BetaCam – A Room Temperature System for Beta Autoradiography

Introduction

The technique of Beta Autoradiography is used in many scientific disciplines for analyses ranging from rock porosity to drug discovery. We have developed a digital imaging system based on CCD technology derived from X-ray Astronomy to replace conventional film which offers the benefits of high sensitivity, excellent linearity, real-time data acquisition, with the major benefit of operating in air at room temperature.

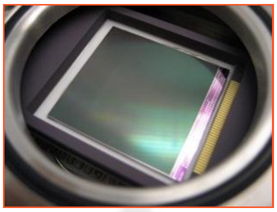

Figure 1 One of the many CCD area sensors applicable to beta autoradiography

Beta Autoradiography

CCDs are very good detectors for ionising radiation, enabling the spatial information to be recorded, alongside the deposited energy signature of the particle. The ionisation trails of energetic electrons can be detected, including the very elusive low-energy betas from sources such as Tritium (^3H), down to sub-keV energies. This offers a unique capability to record the activity from these sensitive sources. Figure 2 below shows the individual low-energy beta particle events are clearly resolved in a CCD.

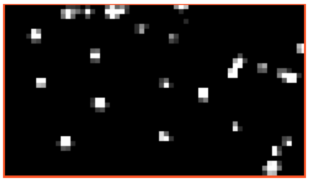

Figure 2 Beta particle signals being recorded in a CCD at room temperature

Carbon-14 and Tritium (^3H) Imaging

Quantitative testing is carried out using calibrated beta microscales which have a known activity. Figure 3 gives images accumulated over several hours using ^{14}C and ^3H microscales. The beta particles from ^{14}C have an energy of ~5 keV, but the distribution of betas exiting thin tissue samples is around 50 keV. These penetrating particles can be relatively easily detected in the CCD, even at room temperature. The betas from ^3H, on the other hand, are much lower in energy, with maximum emission at 18 keV, and a mean emission energy around 5 keV. Detection of these particles at room temperature is challenging and represents a state-of-the-art measurement.

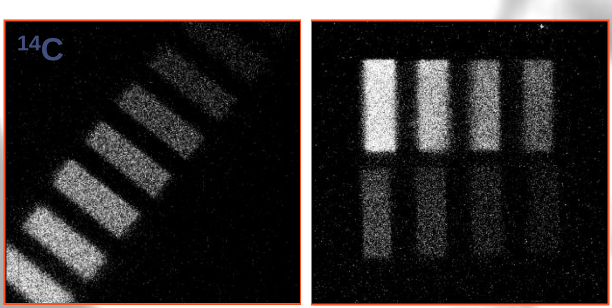

Figure 3 Accumulated images taken using ^{14}C image taken over 5 hours and ^3H over 48 hours

Calibration and Quantification

A high degree of linearity has been demonstrated with the applied beta activity, and the detectors exhibit low background. Figure 3 gives a profile through the microscale demonstrating both the spatial resolution, and activity quantification, together with a plot giving analysis of the measured activity versus actual activity. The high degree of linearity is far superior to the performance achieved using film and sensitivity is competitive with published data from alternative technologies.

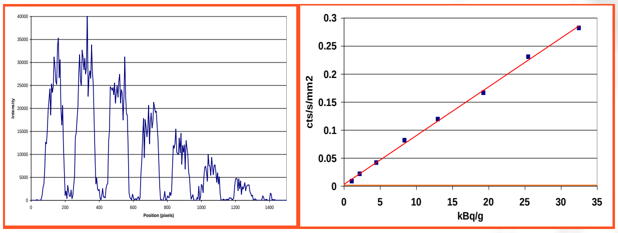

Figure 4 Profile through the microscale images, together with linearity plot from ^{14}C including the measurement background which is insignificant

Background

The sensitivity of the measurement technique can be limited by the background experienced by the system. Using CCD technology the background is very low and can be as low as the sea-level cosmic ray rate. Background rejection techniques can further enhance the measurement sensitivity, extracting the maximum science from the sample under test.

Astronomical Image Processing

The results can be enhanced using adaptive filtering techniques developed from X-ray Astronomy, which is designed to bring the most out of sparsely populated photon images. The astronomy application and that of Beta Autoradiography have substantial overlap in data format and user requirements.

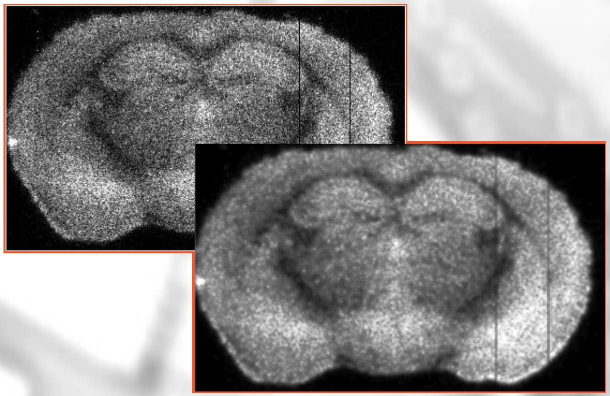

Figure 4 Image created from a labelled thin tissue sample of a mouse brain (courtesy U. Surrey). The sparse image data plus background gives an image with high granularity. The corresponding image after using an astronomical adaptive filter is closer to that of film.

Future developments

Further improvements to the systems will include large area sensors, with web-enabled systems offering remote monitoring of the experiment, and sub-pixel resolution for imaging at the cellular level.

XCAM Limited, 2 Stone Circle Road, Round Spinney, Northampton, NN3 8RF
Tel: 44 (0)1604 673700, Fax: 44 (0)1604 671584
Web: www.XCAM.co.uk, Email: info@XCAM.co.uk

BUSI-XCAM-AP-00017