Fabrication and Properties of Metal Matrix Composites as a Neutron Absorber Material of the Spent Fuel Dry Storage System

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KAIST

Ji Won Mun, Tae Gyu Lee, Ho Jin Ryu*

Department of Nuclear and Quantum Engineering, KAIST, Yuseong-gu, Daejeon 34141, Republic of Korea

*corresponding author: hojinryu@kaist.ac.kr

Objectives

❖Fabricating next generation neutron absorbing material with Gd_2O_3/Al MMC.

❖Comparing properties between conventional dry cask basket material 20vol.% B_4C/Al MMC with Gd_2O_3/Al MMC.

Introduction

❖ Demand of dry spent nuclear fuel(SNF) storage is increasing because it has more advantages than wet storage such as transportability, expandability of capacity, reduced management and passive safety.

❖ Neutron absorbing materials is important for dry spent nuclear fuel storage because material can reduce criticality of SNF more effectively and dry storage can store shorter period wet stored spent nuclear fuel.

❖ When B_4C content is increasing there is a significant decrease of impact energy so 20vol.% is the maximum volume fraction of B_4C reinforcement[1].

❖ By substituting 1.5vol.% Gd_2O_3/Al MMC that has the same effective of 20vol.% B_4C/Al in terms of neutron absorption, better mechanical properties will be achieved.

[1] I. Topcu, H.O. Gulsoy, N. Kadioglu, Journal of Alloys and Compounds 482 (2009) 516–521.

Sample preparation & Procedure

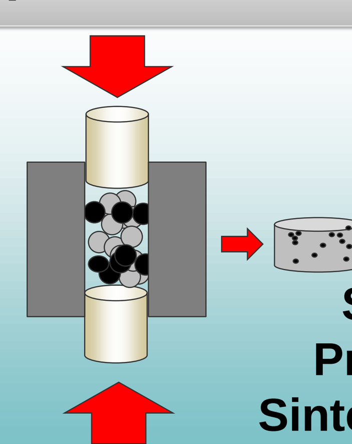
- Material properties

	B_4C	Gd_2O_3	Al 7075 powder
Size	40µm	1µm	80µm
Density	2.52g/cm³	7.07g/cm³	2.81g/cm³

