MCP CMOS hybrid mass spectrometer detector

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Description:

The aim of the project is to investigate the use of 2D imagers coupled with a Micro-Channel Plate (MCP) as a detector for mass spectrometers. Magnetic sector mass spectrometers are commonly employed in sample analysis because of their stability and ability to measure accurate isotopic ratios. However, miniaturising magnetic sector instruments for space flight is limited by the physical separation that can be achieved between adjacent ion beams at the detector. In isotopic analysis with mass spectrometers, Faraday cup detectors are usually adopted due to their high dynamic range (~10^8), but these are 1D arrays of sensors which only provide poor spatial resolution (minimum widths ~500 µm) in one dimension of the ion beam profile. A 2D CMOS active pixel sensor used for direct detection of the ions would allow spatial resolutions down to ~10 µm, as well as determining the profile of the beam in 2D in order to measure the profile of the beam shape for tuning the mass spectrometer. However, most CMOS sensors have a dynamic range of ~10^3 and so it is proposed to couple it with a Microchannel Plate (MCP). These have a spatial resolution ~20 µm and a dynamic range that is tuneable with the voltage across it up to 10^5. By combining the MCP with a CMOS detector, a detector with 2D spatial resolution ~20 µm and a dynamic range ~10^8 could be achieved, providing a vast improvement over the current state of the art.

An MCP coupled with a CMOS detector enables,

- Smaller mass spectrometers with improved spatial resolution
- Higher dynamic range
- Rapid ion beam shape measurements to tune the mass spectrometer
- Rapid response to short ion beam pulses, e.g. from a gas chromatography column

This studentship is an opportunity for the candidate to be involved in the technology development journey from the point of idea conception, through the assembly and evaluation of a proof-of-concept system. The successful candidate will be working with both the Space Instrument Development (SID) group and the Centre for Electronic Imaging (CEI) at The Open University assembling a proof of concept system. The MCP-CMOS sensor will be mounted in a mass spectrometer system developed by the SID group, to evaluate its capabilities and limitations. The detection process will be explored in order to apply algorithms and understanding from similar imaging schemes (e.g. direct soft X-ray and scintillator-coupled detectors that have been studied in the CEI previously) to explore potential further improvements to spatial resolution performance of the detector. The effectiveness of the MCP-CMOS sensor coupled system at different ion flux regimes (and MCP gain) will be explored using mass spectrometers developed for space flight, and the limits of the extremes of the flux ranges determined.
The Spacecraft Instrument Development team has over 15 years of experience developing space flight mass spectrometer systems. It built the Ptolemy mass spectrometer which was on the Philae lander Rosetta mission and successfully operated and returned results to Earth (1). The group is currently developing the ProSPA instrument for the Luna-27 mission to measure the composition and concentration of lunar volatiles (2).

The Centre for Electronic Imaging (CEI) is a collaboration between the Open University and Teledyne-e2v, a world-leading manufacturer of scientific image sensors. The CEI has established a reputation as a centre of excellence in semiconductor imaging technology and knowledge exchange, with research involving the detailed characterisation, design and study of CCD and CMOS image sensors for applications in space, astronomy and synchrotron radiation detection. The CEI has involvement in major current and upcoming space missions led by space agencies such as NASA and ESA.

References:


Qualifications required: BSc Physics/electronics/engineering or similar