§4. Behavior of Rhenium Interface on Tungsten Coated Carbon by Heat Load

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Thick tungsten coatings on CFC and isotropic fine grain graphite have been successfully produced by vacuum plasma splay (VPS) technique and their good thermal and adhesion properties have been confirmed by high heat flux tests. For the near term application for LHD, tungsten coated tiles could be convenient because the tiles could be easily replaced without big change in heat transfer properties to cooling channels.

In recent, higher density VPS-W(Vacuum plasma spraying tungsten) coated CFC and isotropic fine grained graphite comparing with the previous ones have been developed. In the present work, to investigate behavior of rhenium interface under steady state heat flux condition, thermal response and thermal fatigue lifetime tests using an electron beam facility have been carried out on the VPS-W coated CFC and isotropic fine grained graphite brazed on the OFHC with a cooling tube under the actively cooling condition. In addition, FEM analyses have been performed to evaluate the thermo-mechanical behavior. Tiles (20mm x 20mm x 10mm) of carbon/carbon composite CX-2002U and isotropic fine grained graphite IG-430U made by Toyo Tanso Co. were coated with tungsten by the vacuum plasma spraying technique(VPS). The thickness of the VPS-W layer was 0.5 mm and its density was 98% of the theoretical value. Mock-ups were made by brazing the VPS-W/CX-2002U, VPS-W/IG-430U on OFHC block with a cooling tube by inserting a Ti foil of 0.05mm-thick in between.

Heat load tests were performed on the Active Cooling Teststand (ACT) of National Institute for Fusion Science (NIFS). Uniform electron beam at 30keV was irradiated on the tungsten surface through a beam limiter with an aperture of 20mm x 20mm. Beam duration during ramp-up, plateau and ramp-down were 20s, 22s and 0s, respectively. Heat flux was changed from 1 to 10 MW/m^2. Thermal fatigue tests were also carried out for up to 100 cycles at a heat flux of 10 MW/m^2. Surface temperature of the tile was measured with an optical pyrometer. Temperatures of upper side(T1) and down side(T2) of interface of brazed area were also measured with thermocouples. The heat flux tests have been carried out under the condition that the water flow velocity, pressure and temperature were 15.0 m/s, 0.5 MPa and 293 K, respectively. After the heat flux experiments, the mock-ups were observed with a scanning electron microscope to investigate modification such as crack and exfoliation formation.

Figure 1 shows typical time evolutions of the electric current(a) through W/CX-2002U/OFHC mock-up and temperatures(b) at its surface, upper (T1) and lower (T2) parts of the brazing interface under heat loading of 7 - 10 MW/m^2. The temperatures closely follow the changing electric current. The thermal fatigue tests indicate that temperature change is not observed. In addition, no failure occurred at the braze interface or in the W coating during cyclic heat load. Therefore, it is demonstrated that the the mock-up successfully withstood of heat load 10 MW/m^2 and the rhenium interface shows good thermal and adhesion properties at steady state codition.

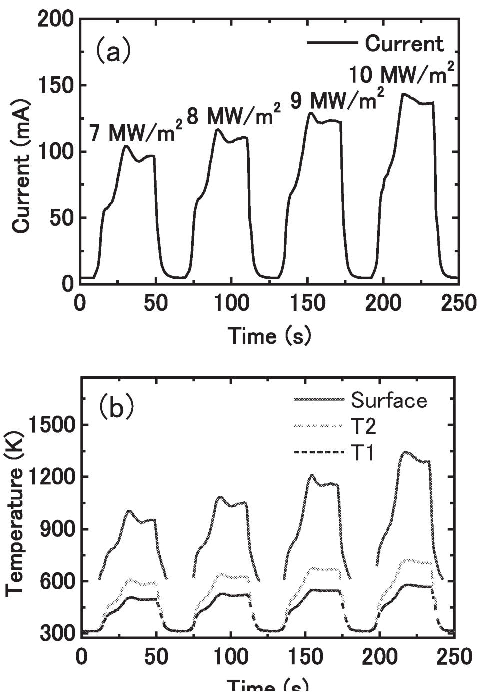

Fig.1 Time evolutions of the electric current(a) through W/CX-2002U/OFHC mock-up and temperatures(b) at its surface, upper (T1) and lower (T2) parts of the brazing interface under heat loading of 7, 8, 9 and 10 MW/m^2.