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P3.048 Study of the methods to enhance infrared emissivity of Molybdenum surface

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Single crystal Molybdenum is one of the most promising materials for the First Mirror (FM) for ITER optical diagnostics due to high resistance to erosion under the neutral atom bombardment. Other advantages are: low CTE, high thermal conductivity, good mechanical properties at elevated temperatures. The FMs are normally located in the front-end of ITER port plugs, being subject to the volumetric heat loads up to ~1W/cm3 and higher. Active cooling of Mo mirrors by the water or gas flow has limited applicability due to remote handling, integration and risk requirements. So-called athermal design with radiative cooling is developed for the H-alpha FM unit with all-Mo structure comprising the housing, two mirrors and cleaning electrodes. Main idea is to minimize the mirror displacements and to keep the alignment at the temperatures up to ~350℃. That requires the balance between thermal contact and radiative heat sinks. Most uniform profile is obtained by weak thermal contact between FMU and support structure, but it leads to the highest FM temperature, since the normal as-milled Mo surface has very low effective emissivity <10% at 200..300℃. The well-known tools for the surface blackening: enhanced roughness, oxidation, V-grooving, coatings, must be analyzed for the outgassing rate, thermal, radiation and long-term stability in Hydrogen environment.
In this study, a number of the techniques to enhance Mo surface effective emissivity have been tested: V-grooving, detonation spray coating and surface electro-erosion. Spectral emissivity of the test samples have been measured by Bruker Vertex-70 infrared Fourier spectrometer and the effective values are derived for the subsequent thermal analyses. Alumina coatings were found to be the most effective tools with emissivty ~80%. However, the V-grooving technique also gives the acceptable result ~25..30% and it does not require the qualification for applicability to ITER. The trade-off between different techniques is discussed in detail.

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