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Plasma facing and high heat flux material development and down-selection process within the European fusion materials program

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Material development for future fusion devices has a decades-long history in Europe, initiated under EURATOM through the EFDA collaborative agreement and further developed in the framework of the EUROfusion Consortium. One particular topic thereby is the development of advanced plasma facing and heat sink materials, which should allow extending the operational regime and the lifetime of in-vessel components as well as tackle safety concerns in case of accidental scenarios with regard to the baseline materials tungsten and CuCrZr.
While the primary focus in the European framework program FP8 was still on the optimization of the material concepts including chemical composition, manufacturing technology and material design, progressing into the conceptual design for DEMO the focus shifted towards industrial upscaling and technological implementation of the materials in the actual component design, which inevitably includes also qualification at operationally relevant neutron fluences. The progress thereby is, amongst others, monitored via assessment of the material technology readiness level of the individual materials, which also includes the identification of showstoppers leading to either modifications of the material / material concept or to discarding the material completely.
In this down-selection process, which is a necessity with regard to available manpower and financial resources and which require a variety of material data to take a sound decision, on the one hand a multitude of materials and fabrication processes have been discarded. This includes amongst others powder injection molding for plasma facing materials, SiC-fiber reinforced tungsten, TiC- and Y2O3 particle reinforced tungsten, quaternary Cu-alloys. On the other hand, several materials and technologies are still part of the selection process for DEMO, which are self-passivating tungsten alloys for First Wall applications and K-doped as well as WC-reinforced tungsten materials as plasma facing material and W-fiber and –particle reinforced Cu-alloys as well as ODS-Cu (Y2O3) as heatsink. On top of that additive manufacturing technologies for both, tungsten and Cu-based structures, are assessed for in-situ repair as well as alternative and complex shaped design concepts as well as prospective material concepts for a fusion reactor that are yet on a low maturity level.
The history as well as the actual status of this development and down-selection process will be presented and an outlook on the final decision on the most promising concepts for the engineering design given.