

## **Review on the EFDA Programme on Tungsten Materials**

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Tungsten and tungsten alloys are currently considered as candidate materials for various divertor applications in future fusion reactors as well as for shielding the first wall. This is mainly due to their high temperature strength, good thermal conductivity, and comparably low activation under neutron irradiation. The main components where these materials could be applied are (1) plasma facing shields, (2) high temperature cooling structures, and (3) high temperature backbone/support structures. For the shields, tungsten is used as armour material (also due to its high sputter resistance) to protect the subjacent cooling structure. Depending on the plasma operation conditions in tokamaks the shielding surface temperatures might, on the one hand, well exceed 1800 °C, and on the other hand, drop down to the maximum operation temperature of the cooling structure, which is limited for most tungsten materials to about 1200 °C due to recrystallization and loss of strength.

The most important, and necessary, properties of the armour materials are therefore related to crack resistance under thermal shock load and resistance to irradiation damage in general. Obviously, the backbone/support structures should be made of steel which restricts its operation temperature to about 550 °C for conventional steels and to 700 °C or possibly above for ODS steels. Therefore, the cooling structures are expected to work within the temperature interval of about 450-1200 °C. In that temperature range the most critical requirements for possible structural tungsten materials are ductility, the creep strength, and resistance to recrystallization – all under severe neutron irradiation.

The long-term objective of the EFDA W and W alloys programme is to develop structural as well as armour materials in combination with the necessary production and fabrication technologies for future divertor concepts. The programmatic roadmap is structured into four engineering research parts which are (1) fabrication process development, (2) structural material development, (3) armour material optimisation, and (4) irradiation performance testing, which are complemented by a fundamental research programme on "Materials Science and Modelling".

This paper presents the current research status of the work on the experimental and testing programme for divertor applications carried out in Europe under EFDA, and gives a detailed overview on the latest results on tungsten alloys, mass fabrication, joining, high heat flux testing, plasticity, fracture mechanics, modelling, and validation experiments.

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