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Application of TEM to study the changes in sub-surface defects in Tungsten samples as a function of annealing temperature

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In a nuclear fusion reactor, hot and dense D-T plasma is confined using a combination of magnetic fields in a toroidal shaped vacuum vessel. Interaction of this plasma with the wall materials of vacuum vessel is one of the very important areas of interest as plasma-wall interactions will decide the operational life-time of the reactor in terms of plasma as well as material stability. The choice of the wall-material hence becomes an important factor and high atomic number materials such as tungsten and its alloys are currently identified as candidate materials due to their relatively low H-isotope affinity. However, high energy neutrons and alpha particles produced in the fusion reaction can introduce sub-surface defects in tungsten, which may lead to H-isotope trapping through these defective sites.

In-order to understand the effect of these defects, it is critical first to identify them. The defects concerned here, such as dislocations, are like bulk features of the materials and cannot be identified using surface characterization equipment such as Scanning Electron Microscope (SEM). Transmission Electron Microscope (TEM) is one of the very few instruments which can identify these meso-scale sub-surface defects. In the work discussed here, we had used a 300 kV TEM to identify these defects in tungsten (W) samples. TEM microscopy of the as received W samples (cold rolled) was carried out. Grains were observed to be elongated and the dislocation density is very high. Later the W samples were subjected to annealing at various temperatures ranging from 773 to 1838 K. The annealing was carried in a vacuum furnace under a reducing atmosphere of Argon and Hydrogen mixture. A base pressure of 10-5 mbar was obtained before the Argon, Hydrogen mixture was introduced. The effect of annealing temperature on the changes in defect distribution and restructuring was studied using TEM. Defect density is observed to reduce with increase in annealing temperature (below recrystallization temperature), though there is not much change in grain size. However, above recrystallization temperature, the grain size was observed to change from elongated to regular shape while the defect density was reduced. Present work also explains in detail about the sample preparation procedure adopted for preparing the W samples for TEM analysis.

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