Designs of Langmuir Probes for W7-X

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Observing the edge plasma density, edge electron temperature and the floating potential in front of the divertor target in the stellarator Wendelstein 7-X (W7-X) is an essential task of the diagnostic. This measurement will be fulfilled by the Langmuir probes. A simplified Langmuir probe is a conducting probe tip which is exposed to the plasma and over a voltage source connected to the outside. According to the control of the voltage source a number of particles will impinge at the probe tip and result in a current. The desired plasma parameters can be obtained from the characteristic curve of the voltage-current [1].
In the initial phase of operation W7-X will be equipped with an inertially cooled divertor with graphite target tiles designed to withstand heat loads of up to 8 MW/m² for pulse operation. After testing various design options (stiff probes arrays, flexible arrays and fixed inlay probe arrays) it was decided to equip four targets with ten fixed inlay probes each, consisting of the same graphite as the targets and electrically insulated by aluminum nitride, which has nearly the same thermal expansion as graphite and has a heat conductivity of up to 220 W/mK. A FE calculation has confirmed the design of the fixed inlay probes [2] and a first mockup of these probes was tested at neutral beam test stand GLADIS with a standard case of 8.5 MW/m² for 6.25 s and an overload of 13 MW/m² for 10 s. No damage or loss of electrical insulation occurred at the surface temperature of up to 1700 °C [3]. A second mockup with an even simpler design, which reduces the cost of the manufacturing process, is in progress and will prove the favorable characteristics of the fixed inlay probes in GLADIS test. The advantage of the fixed inlay probes is the simplicity of the design because there are no moving parts and no active cooling. The surface of the probe tips is defined even in case of thermal deformation of the targets.
After initial phase of operation of W7-X the test divertor will be replaced by an actively cooled high heat flux divertor. This divertor is designed for continuous heat loads of 10 MW/m² [4]. For stationary operation further designs of Langmuir probe are in development, such as probe tips moved to the plasma edge by piezo electric actuators with ultra high temperature piezo ceramics. Another solution could be a probe array mounted on actively cooled target.
The developments, design decisions process and the final design of the Langmuir probes for the W7-X will be reported in this presentation.

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