§42. Improvement of the Spectroscopic System for Material Probe Experiments

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Real-time spectroscopic measurements provide very useful information for understanding plasma-material interactions in plasma exposure experiments using the material probe system in the Large Helical Device (LHD). Two small spectrometers (Avantes, AvaSpec-ULS2048) have been installed at the 10.5U port, looking down on the material probe system at the 10.5L port. However, the alignment of the spectrometer line of sight is quite difficult due to the restriction of the available port. Thus, the objective of this study is to ease the alignment by installing a small high-sensitivity CMOS camera at the 10.5U port. This will enable us to efficiently perform the preparation of experiments, and make spectroscopic measurements more reliable. While equipment for the alignment was selected and purchased, the alignment of the spectrometer line of sight was not conducted during this fiscal year, since the LHD experimental campaign was cancelled,

Three pieces of equipment were purchased: (1) a small USB2.0 CMOS camera (Thorlabs, part number DCC1645C), (2) a fixed focal length camera lens (Thorlabs, part number MVL100M23), and (3) a handheld fiber-coupled laser source (Thorlabs, part number HLS635).

The CMOS camera contains a color sensor (format: 1/3”), the resolution of which is 1280 x 1024 pixels. Thanks to the small dimension of 48.6 mm (height) x 44.0 mm (width) x 25.7 mm (depth) and to the light weight of 32 g (see Fig. 1), it is suitable for the small working space at the 10.5U port. The camera is connected to a PC and is powered via the USB2.0 port. A software, ThorCam, provided by Thorlabs is used to control the camera, and to take images. Fig. 2 shows the wavelength dependence of the relative sensitivity of the camera, taken from the Thorlabs website.

The focal length of the camera lens is 100 mm fixed. The maximum aperture of the lens is f/2.8, and the design format is 2/3”. As mentioned above, the camera format is 1/3”, and the field of view is 3.4 degrees according to the specification. The distance between the 10.5U port window and the material probe at the plasma-exposed position is around 5.1 m. Thus, the observation area is estimated to be around 300 mm, which is thought to be the appropriate size for the typical target (~80 mm x 30 mm) installed in the material probe system.

The handheld fiber-coupled laser was purchased to illuminate the spectrometer line of sight. Handling is easy because of the compact design: 147 mm (height) x 79 mm (width) x 35 mm (depth). The central wavelength is at 635 nm, which corresponds to the high sensitivity wavelength of the camera (see Fig. 2). This allows us to easily find the spot during the alignment. The output power is selectable from low (~1 mW, CW), high (> 2.5 mW, CW), and pulse (> 2.5 mW/~0 mW) at 2 Hz, 50% duty cycle. This will also ease the alignment. The fiber connector is FC/PC, which is used for the spectroscopic system.

With these apparatuses, the alignment of the spectrometer line of sight will be performed. Furthermore, these apparatuses are expected to be widely used also for other purposes.

Fig. 1. USB2.0 CMOS camera (Thorlabs, DCC1645C). Cited from the website of Thorlabs, Inc. (http://www.thorlabs.us/images/tabImages/USB_CMOS_Camera_A1-780.jpg)

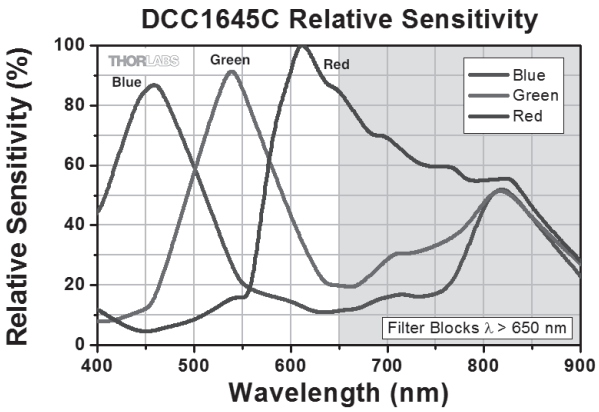

Fig. 2. Wavelength dependence of the relative sensitivity of the small CMOS camera (DCC1645C). Cited from the website of Thorlabs, Inc. (http://www.thorlabs.us/images/TabImages/DCC1645C_780.gif)