- Fabrication process

Powder mixing → Spark Plasma Sintering

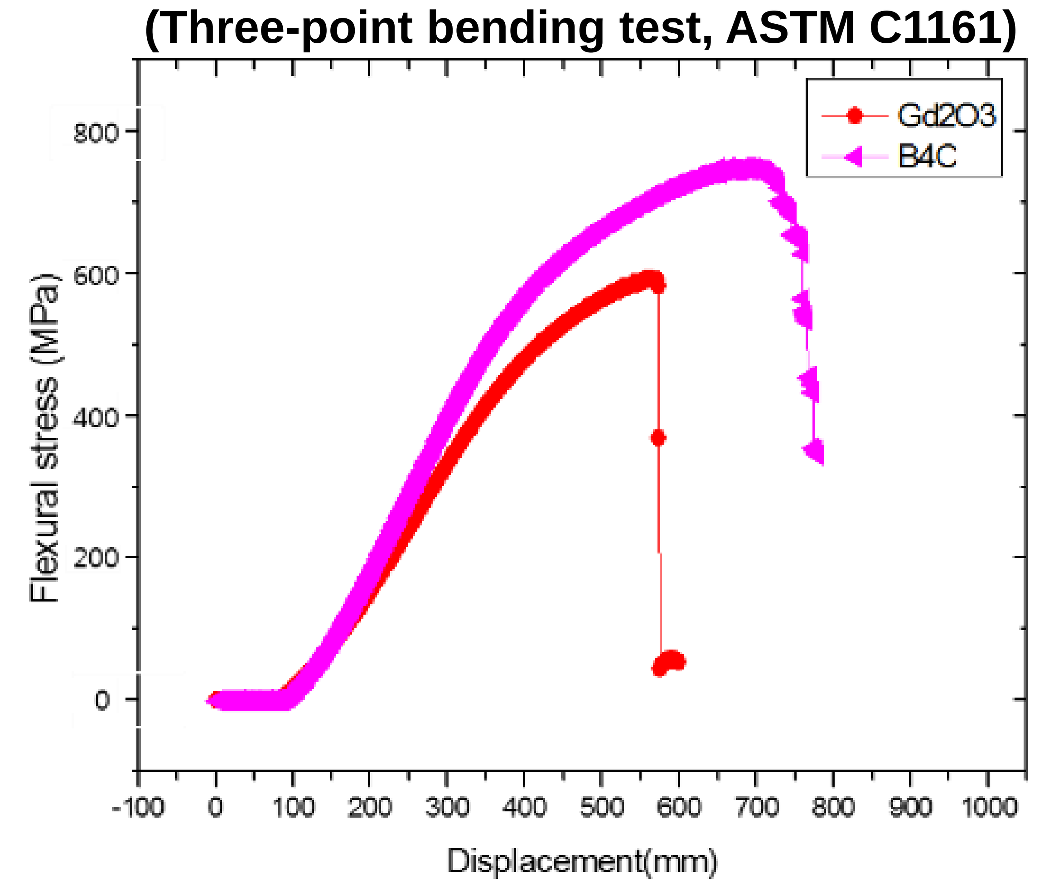
3D mixing condition:
40 rpm for 5 hours

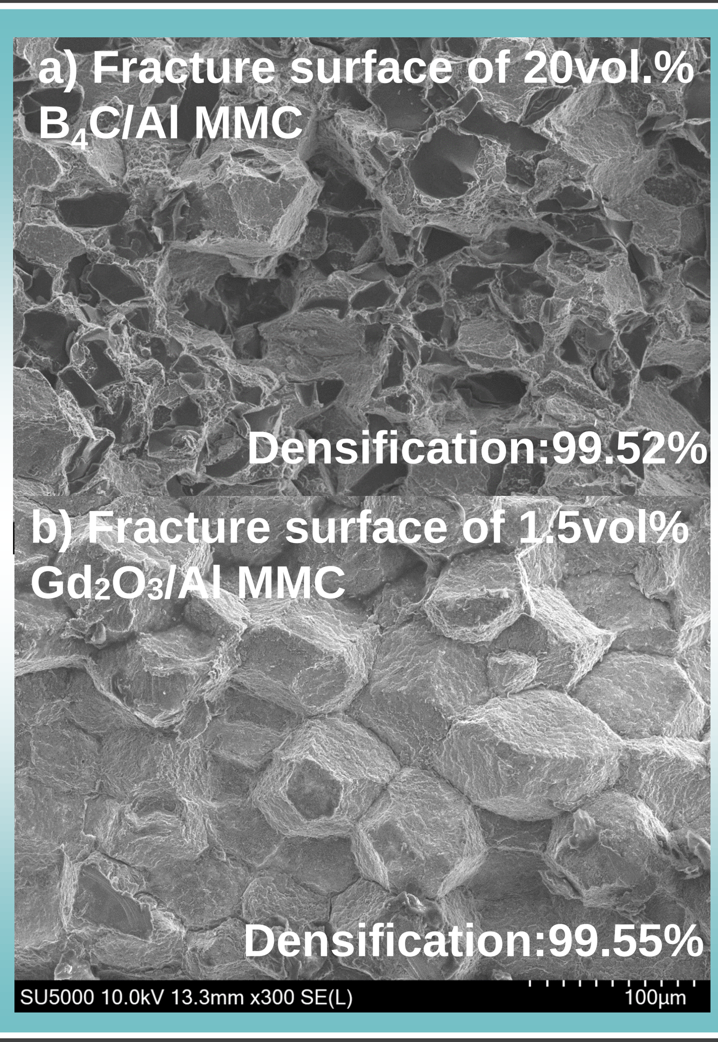


SPS condition:
Pressure: 40 MPa
Sintering Temp.: 450℃
Holding time: 5min

Fracture surface and Strain & stress curve

- Stress & Strain curve of fabricated samples (Three-point bending test, ASTM C1161)

