§5. Experimental Setup of Basic Research for Cleaving of Single Crystal Semiconductor Materials

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The cleaving process is one of cutting methods, and it is used to create the solid-state laser because the flatness of the cleaving surface is the atomic level. The diamond needle is used to make the cleaving of the sapphire substrate for LED in the present time. The electron beam cleaving was also tested for the silicon and GaAs substrates. The voltage of the electron beam was around 50kV, and the current is 1 to 20 mA. However, it is necessary to use the high vacuum for the electron beam gun, and the focus of the electron beam is important, and the scanning speed should be faster than the sound velocity of the substrate. These two conditions are not easy to do the experiment[1]. If we can use the laser cleaving and we can adopt the line focusing, it would be easier than the electron beam's.

By anomalous absorption of laser light to plasmas and by effective progression of plasma heating, inertial fusion reaction occurs. Anomalous absorption is known to occur also in solid materials. This phenomenon is used as one of the glass processing technology, sapphire, and silicon for that. Recently, laser dicing using anomalous absorption phenomena with semiconductor laser is becoming standard method as dicing of silicon wafer.

We received support from Aichi Science and Technology Foundation and carried out cleavage experiments of silicon, GaAs and sapphire using electron beam. In the experiments, cleavage of materials was confirmed. And we examined thermal stress in silicon material by calculations using ANSYS Multiphysics (academic package version). We calculated that thermal stress exceeds fracture stress of silicon by thermal heating with electron beam. In this research, we will study the cleavage machining to change from electron beam to laser. Laser beam can be easily changed beam shape more than that of electron beam.

In this research, we pursue possibility of development of new material machining technology by anomalous laser absorption. Then we obtain data about anomalous absorption, and accumulate these. In particular, focal spot shape on target is adjusted by focus lens and various shapes are studied.

Nd:YAG laser (GCR by Spectra-physics Co.) is applied to the experiments. Laser energy and laser pulse width are 0.6 J and 10 ns, respectively. We overhauled and repaired the instrument. Then we confirmed laser oscillation. For optical design as figure 1, we also confirmed beam divergence of 0.5 mrad and beam diameter of 10 mm. We already finished preparing alignment tools for optical axis and pure silicon materials as target. However instruments for measurement of laser condition are not. Therefore we will prepare and start to examine in this year.

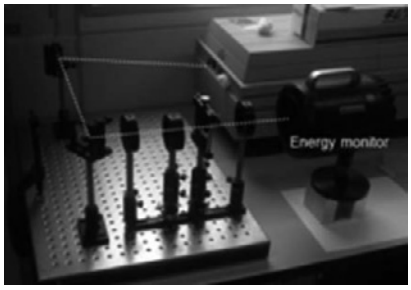

Fig.1: Photograph of optical design.

1) S. Yamaguchi et al, "Report of Electron Beam Cleaving for various substrate", Aichi Science and Technology Foundation, 2008.