§10. Development of the Liquid-Crystal-Based Tunable Lyot Filter Spectra Camera System Combined with Color CCD Detector

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Recent progress in the plasma modeling that describes the 2D or 3D structure in the boundary plasmas enhances the demands of imaging spectrometry based on the collisional radiative model [1].

We have developed a liquid-crystal-based tunable Lyot filter spectra camera system for plasma imaging spectroscopy [2]. The Lyot filter is advantageous over a conventional interference filter in the sense that in the former, the wavelength can be tuned in the range of 400–720 nm within a response time of 50–100 ms. However, our study revealed that the Lyot filter has “leak-bands,” which transmit light longer than 590 nm at specific wavelength settings below 448 nm; these wavelengths and the transmittances are found to be slightly different for the individual LOT number of the Lyot filter [3].

In this fiscal year, we proposed a method for eliminating the leak-bands that uses a color CCD detector [4,5].

The detector we employed is a single-panel Bayer array color CCD (Bitran Co., BU-52C) equipped with an external trigger input. The number of pixels is 2048 × 2048, with pixel dimensions of 7.4 × 7.4 μm^2. The CCD can be controlled by a PC using a USB interface. The dynamic range of digitization is 16 bits. We can obtain images of the red, green, and blue layers separately. Figure 2 shows the spectral efficiency of the CCD detector obtained by using the halogen lamp illuminating the perfect diffuse reflector. The wavelength of the Lyot filter was scanned by every 5 nm. Throughout the range of 400–760 nm, there is no overlap in the transmission bands between the blue and red color filters, and their boundary is at about 560 nm. One can thus expect that at the leak-band position, the blue filter does not have sensitivity. Therefore, the leak-band contamination can be eliminated by evaluating just the blue layer of the color image when we perform the measurement below 448 nm.

The bump found around the set wavelength of 420 nm in the red layer in Fig. 2 was confirmed to be attributable to the leak-band that transmits longer (red) wavelength. Indeed, by inserting the band-pass filter, the bump disappeared [6].

In the future, we intend to apply this leak-band-free spectral camera to MAP-II (material and plasma) divertor-simulating plasmas [7] for determining the images of plasma parameters by using the line intensity method considering the radiation trapping effect, which causes the broadening of the spatial distribution of the resonant excited states [8].

Acknowledgement

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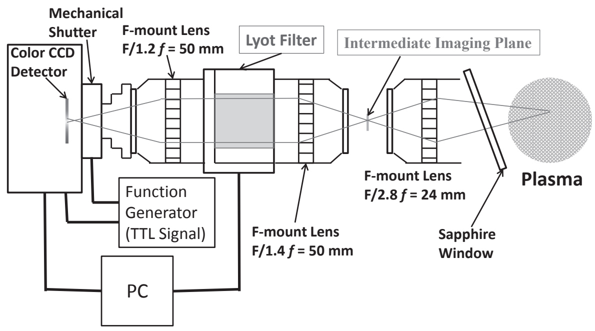

Fig. 1. Schematic of liquid-crystal-based tunable Lyot filter spectra camera system.

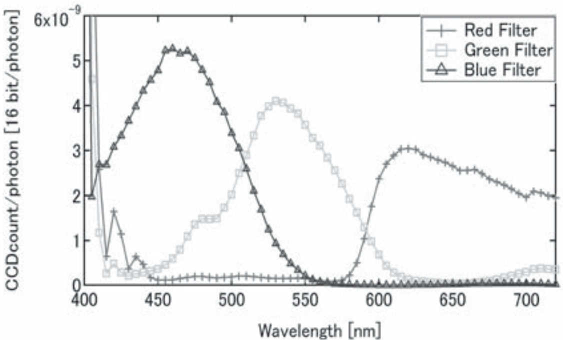

Fig. 2. Count of the color CCD detector (16 bits) per photon measured using the liquid-crystal-based tunable Lyot filter spectra camera system (Fig. 1). The red and green peaks below 450 nm are attributed to the leak-bands of the Lyot filter, so the CCD count of the red layer below 450 nm cannot be used as a calibration function.