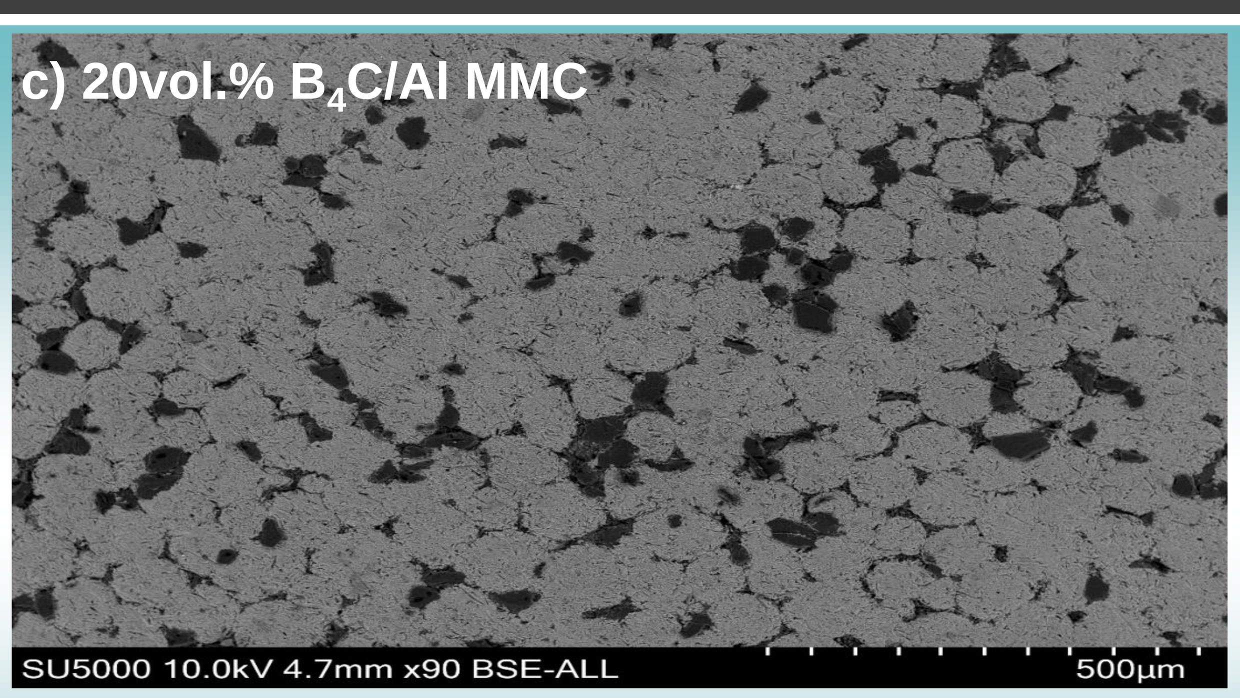




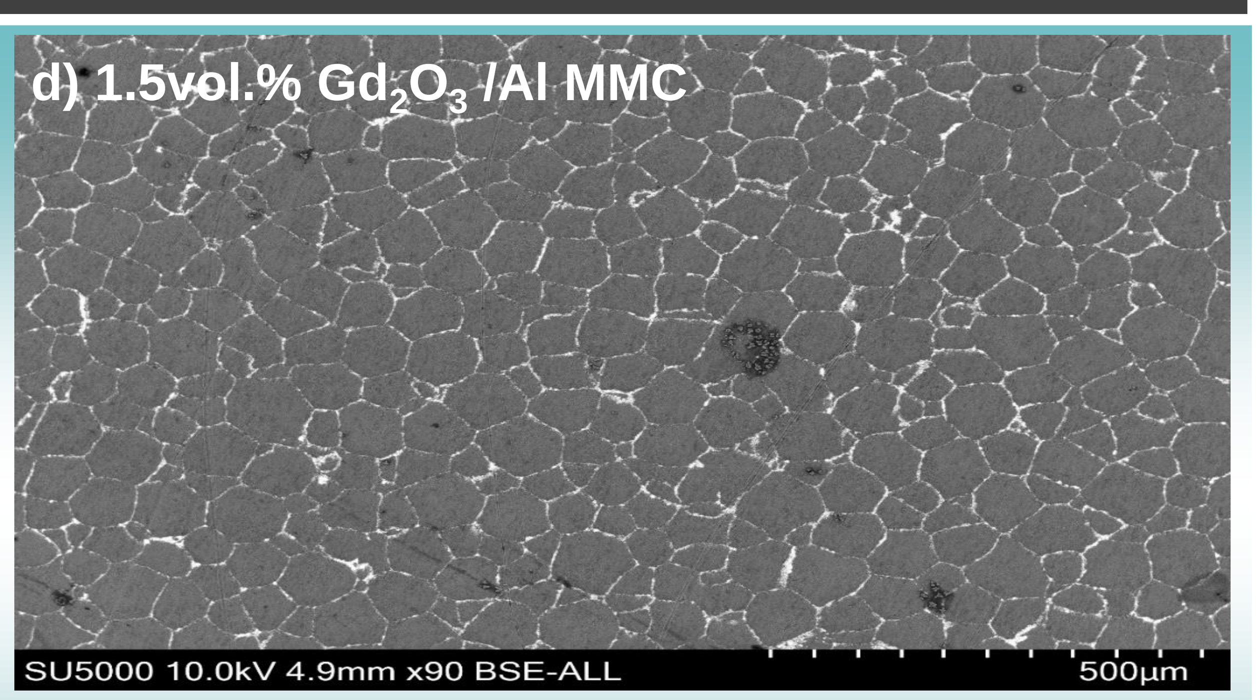
1. The bending strengths of B_4C MMC is 760MPa.
2. By image a), dimple structure was observed, which indicates that failure mechanism is ductile fracture.
3. B_4C/Al MMC shows higher elongation and strength than Gd_2O_3/Al MMC.

1. The bending strengths of Gd_2O_3/Al MMC is 600MPa.
2. By image b), only interface separation between Al granules was observed, without deformation.

Microstructure



1. No porosity
2. Reinforcement is well distributed between Al granules
3. Al-Al bond is well formed



1. No porosity
2. White Gd_2O_3 particles fully cover Al granule boundary
3. Al- Al bond is blocked

Conclusion

1. Fully dense 20vol.% B_4C/Al MMC and 1.5vol.% Gd_2O_3/Al MMC was fabricated in this study.
2. In Three-point bending test result, high volume fraction B_4C/Al MMC shows higher elongation and strength than Gd_2O_3/Al which is not matched with the general tendency of MMCs.
3. SEM image of fracture surface shows that B_4C/Al MMC has a ductile fracture and Gd_2O_3/Al MMC has a brittle fracture.
4. Microstructure shows the reinforcement distribution difference causes two different fracture mechanism.
5. It is expected that the unified size of B_4C powder and Gd_2O_3 powder will show general MMC behavior.

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