

Electrical and mechanical behaviour of improved platinum on alumina bolometers

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In-reactor tests at JMTR (Japan) on JET type bolometers using Au meanders on a mica substrate demonstrated that under irradiation they suffer severe degradation before 0.01 dpa due to transmutation of Au into Hg, meander detachment from the substrate, substrate swelling, and electrical failure possibly related to the spring loaded contacts. As a result work was undertaken to examine alternative more radiation resistant substrates, together with the substitution of Au by Pt, as well as the possibility to modify and improve the electrical connection. Basic prototypes from CIEMAT with sputtered Pt meander sensors on Al₂O₃ and AlN ceramic substrates, together with direct electrical wire connections to the meanders were tested during electron and neutron irradiation at CIEMAT and SCK/CEN Mol. Results up to 0.01 dpa showed acceptable behaviour of both substrates and better radiation resistance response of Pt compared with Au. However the electrical connection between terminals and meander was again identified as a weak point of the design. In addition the electrical response of the sputtered metal films was observed to degrade at high temperatures ($\geq 900\text{C}$) as a consequence of the discontinuity of the thin metal film and the formation of Pt islands. Here we report on an improved prototype, with reduced meander area, enhanced Pt film quality and adhesion, and better electrical connections. An analysis of the quality of the platinum sensor adhesion and the metal-substrate interface features has been performed to optimise the bonding. The bonding and hence stability of the meander has been improved by electron beam evaporating firstly an extremely thin layer of titanium as interface and then the Pt sensor on to a 20 nm roughness polished surface of Al₂O₃. The thermal stability of the evaporated platinum deposit has also been studied using an environmental scanning electron microscope during in-situ sample heating. After vacuum annealing at 500C, these new prototype Pt on alumina substrate bolometers were electrically characterized. The electrical resistance as a function of thermal cycling and radiation dose was registered up to 300C during electron irradiation. Comparison of their electrical and mechanical behaviour with bolometers made of sputtered metal sensors is also discussed.