§3. Study on Characterization Methods for Ceramic Components and Coatings Using Luminescence Materials

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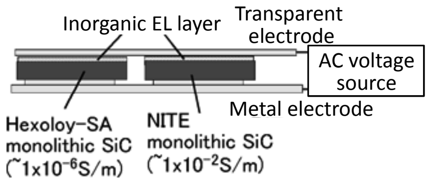
Developments of ceramic components and coatings have been conducted for suppression of MHD pressure drop in a liquid metal coolant flow and tritium fuel permeation thorough blanket walls. In various tests of their electrical insulating performances and hydrogen permeation reduction performances, a distribution of the constituent materials and microscopic defects such as cracks and pores changes their performances drastically. In the present study, visualization methods of distributions of material properties and microscopic structure by using luminescence materials have been investigated for characterization of the ceramic components and coatings used in a fusion blanket system.

A preliminary visualization test of an electrical conductivity distribution using an inorganic electroluminescence (EL) material has been performed on SiC plates. Figure 1 (a) shows the schematic drawing of the test. Electrical conductivities of the Hexoloy-SA monolithic and NITE monolithic SiC plates were ~1 x 10^{-6} S/m and ~1 x 10^{-2} S/m, respectively. On the lower surfaces of the SiC plates, Pt electrodes were made by DC sputtering. On the upper surfaces, an inorganic EL paste was painted with a brush. The SiC plates were sandwiched with metal and transparent electrodes. An AC voltage of 400 Hz and 20V was applied between the electrodes. A luminescence of the EL material was observed only on the NITE-SiC plate as shown in Fig. 1 (b). It is considered that the most of applied voltages was distributed to the ELlayer on the SiC plate with a lower conductivity and the luminescence was observed. From the result, EL materials could be used for visualization of electrical conductivity distribution in ceramic components.

Another trial of a visualization of an electrical conductivity distribution has been performed by using organic luminescence reagents of GFP and DiBAC4(3). These reagents are commonly used for studies of functions of biological cells. Figure 2 (a) shows the schematic drawings of a response examination of the reagents under an applied electric field. In the liquid of the reagent, Pt electrode wires were inserted and a DC voltage was applied. The luminescence of the reagent in the range of 467-498 nm was observed by excitation with a light of 457-458 nm. The response of the GFP reagent is shown in Fig. 2 (b). The luminescence of the reagent weakened around the electrode with a positive voltage. A similar response to an applied electric field was observed also for the DiBAC4(3) reagent. However, in the case of DiBAC4(3), the luminescence weakened around the electrode with a negative voltage. Figure 3 (a) shows the response examination of DiBAC4(3) on a ceramic coated sample. The sample was a stainless steel plate coated with the Er_2O_3 ceramic coating of ~1 μm in thickness. A part of the coating was removed by sputtering with an Ar^+ ion beam. A transparent electrode was placed on the sample by keeping the distance of ~40 μm. Figure 3 (b) shows a change of luminescence area observed 5 minutes after a DC voltage of +2.3V was applied to the stainless steel substrate. The luminescence weakened on the non-coated area.

While a further study is required to understand the mechanism of the responses of the reagents under an electric field, these methods would be effective for characterization of ceramic components and coatings in the large scale blanket. The applicability to more microscopic characterizations is being studied at present.

(a)



(b)

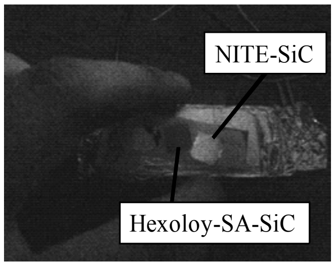
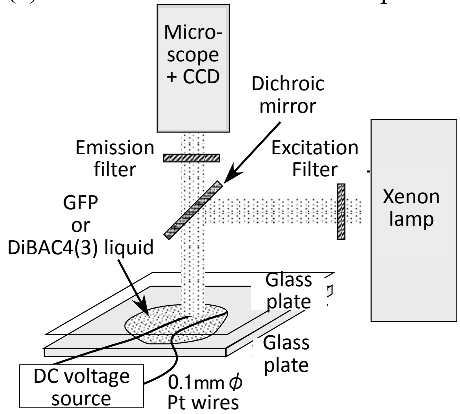


Fig. 1 (a) Preliminary visualization test of electrical conductivity distribution using inorganic EL material and (b) luminescence observed on SiC plates



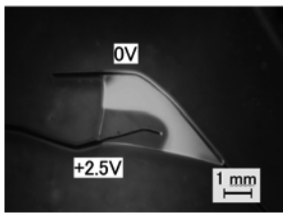
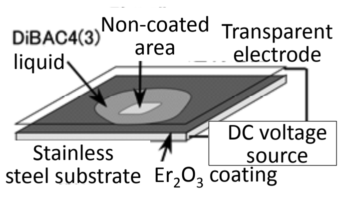


Fig. 2 (a) Schematic drawing of response examination of organic luminescence reagent under electric field and (b) change in luminescence area of GFP reagent by applied voltage.



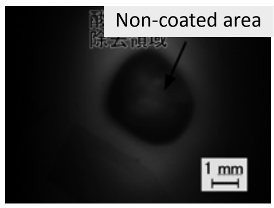


Fig. 3 (a) Observation of luminescence of DiBAC4(3) reagent on ceramic coated stainless steel and (b) attenuation of luminescence intensity at non-coated area.