Active suppression of tungsten impurity influx using lithium aerosol injection in EAST

1. Introduction

Tungsten is considered a PFM divertor materials in ITER, but encountering with some serious problems:

- Serious power radiation loss induced by high-Z impurity;
- Lower tolerance in plasma core, 10%;
- MHD instability induced by high-Z impurity accumulation;

EAST device introduction:

- Plasma facing area 6m²
- IETR-like upper tungsten divertor
- Steady-state, H-mode, high parameters operation with increased heating power in near future.

Tungsten impurity accumulation core deteriorates plasma performance:

- Hollow Te profile and MHD mode locking
- Result in plasma disruption

Controlling tungsten impurity is important key to obtain high confinement plasma.

2. Lithium aerosol dropper

The active coating system using Li aerosol dropper on EAST:

- Li aerosol diameter 45µm, 99.9% Li;
- Li injection rate among 10-100µs, injection velocity 10m/s;
- Located directly above upper X-point, real-time injection;

3. Li aerosol injection before Li coating

- Light emission appears predominantly yellow, which is much different with previous green color;
- Li is hard to thoroughly ionized due to poor plasma performance;
- No obvious tungsten impurity suppression observed

4. Lithium aerosol injection after Li coating

- LAIs in H-mode discharges after Li coating:
  - Strong Li ions formed in SDL region;
  - Real-time suppress W impurity;
  - Decrease recycling;
  - Increase stored energy;
  - Improve plasma confinement;
  - Prognostically decreased W source and W concentration in plasma core with sequential LAIs.

5. Possible mechanism for W impurity suppression by lithium aerosol injection

Four kinds of W mitigation mechanism model:

- (a) bare W surface subjected to D ion impingement;
- (b) bare W surface with an incomplete layer of injected Li ions, which could provide a transient suppression;
- (c) W surface coating with a thick Li film provide a more robust defense against W sputtering, but the effects would be weaken after a few tens of discharges;
- (d) W surface with more complete protection offered by an complete Li ions layer on exiting thick Li film, which mitigates degrade Li coating one side and shield W surface with uniform Li ions;

Summary:

A systematic study of the effectiveness of real-time LAI in suppressing W influx from the EAST upper W divertor has been accomplished.

Lithium aerosol injection has been successfully used to mitigate W influx from plasma impingement, but the accumulated Li could cause a serious and transient deflagration in the SOL region.

Lithium aerosol injection could effectively suppress W impurity concentration, but the effects typically last for 40-100 discharges.

6. Summary

Effectively reduce the heat flux on target, reduced the ion saturation current density at divertor target, reduced the ion saturation current per unit area;

- The divertor electron temperature decrease from 40eV to 10eV;
- Effectively reduce the heat flux on target;
- The IR-measured strike-point temperature decrease sharply from 400°C to 220°C;

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