretical studies had reported. The phase obtained depends on the molar ratio used: in the molar ratio 1:1 a non-stoichiometric δ-$Ta_{1-x}N$ phase is obtained, while in the molar ratio 2:1 a stoichiometric δ-TaN phase and secondary phases are obtained. The amorphous boron remains dispersed in the material until the mechanical energy is high enough to trigger the formation of tantalum borides.

Introduction

In recent years, materials with the combination of light elements and transition metals have gained interest, especially carbides, borides, and nitrides [1]. These materials show high hardness, high melting points, high thermal and chemical stability, high resistance to corrosion, good electrical conductivity and interesting magnetic properties [[2], [3], [4], [5], [6]]. Among the binary transition metal nitrides, tantalum nitrides are some of the most widely used nitrides. Tantalum nitrides have