Characterization of Nano-Tube and Fibers Formed by Self-propagating High Temperature Synthesis

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Abstract

Titanium carbide nano-tube and fibers were synthesized by self-propagating high temperature synthesis (SHS) method. The average diameters of the nano-tubes and nano-fibers are about 100 and 20 nm in diameter, respectively. The non-stoichiometric numbers of the titanium carbide determined by neutron diffractometry were 0.87 and 0.94.

1. Introduction

Nano size titanium carbide tubes and fibers are very attractive for their several engineering applications such as bio-filer and nano-size structure. Since the nano-size tubes and fibers are not the morphology with the lowest free energy of activation for nucleation compared to sphere or in some cases incorportate planar facets, a non-equilibrium process such as self-propagating high temperature synthesis (SHS) has been applied to make the nano-size tubes and fibers. In this study, the material with electrical conductivity and non-stoichiometry such as titanium carbide was selected to make nano-size tubes and fibers and to study the formation mechanism during the reaction.

2. Experimental Method

Reagent grade of titanium with 1-75 μm in size and 99.99% in purity and carbon fiber of less than 1 μm in diameter and graphite powders of less than 1 μm in average particle size were used in this study. The reactant powders were ignited at inert argon atmosphere. The chemical analysis of the SHS products was carried out using a 32-detector high resolution powder neutron diffractometer (HRPD). Microstructure was observed by transmission electron microscopy (Jeol 2010).

3. Results and Discussion

Fig. 1 is the typical neutron diffraction spectra of the final product. The non-stoichiometric numbers of the titanium carbide determined by neutron diffractometry were 0.89-0.94. The Rietveld refinement of each patterns converged to good agreement (x^2=0.49-1.34). Fig. 2 is the microstructure of the titanium carbide nano-tube and fibers formed by SHS reaction. The titanium carbide tubes are about 100 nm in diameter with a hole inside, whereas the titanium carbide fibers are about 20 nm in diameter. This kinds of the shape is well agreement with the previous results [2]. Two different mechanisms such as solution-precipitation model and shrink core model may be invoked to explain this morphology. Both models may explain the morphology change during SHS reaction. Considering the numerical evaluation of the titanium carbide formation, the limited diffusion length is estimated as at least about 100 nm.[3] Since the combustion wave length is longer than the limited diffusion length, final product

becomes solid whereas the combustion was length is shorter than the limited thickness, the final product becomes hole shape. Hence, solid titanium carbide fibers with about 20 nm in diameter were observed. This result supports that SHS process is one of promising fabrication processes to make nano-size carbide tube and fiber.

Conclusions

Titanium carbide nano-tubes and fibers with the average diameters of about 100 and 20 nm were prepared by SHS. The non-stoichiometric numbers of the titanium carbide determined by neutron diffractometry were 0.89-0.94. The formation mechanism of fibrous titanium carbide is well explained by a diffusion limiting shrink-core model.

Acknowledgement

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References

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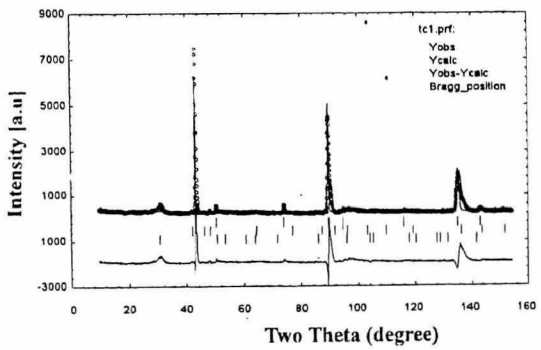

Fig. 1. Typical neutron diffraction spectra of TiC_x formed by SHS reaction

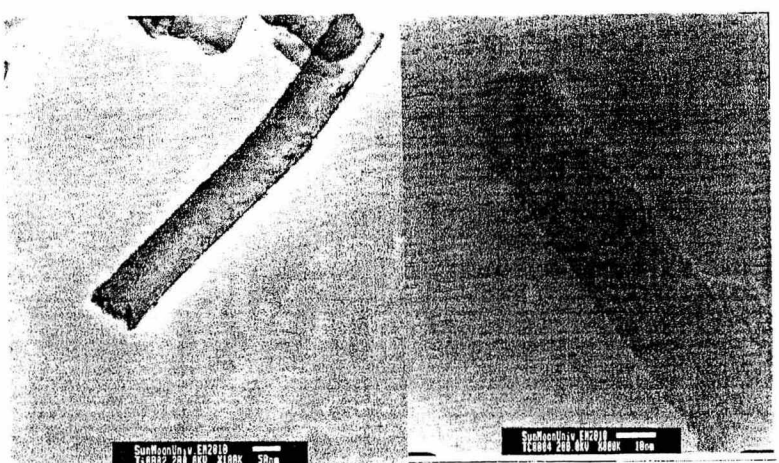

Fig. 2 TEM image of TiC_x nano-size tube (left) and fiber (right) formed by SHS