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学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称　博士（工学）　氏名　ZONG Yun

学 位 論 文 題 名

Study on refractory high-entropy alloys for nuclear fusion application
(核融合用の BCC 型高エントロピー合金に関する研究)

Nowadays, more and more researchers have paid attention to nuclear power because of its high production efficiency. With a performance target for the next 20 years, scientists start to work on controlling nuclear fusion to make a fusion reactor since the releasing energy of fusion is several times the amount produced from fission. As the important part of fusion reactor ITER, diverter, the materials designed for it require special properties that could survive at high temperatures, high corrosion, and high irradiation environment. After a few years of development, Carbon-fiber composite (CFC) and tungsten have become the candidate materials for the ITER divertor, but both kinds of materials have disadvantages. Considering this, high-entropy alloys with Ti, Zr, Hf, Ta, V, Nb, W, and Cr may be a good candidate which can replace pure tungsten in the future. In this research, MoNbTaTi, MoNbTaW, MoNbTaTiW, HfNbTaTiZr and HfNbTaTiV high-entropy alloy was investigated with a special focus on the irradiation hardening and microstructure.

First of all, we developed body-centered cubic refractory high-entropy alloys, MoNbTaTi, MoNbTaW, and MoNbTaTiW, and explored their microstructure, and mechanical properties in order to develop a new high-irradiation resistance material suitable for fusion reactor components. Three HEAs were annealed at 1200 ℃ for 48 hours to form single face BCC alloys, while MoNbTaW was also annealed at 1500 ℃. SEM inspection and EDS mapping have both validated this result. The Vickers hardness of three HEAs was investigated, and the stable results indicate that they are all stable at elevated temperatures. Three HEAs are ion irradiated with 6.4 MeV Fe3+ at a temperature of 500 ℃, and the irradiation hardening is examined using nanoindentation. In comparison to pure tungsten, the three HEAs exhibit increased resistance to irradiation.

Secondly, based on Senkov alloy, which has been identified as BCC alloys with good ductility, this work developed the HfNbTaTiV, and explored its microstructure, and mechanical properties to make a comparison between F82H and Senkov alloy (HfNbTaTiZr). The phase diagram of HfNbTaTiV indicates that this alloy is stable with a single BCC matrix the temperature above 800 ℃. The mechanicapropertiesed including Vickers hardness and the tensile property has been conducted to HfNbTaTiV, Senkov alloy, and F82H. The results indicate that HfNbTaTiV has higher Vickers hardness than Senkov alloy, and the yield stress and tensile strength of HfNbTaTiV are larger than that of Senkov alloy and F82H, while elongation was found to be larger in the order of HfNbTaTiV, Senkov alloy, and F82H. Three HEAs are ion irradiated with 6.4 MeV Fe3+ at a temperature of 300 ℃, the irradiation hardening of Senkov alloy is larger than that of HfNbTaTiV and F82H. However, the TEM observation represents different results and the possibilities of this phenomenon will be discussed in this work.