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Formation of W Layers on SiC Ceramics [†]

— Study on EB-PVD (report1) —

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KEYWORD: (W layer) (SiC) (EB-PVD) (SiC/SiC) (Welding)

At present, SiC/SiC composite material is mainly studied as a heat-resistant material for high temperature environments e.g. inner wall materials for nuclear fusion reactors. However, an effective method for joining SiC/SiC composite material has not been developed. In this report, the formation of W layers on SiC surface for joining of SiC/SiC was examined by EB-PVD with small heat affection of the substrate material. It was found that environmental gas pressure greatly influenced the coating layer by the contamination of the impurity in the preliminary experiment. Therefore, a high vacuum EB-PVD equipment was newly developed, and the characteristics of the layers were examined.

A schematic drawing of the experimental apparatus is shown in Fig.1. As a heat source, an electron beam welder with 6kW maximum power was used. An EB-PVD equipment consisting of a cylindrical vacuum chamber made of SUS304 (diameter : 400mm, height : 520mm) which could reach to a pressure of 10^{-3} Pa within 5 minutes by a turbo molecular pump of an exhaust speed of 1800l/sec was used.

Porous SiC (SCP-5 : Ibiden Co.,ltd.) was used for the substrate material. Physical properties of the substrate material are shown in Table1. A tungsten

powder of $5.2\mu\text{m}$ of mean particle size was used for the layer material.

The electron beam was spirally scanned by a oscillation coil and irradiated W powder in the crucible.

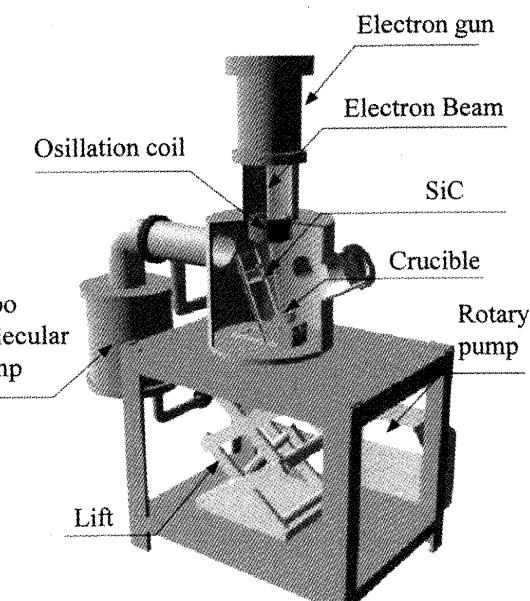


Fig.1 Schematic drawing of experimental apparatus of EB-PVD

Table1 Physical property of SiC (SCP-5)

Appearance	Porosity rate	Vickers hardness	Thermal conductivity	Specific heat
Porous	45-40%	300kg/mm^2	$0.07-0.08\text{cal/cm}\cdot\text{sec}\cdot^\circ\text{C}$	$0.21-0.23\text{cal/g}\cdot^\circ\text{C}$

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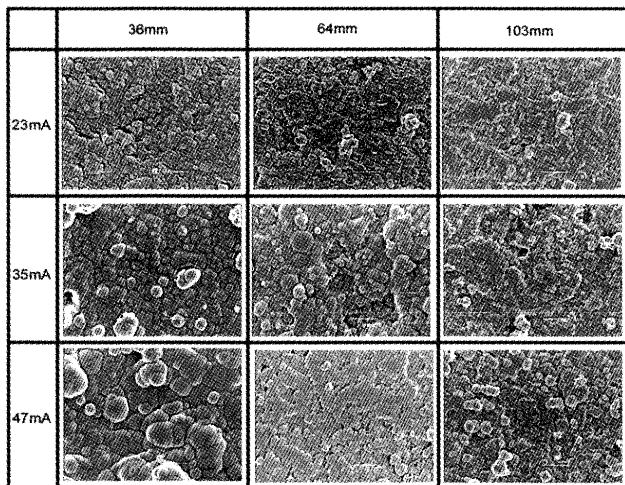


Fig.2 SEM photographs of W layers with EB-PVD for various beam currents and distances from crucible
Accelerating Voltage=60kV
Coating time=10sec
Gas pressure= 4×10^{-3} Pa

W layers were formed on the substrate by the vapor deposition of tungsten ultra time particle rapidly. Reduction of the contamination by the impurity was examined under high vacuum atmosphere and morphology of the coating layers on the beam current was investigated.

