European Fusion Materials Research Program - Recent Results and Future Strategy

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The European Long Term program is focused on the R&D of the materials and key technologies needed for a demonstration (DEMO) reactor, and in particular, on structural materials for the blanket and the divertor. The strategy is based on the assumption of a 'fast track' approach: (i) ITER operation staring in 2015, (ii) IFMIF first beam operation (with half power) in 2017, (iii) DEMO design starting around 2022. In the European power plant conceptual studies (PPCS) several types of breeding blankets and divertors have been considered utilizing moderate extrapolation up to very advanced concepts, in both, physics and technology. This planning determines the time schedule for the materials development.

In the EU approach DEMO relevant Test Blanket Modules (TBMs) are to be installed in ITER from day one of operation. Therefore, fully developed and code qualified technologies and materials (up to 3dpa) have to be ready by 2015. Two different breeding options, i.e. a helium cooled lithium lead and a helium cooled ceramic blanket with pebble beds are considered for early DEMO operation. The reduced activation ferritic/martensitic (RAFM) steel, called EUROFER, is the candidate structural material designed to operate at 250-550°C.

In parallel to the development of 'generation one' breeding blankets and materials, research on alternative, so-called 'advanced', materials has to be conducted for operation at higher temperature. In the long term the European Union therefore sees a logical sequence, by supplementing EUROFER with the next generation of advanced ferritic steels based on oxide dispersion strengthening (ODS), and of fibre-reinforced Silicon Carbide (SiC_f/SiC).

RAFM steels of the EUROFER family will undergo several steps of development within the next two decades: from the early use in ITER TBM to a material qualified up to neutron doses of 150 dpa for DEMO application in about 2022. The strategy foresees that, after optimization of mechanical and irradiation properties, in the following step the 'low level waste' standard will be achieved.

The development of ODS steels, started in 2002, is also aiming to be fully developed by 2022 with an operational window that is shifted about 100°C towards higher temperatures. SiC/SiC composites will be used as functional materials inserts in steel blanket structure during the early stage of a DEMO operation. In about 30 years from now, fully qualified SiC/SiC should be available as structural material for a second generation of DEMO blankets and for power plant applications.

Tungsten alloys are considered as structural material for high temperature applications in Gas cooled divertors in DEMO and beyond. They show promising physical properties, but they also exhibit low fracture toughness and suffer from irradiation embrittlement even at elevated temperatures of 600°C and above. In addition, they have, so far, not been used as structural materials for larger components. Therefore, the development of W alloys to be used from 600-1200/1300°C is a real challenge and needs a coordinated international effort.