**CCD Direct Detection on a SPRED Spectrometer**

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Spectroscopic measurements are critical for tokamaks as they provide information on a range of plasma parameters such as composition, power loss channels, impurity content and plasma-wall interaction. The vacuum ultraviolet (VUV) spectral range is of particular importance due to the photon energies emitted by ions in the core and hot divertors. The standard diagnostic used on tokamaks in this spectral range is a grazing incidence “survey, poor resolution, extended domain” (SPRED) spectrometer [1]. This spectrometer is combined with a microchannel plate (MCP) image intensifier, fiber-optically coupled to a Reticon photodiode array. The high voltage and vacuum requirements of the MCP led to reliability issues on the SPRED system installed on the TCV tokamak. Currents induced during plasma disruptions, and increases in vacuum pressure during divertor experiments, were enough to cause arcing and trips on the power supply. These issues were more prevalent on TCV due to the proximity of the system to the tokamak (~3m). It was therefore decided to simplify the system using a direct detection CCD camera.

A thinned, back-illuminated CCD from GreatEyes® was selected due to its sensitivity in the VUV, camera design flexibility and price. A camera design modification was required to offset CCD chip itself from the camera base in order to place it in the focal plane. Once installed, the system was aligned and calibrated using a hollow cathode lamp and visible light sources. As the CCD could operate at atmospheric pressure, a new alignment procedure using zeroth order reflections was developed and will be outlined in this paper. The spectral resolutions achieved were 2.5A and 0.7A for the 450g/mm and 2105g/mm gratings respectively. This represented a 2-3x increase in spectral resolution over the legacy MCP detector system. The CCD detector system has now worked reliably on TCV for over 20,000 plasma discharges. It has been routinely used to assess plasma core content variations due to impurity seeding or the sputtering of material, and provide long term stability analyses that have led to the identification of events which produced impurity injections into the machine.

***References***

[1] Fonck, R. J., A. T. Ramsey, and R. V. Yelle. "Multichannel grazing-incidence spectrometer for plasma impurity diagnosis: SPRED." Applied Optics 21.12 (1982): 2115-2123