Simple calibration method of heat flux measured with thermal probe

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Langmuir probe method is widely used to determine plasma parameters such as electron temperature in various field of plasma processing, fusion divertor plasma, space plasma and so on. It is based upon measuring the current onto a probe as a function of the probe bias voltage. The heat flux onto the probe is also dependent on its voltage. The heat flux-voltage characteristic is more complicated than the current-voltage one. Thermal probe method is proposed to use the heat flux-voltage characteristic to deduce other plasma parameters such as negative ion density or ion temperature [1,2]. Though thermal probes have good spatial resolution like Langmuir probes, their time response is rather poor. We proposed triple thermal probe concept to overcome this difficulty[3].

Other difficulty of heat flux measurement is the calibration of sensors. The heat flux through negatively biased probe sheath is mainly carried by positive ions. This ion flux is decomposed into three terms, which are called as the thermal term, the acceleration term, and the recombination term. Among these terms, recombination term depends ion spices (ionization/dissociation

energy) and probe surface condition (that is work function), and make it difficult to estimate this term theoretically. Total heat flux has minimum value near the floating voltage. If we observe excess heat flux with biasing, recombination term effect can be neglected[4].

According to plane sheath theory, since only the acceleration term depends upon biasing in the ion heat flux, heat flux value can be compared with particle flux value(that is ion saturation current). The detailed procedure is the following. Firstly base heat flux is measured at floating voltage (Vf), which can be check by monitoring total probe current. Then bias voltage is changed to negative value (V1). The increment of heat flux is dQ(V1). The same procedure is repeated at other voltage (V2). Since dQ(V1)-dQ(V2) is proportional to V2-V1 times ion saturation current, heat flux calibration coefficient can be check with ion saturation current.

Our triple thermal probe can also be used as two independent thermal probes. So above method can be tested without assuming plasma reproductivity.

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