CHARACTERISTICS OF TUNGSTEN IMPURITY SOURCES AND TRNASPORT IN KSTAR

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1. INTRODUCTION

To investigate physics issues for tokamak operation with tungsten PFC, the KSTAR divertor has been upgraded with tungsten mono-block cassette in 2023. The first experiment campaign with tungsten divertor has been successfully conducted [1]. However, the behavior of tungsten impurity in plasma and its effect on plasma performance should be investigated further. It should be checked how much tungsten impurity is released from the divertor. It is also unknown how quickly tungsten impurity from source flow into plasma, or tungsten impurity inside plasma flow out. In 2024 KSTAR campaign, tungsten impurity experiment was conducted to investigate above issues.

2. EXPERIMENTAL RESULTS

The goal of this study is to observe changes in tungsten impurity source and transport with various plasma conditions. Target discharge had a plasma current of 0.5 MA, maximum heating power of 6.5 MW and toroidal magnetic field of 1.9 T. Firstly, heating power was scanned in reference shot. As we expected, W source signal from visible filterscope was decreased with heating power reduction. After heating power scan, W transport with various plasma shapes were studied. Tungsten source level was changed with the distance from tungsten divertor target to plasmas. In LSN configuration, tungsten source signal from lower divertor reduced significantly as the lower X-point moved down. For now, only the lower divertor of KSTAR is made of tungsten, so it is difficult to know the effect of the upper plasma boundary on tungsten generation in LSN configuration. Therefore, in USN configuration, the height of inactive X-point was scanned to vary the distance from lower plasma boundary to tungsten divertor target. For these discharges, W divertor erosion rates were also calculated with S/XB method using several W I lines [2].

Some discharges were used to perform the transitions between LSN and USN configurations. As expected, W source level increased significantly when USN plasma changes to LSN (Fig. 2). Conversely, when changing from USN to LSN, the W source decreased significantly. For these discharges, not only W source signal from divertor, W distributions inside plasma are being analyzed using VUV signal and radiation pattern from IRVB. The tungsten confinement (LSN→USN) and penetration time (USN→LSN) in KSTAR plasmas were estimated from the tungsten distributions in plasmas. Controlling tungsten transport with RMP and gas seeding were also conducted. The W source level was reuced significantly with ELM mitigation by $I_{RMP} = 2$ kA, while no changes were shown in lower I_{RMP}. For these experiments, simulation of tungsten transport is ongoing. Outside separatrix, tungsten transport from divertor target to SOL is analysed using SOLEDGE3X code [3]. Since SOLEDGE3X simulation does not cover inside separatrix, KIM code [4] is also used to deal with tungsten transport from SOL to plasma core. By comparison with experimental results, we aim to verify the validity of the simulation, and we will investigate the underlying physics of tungsten transport change.

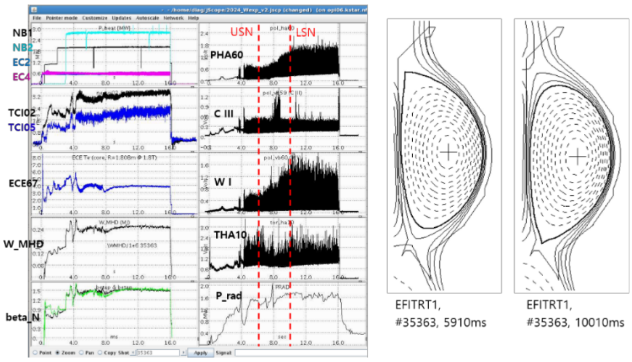

Fig. 2 plasma parameters with the transition from USN to LSN

3. SUMMARY

This study aims to understand the tungsten impurity behavior in KSTAR plasmas. Using various diagnostics, tungsten distributions at upper, lower divertor and plasma center could be obtained. Tungsten source quantity with various heating power and plasmas shape are compared. The characteristic time of tungsten flow into KSTAR plasmas is also estimated. Since ELM is a main source of tungsten impurity, tungsten source change by ELM mitigation is also investigated. Additionally, SOLEDGE3X and KIM code simulations are utilized to investigate underlying mechanisms of tungsten transport changes with plasma shape, heating power and RMP.

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