PSD9
9th International Conference on
POSITION SENSITIVE DETECTORS

Contribution ID: **12** Type: **Oral Presentation**

Development of high temperature AlGaAs soft X-ray photon counting detectors

Tuesday 13 September 2011 09:20 (20 minutes)

New types of detectors based on the wide band gap material AlGaAs have been developed for soft X-ray spectroscopy applications. We report on the spectroscopic performance of simple p-i-n diodes and avalanche photodiodes (APDs). A number of diode types with different layer thicknesses have also been characterised. X-ray spectra from a 55Fe radioactive source show these diodes can be used for spectroscopy with promising energy resolution (0.9–2.5keV) over a −30 to +90 C temperature range .The temperature dependence of the avalanche multiplication process at soft X-ray energies in Al0.8Ga0.2As APDs was investigated at temperatures from +80 ℃ to -20 ℃. The temperature dependence of the pure electron initiated multiplication factor (Me) and the mixed carrier initiated avalanche multiplication factor (Mmix) were experimentally measured. The experimental results are compared with a spectroscopic Monte Carlo model for Al0.8Ga0.2As diodes from which the temperature dependence of the pure hole initiated multiplication factor (Mh) is determined.

Monte Carlo simulations for the avalanche gain of absorbed X-ray photons have also been developed to study the relationship between avalanche gain and energy resolution for semiconductor X-ray avalanche photodiodes. The model showed that the distribution of gains, which directly affects the energy resolution, depends on the number of injected electron hole-pairs (and hence the photon energy), the relationship between ionization coefficients and the overall mean gain. Our model showed that the conventional notion of APD gains degrading energy resolution significantly is incomplete.

We compare the Monte Carlo simulations with experimental data from a number of different Al0.8Ga0.2As diodes.

Preferred medium (Oral/poster)

Oral

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Session Classification: X-Ray and Gamma detectors

Track Classification: X-ray and Gamma-ray Detectors