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小型サーマルプローブチップの熱伝導解析

Heat conduction analysis of a small thermal probe tip

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Plasma surface interaction is an important issue not only in material processing of semiconductor production, but also in divertor design in nuclear fusion technology. Heat flux, or energy transport through the sheath, onto solid surface is one of important parameters in such a study. Various types of thermal probes have been proposed and applied to measure it.[1-3]

Since the time response of thermocouple (TC) used in thermal probe is usually well described with the 1-dimension slab model with a plasma irradiation boundary and a heat sink boundary, thermal diffusion time ($t_{TD} \sim L^2/\alpha$) must be reduce in order to observe fast change of heat flux, for example in detach plasma formation, where α is thermal diffusivity of the tip material and L is the effective size of the tip. When the size of probe tips becomes smaller, however, the difference of a heat sink boundary has larger effect on the fast time response of the temperature measured with the TC. [4]

Right Figures show the effect of the different boundary condition. Here the response of box type heat flux with 2[MW/m^2] and pulse length of 450 [ms] is estimated for three boundary conditions. By considering the powerful heat sink and assuming constant temperature at the boundary, temperature response becomes smaller than the estimation with the infinite boundary model. For isolated boundary, as shown in Fig.1 with the blue line, temperature response is completely different and continues to increase even after plasma pulse.

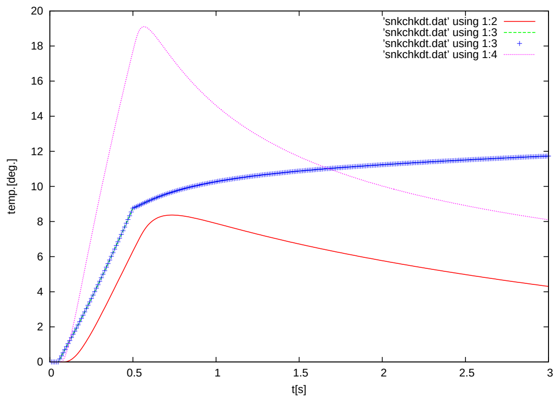

Fig.1：Effect of boundary condition(Magenta: infinite boundary, Red: sink boundary, Blue: isolation boundary) on temperature evolution.

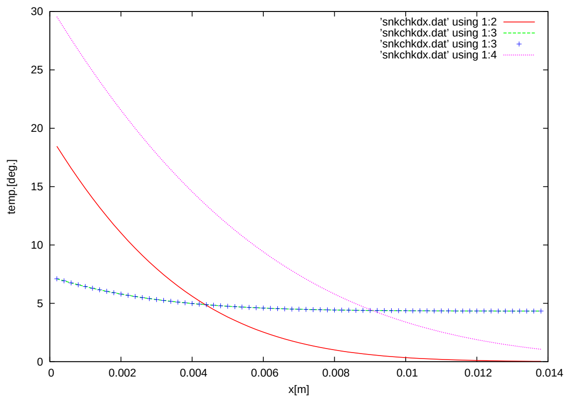

Fig.2：Effect of boundary condition on temperature profile. Color is the same as Fig.1.

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