IIT MADRAS
Indian Institute of Technology Madras
Technology Transfer Office
TTO - IPM Cell
Industrial Consultancy & Sponsored Research (IC&SR)

A LOW TEMPERATURE METHOD FOR FABRICATION OF DENSE BORON CARBIDE COMPOSITES

IITM Technology Available for Licensing

Problem Statement

- **Processing of Boron carbide is extremely difficult** due to its covalent nature and **low diffusion coefficient.**
- It **requires high temperatures (> 2100 °C) and pressures (30-40 MPa) for densification.**
- Such processing conditions **are expensive** and also favor grain coarsening which **degrades the mechanical properties.**
- **There is a need for an** improved approach for low temperature sintering processes **for fabricating dense B_4C components.**

Intellectual Property

- IITM IDF Ref. **1794**
- **IN 376105- Patent Granted**

TRL (Technology Readiness Level)

TRL - 4: Technology validated in lab scale.

Technology Category/ Market

Category-
Advanced materials and Manufacturing
Industry Classification:

- **NIC (2008)- 23935-** Manufacture of ceramic laboratory, chemical and industrial products
- **NAICS (2022)- 327110-** Pottery, Ceramics, and Plumbing Fixture Manufacturing; **339113**-Bulletproof vests manufacturing
- **Applications**- Manufacturing of Neutron absorber, Body Armor material, Blast nozzles, cutting tools, control rods

Market Drivers-

- From 2023 to 2033, the boron carbide market is projected to exhibit a 5.3% CAGR. It is anticipated to rise at a valuation of US$ 153.9 million in 2023

Research Lab

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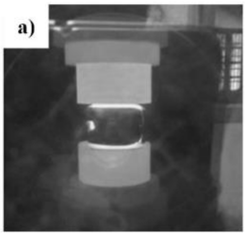

Figure: (a) B_4C 5wt%TiB with punches during sintering stage

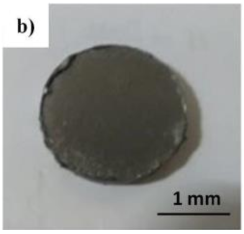

Figure: (b) B_4C sample after sintering B_4C 18 with graphite layer

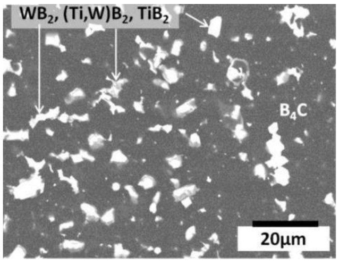

Figure: SEM image of back scattered electron image of polished cross section

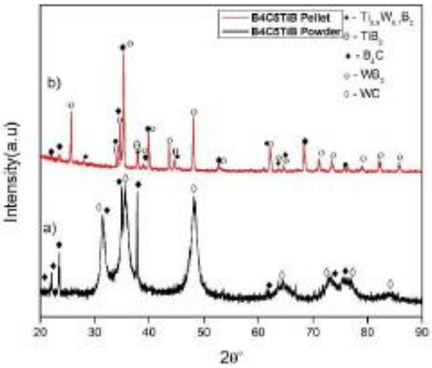

Figure: Graphical representation illustrating XRD patterns of B_4C with 5wt. % Ti-B

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Technology

1. The process consists of sintering of B_4C composite at Spark Plasma Sintering (SPS) temperature of 1400°C and 50 MPa pressure using mechanically activated Ti-B as sintering aid
2. Mechanical activation of Titanium and Boron powder in the ratio 5:95 (by weight) followed by ball milling for 4h for homogeneity and better dispersion
3. Spark plasma sintering was carried out at 1400 ˚C with a heating rate of 100 9 ˚C/min and hold time of 10 min at peak temperature with 50 MPa pressure.
4. The grain size of the Boron carbide obtained was approximately 15-20 µm with no porosity
5. The hardness of the sample measured form Vickers micro hardness tester was ~29 GPa

Key Features / Value Proposition

- The invention enables fabrication of B_4C composites at 1400°C compared to conventional technologies that require a minimum temperature of 1700°C.
- The calculated theoretical density of the composite is 3.27 g/cc while the measured density of 3.35 g/cc indicates that the achieved density is almost same as the theoretical density. Whereas, prior art processes have reported achievement of only 95-98% of theoretical density.
- Fine grain size and no porosity enhance suitability of the obtained composites for high performance applications.
- The low temperature process reduces fabrication costs without compromising on mechanical properties.

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