Measurements of ^{3}He Retention in Tungsten, Simulating Conditions at the First Wall of an IFE Reactor, Using ^{3}He(d, p)^{4}He Nuclear Reaction Analysis

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In an inertial fusion energy (IFE) reactor, the tungsten-armored first wall will be subjected to intense doses of helium ions produced by DT fusion reactions. The retention of helium in tungsten may cause significant damage by forming bubbles below the surface, resulting in blistering and eventual exfoliation of the surface. Therefore, it is of paramount importance to understand the helium retention characteristics of tungsten as a function of dose, temperature, and crystalline structure.

The present study consists of implanting 1.3 MeV ^{3}He into three forms of tungsten: single crystal, polycrystalline, and CVD (columnar grain structure). Implantation doses ranged from 1E19/m^2 to 1E22/m^2, and target temperatures were 850°C. The as-implanted tungsten specimens were analyzed by the ^{3}He(d,p)^{4}He reaction with deuterons of 910 keV incident energy. This reaction produces 13 MeV protons, which can be detected to obtain a profile of the implanted ^{3}He. Some specimens were flash-annealed at 2000°C, to simulate the thermal pulse following the fusion reaction in IFE reactors, and reanalyzed to measure any change in helium retention.

For low doses (1E19/m^2) of ^{3}He implanted at 850°C, similar helium retention levels were observed in single crystal, polycrystalline, and CVD specimens. When much higher doses (1E22/m^2) of ^{3}He were implanted into polycrystalline tungsten specimens at 850°C, blistering of the surface was clearly visible after annealing at 2000°C. Future experiments will determine the minimum helium dose at which blistering of the surface occurs in each of the three crystalline structures. This work is supported under the DOE High Average Power Laser program.