§28. Fundamental Study of Energy Conversion Divertor for Helical Reactors

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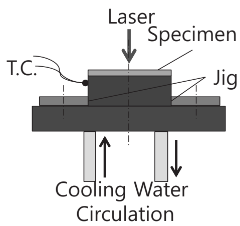
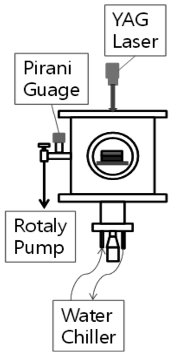
This study intends to investigate a possible concept of divertor to utilize the high heat and particle flux load by the conversion to high grade heat. It has a tungsten armor plated on the surface of the heat sink utilizing sublimation of heat transfer media in a closed channel. Typical heat flux is 10 MW/m^2 average, and the output temperature above 500 degree C is expected.

This year, some key issues required to integrate the divertor component as a heat transfer system were investigated. Based on the previous years achievements, YAG laser irradiation was established as a





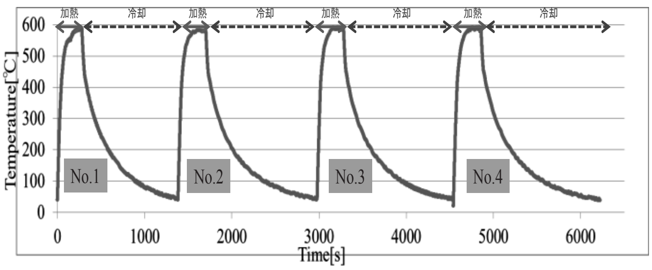
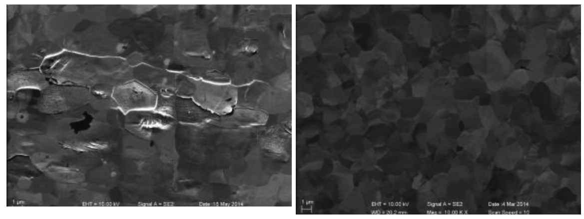


Fig. 1. Repeated laser pulse irradiation simulating heat load on a divertor target.

simulating experiment fir divertor target. As shown in the fig.1, repeated pulses with 10MW/m^2 order heat load was given on the tungsten coated F82H targets with respectively 0.2mm and 3mm thickness and the bask side of the specimen cooled with water. This configuration typically simulates the temperature gradient with heat flux and stress on divertor. Each heat cycle is consisted of 1500 laser pulses that gave up to 30MW/m^2 average load. Little degradation of thermal conductivity around 29W/mK was maintained indicating the integrity. However the slight degradation by formation of a compound phase could occur. As shown in the fig.2, cracks were observed on the tungsten surface after the laser irradiation even at the temperature below melting point or recrystallization temperature. From the comparison with the FEM analysis, this damage was considered to be caused by the repeated pulsed load that causes large stress.



After the 0.25MJ/m2 laser irradiation ,x10000

Before laser irradiation ,x10000

Fig. 2. Tungsten surface before and after the laser irradiation.

In order to fabricate the target body of the divertor, underwater explosive bonding was developed. In this year, tungsten plated copper was tested. Considering the current demo design studies, copper is regarded as feasible because anticipated radiation damage could be less significant. Figure 3 shows the profile of the Cu-W cross section and its mixing of elements. Clear wave structure is not observed in this combination, and the mixing of elements suggests local melting have occurred.

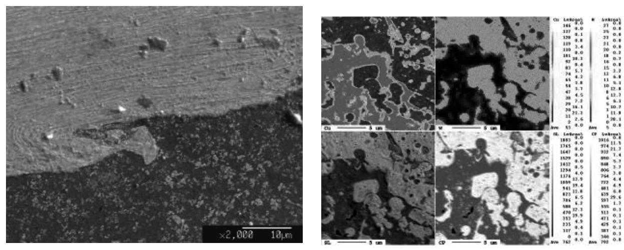


Fig. 3. Cross section of the Cu-W interface by SEM(left) and elements (right) made by underwater explosion .

Figure 4 shows the typical result of the heat transport characteristics with a heat pipe structure, that works as heat sink of this divertor concept. Approximately 1/4 of expected capacity limited by entrainment of liquid was observed, suggesting interaction between vapor and liquid dominates the performance.

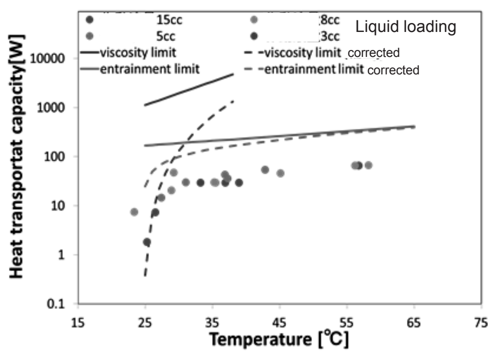


Fig. 4.heat transfer by heat pipe structure.