

In-situ in-reactor testing of potential bolometer materials for ITER plasma diagnostics

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ITER will rely on bolometric systems to provide information on the spatial distribution of the radiated power from the main plasma and in the divertor region. Bolometer arrays will be installed in the equatorial and upper ports, in selected locations on the vacuum vessel, and on the divertor. Initially, it was supposed to use JET type high-temperature bolometers, which employ a thin mica substrate as the support for a delicate gold meander electrical resistance bridge network. However, an in-reactor experiment at the Japan Materials Testing Reactor (JMTR) in Oarai, Japan, revealed that such bolometers may not sustain the expected dose of neutron radiation of 0.02 dpa [Al] due to the both mica instability and the Au→Hg transmutation. As an alternative, AlN and Al₂O₃ ceramic substrates have been proposed. These materials were expected to be stable under radiation and have an advantage of considerably increasing the temperature limit for continuous use above the 500C recommended for mica. To cope with the transmutation problem, gold was replaced with platinum.

The paper describes the results of in-reactor test of two prototype bolometers: a Pt/AlN (i.e. Pt meander on AlN substrate) and a Pt/Al₂O₃ one. A dedicated vacuum capsule with a hot stainless steel holder for the bolometers was designed and fabricated in order to allow irradiation in vacuum at 400C using nuclear (gamma) heating. The irradiation was performed at SCK-CEN in BR2, a high flux materials testing reactor, at a neutron flux 0.001 dpa/day [Al] with a gamma heating ~1 W/g (Al) up to a total fast (E > 0.1 MeV) neutron fluence of 1.3x10¹⁹ n/cm² (0.013 dpa [Al]). The temperature of the bolometers during irradiation was in a range 400-500 °C and for a short period of several minutes it was above 700 °C.

In-situ electrical measurements of the Pt meander resistance were performed at the first step of the experiment, corresponding to an accumulated fast neutron flux of 0.8x10¹⁸ n/cm². The resistance of the Pt/AlN meander remained unchanged within 0.5 Ohm and for Pt/Al₂O₃ increased by 7.5 Ohm. Insulation resistance measurements were performed during the whole experiment and a degradation was observed.

Visual PIE (Post Irradiation Examination) was performed in a hot cell and did not reveal any change of either the meander or the substrate for both bolometers, indicating that Pt/AlN bolometers should sustain radiation loads in excess of 0.01 dpa. Further experiments to confirm this are underway.