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# Growth of nano-tendril bundles on tungsten in impurity-rich helium plasmas

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Tungsten samples were irradiated with helium plasma which contains impurity gases to investigate the effect of impurity ions on the morphology changes under the sputtering dominant regime. The surfaces of the samples after irradiation were not uniform and the isolated nano-tendril bundles were found on the surfaces when the incident ion energy was higher than the threshold energy of sputtering by He ions. The size of the nano-tendril bundles were several tens μm and this was unexpectedly huge considering the sputtering effect under several hundreds eV of the incident ion energy. This result suggests that the impurity ions may work as an important source to form the isolated nano-tendril bundles.

## 1. Introduction

It is known that surface morphology changes occur on tungsten (W), one of the most promising candidates of divertor plate material in nuclear fusion devices, when exposed to helium (He) plasmas: nanostructures, so-called fuzz, are formed [1]. The growth mechanisms of the fuzz have been argued in several ways: surface migration by viscoelastic model [2] or adatom diffusion [3], or growth and burst of He bubbles under the surface [4].

It has been known that fuzz growth is affected with sputtering by impurity ions in He plasmas [5]. Here we examine the effect of impurity ions on the morphology changes on the W surfaces when the incident ion energy is higher than the threshold of He ions, It is demonstrated unexpected formation of nano-tendril bundles(NTBs) in impurity-rich He plasma irradiation is introduced.

## 2. Experimental setup

Experiments were performed in the linear divertor plasma simulator NAGDIS-II. He plasmas were produced in DC arc discharge with the typical electron density and temperature of $\sim 1 \times 10^{19}$ m$^{-2}$ and ~5 eV, respectively. W samples were installed in the He plasma and biased negatively via a bipolar power supply to control the incident ion energy. The ion flux was in the range of 0.8 - 2 $\times 10^{22}$ m$^{-2}$s$^{-1}$. To compare the effect of sputtering by impurities, two different discharge conditions were set up by opening/closing the moving valve of turbo molecular pump near the end target of NAGDIS-II. By closing the valve, background pressure was changed from $\sim 6 \times 10^{-7}$ to $\sim 2 \times 10^{-6}$ Torr, meaning that the impurity level increased by factor of three. He gas flow was fixed in the range of 150-160 sccm.

## 3. Results and discussion

After the plasma irradiation with high impurity level condition, although the surfaces of samples were not covered with fuzz, isolated nano-tendril bundles were formed on the surfaces. As shown in Fig. 1, the sizes of the NTBs were over several tens μm, which was unexpectedly huge considering the present condition, such as 500 eV of incident ion energy. The remaining surface where the NTBs were not formed had no fuzz or tiny loops grown. Similar bundles were fabricated with the addition of RF modulation of the ion energy [6]. This result suggests NTBs can also be fabricated without ion energy modulation in the impurity-rich He plasmas.

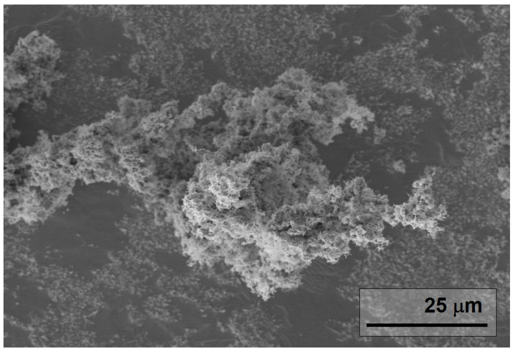


Figure 1. SEM micrograph of nano-tendril bundle with incident ion energy 500 eV.

## References

[1] S. Kajita et al., Nucl. Fusion **49** (2009) 095005.
[2] S.I. Kracheninnikov Phys. Src. **T145** (2011) 014040.
[3] D. Trufanov et al., Phys. Procedia **71** (2015) 20.
[4] A.M. Ito et al., Nucl. Fusion **55** (2015) 73013.
[5] T.J. Petty et al., Nucl. Fusion **55** (2015) 093033.
[6] K.B. Woller et al., 26$^{th}$ IAEA FEC, MPT/P5-26, Kyoto, Japan, 2015.