§24. Boronization in LHD and Future Devices

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It has been widely recognized that boronization [1] plays an important role in present fusion devices. But roles and availability are not seriously discussed for future devices with long-time steady state operations.

Key roles of a flesh, thin boron film in the present machines are (1) suppression of oxygen contamination to core plasmas, (2) reduction in hydrogen recycling compared with carbon walls and (3) suppression of contamination by wall materials. The first two is regarded as a utilization of a wide area of the first wall for pumping oxygen or hydrogen. It is useless in a long-time discharge because the surface will be saturated with them within a few hundreds or a few thousand seconds [2]. These two roles will be taken over by active pumping of limiter/divertor in future devices. The third role would be useful if the thin film could be maintained for a long time without additional boron compound.

A possibility of another role has been pointed out [3], that is, the thin film would help to reduce tritium inventory and permeation in DT devices. It is based on an experimental fact that hydrogen is completely removed from the B film at a surface temperature below 400 °C [3]. In long discharges, it will be not difficult to maintain the temperature of plasma-facing surfaces as high as 300 to 400 °C due to heat flux from plasma. An expected temperature difference between the top surface to water-cooling channels could be less than 300 °C, which gives a design of the first wall without difficulty of mechanical problems due to a large temperature gradient (see Fig. 1). If the boronized surface is maintained at 300 - 400 °C, most of tritium is released from the surface which results in low T inventory. Energetic T atoms from a plasma is blocked by the thin B-film and the tritium is re-emitted to the plasma side at this temperature. This B-film protect the wall from micro-damages by energetic particle impact [4], too.

A question is whether a thin boron film can be maintained for a long time or not ? Different from carbon, boron hydride is very fragile and easily dissociated, redeposite inside the vessel and does not reach pumping duct. Then the total number of boron atoms is not reduced even for a long time discharge. A concern is gross immigration of boron atoms from erosion-dominated area to deposition-dominated area.

This idea is presented in the 13th PSI Conference held at San Diego in May of 1998.

References

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[3]K. Tsuzuki et al.,J. Nucl.Mater.**241-243** (1997) 1055.
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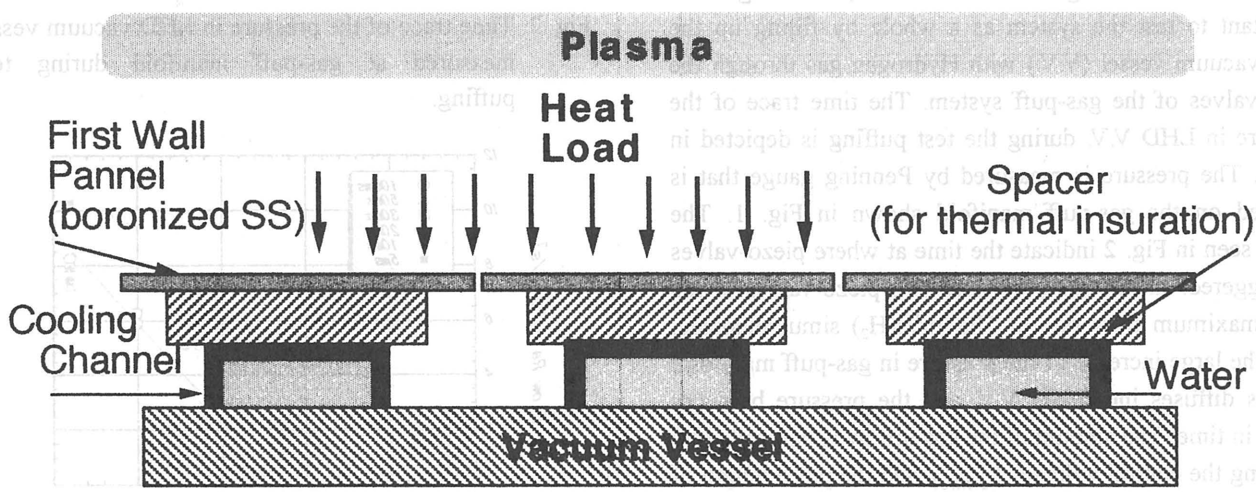

Fig. 1. A concept of the first wall in LHD. The plasma facing part is stainless steel panels coated with pure boron. The temperature of the boronized layer can be kept to be high enough with a heat flow from a long-time discharge in helium. This gives a low-recycling condition in a hydrogen discharge following to the long-time discharge.