SEM photographs of layer surface are shown in Fig.2 formed at an acceleration voltage of 60kV, beam currents of 23-47mA, distances of 36-103mm, gas pressure of 4×10^{-3} Pa, coating time of 10sec. There was unequal growth of the W particles, when the distance from crucible was near and the beam current was high. However, minute and uniform W particle layers were formed at larger distances and low beam currents.

For the layer formed at a beam current of 23mA and a distance of 103mm an EDX analysis of the sample surface is shown in Fig.3. M and L series peaks of W are clearly recognized. Si and C peaks of substrate component could not be seen. It is thought that layers of sufficient thickness for EDX were used.

An SEM photograph of the cross section of the W coating layer is shown in Fig.4 for a layer formed at a beam current of 47mA, distance from the crucible of 64mm and coating time of 10sec. A W layer of $2\mu\text{m}$ thickness was formed on the substrate in a short time of 10sec.

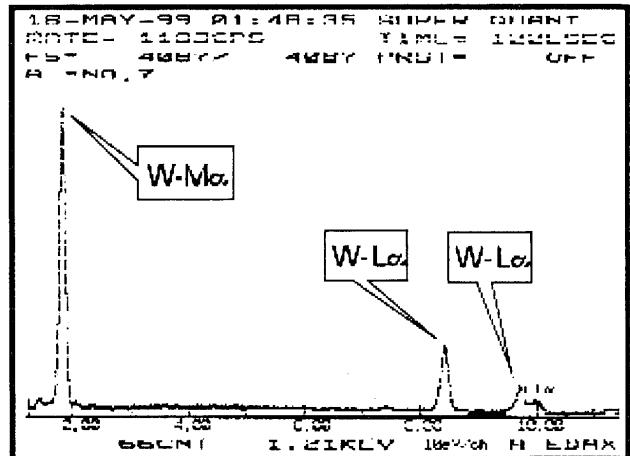


Fig.3 EDX analysis of W coated layer
Accelerating voltage=70kV
Beam current=23mA
Distance from crucible=103mm
Gas pressure= 4×10^{-3} Pa
Coating time 10sec

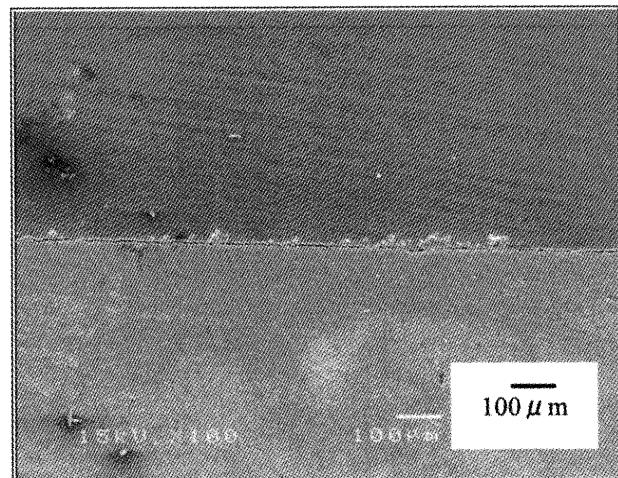


Fig.4 SEM photograph of cross section of W layer with EB-PVD
Accelerating voltage=60kV
Beam current=47mA
Distance from crucible=64mm
Gas pressure= 4×10^{-3} Pa
Coating time=10sec

Reference

- 1) N. Abe, H. Serizawa ; Proc. of the 16th Fusion Reactor Materials Forum, The SiC/SiC composite material workshop(1998), 82-83.