Characterisation of Semi-Insulating GaAs and InP for use in Radiation Detection

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Abstract

A range of optical, electrical and radiation techniques were used to study the performance of GaAs and semi-insulating InP detectors, to assess their suitability as low energy X-ray detectors for medical imaging applications, all of which were grown using different techniques and approaches. Alpha-particle spectroscopy experiments were used to study the charge collection efficiency of the materials. Also used were optical and electrical methods such as photoluminescence mapping, photo-induced current transient spectroscopy and capacitance-voltage measurements. Room-temperature photoluminescence mappings have also been used to reveal the excellent homogeneity of the SI InP samples and epitaxial GaAs.

Understanding of the best growth technique(s) and suitable device fabrication methods for these materials would encourage their commercial use as a radiation detector. For instance, an inverse correlation of the Fe concentration in InP with the mobility-lifetime product of the carriers has been shown to exist. A low amount of Fe is required for good detection properties, although a sufficient amount is needed to render the material semi-insulating. Fe-diffused InP by annealing of Fe concentration 4.5×10^{15} cm^{-3} is shown to have an electron μt-product of 3.6×10^{-5} cm^2/V and hole μt-product of 1.5×10^{-5} cm^2/V at room temperature. This is still about an order of magnitude lower than that typically observed for CdTe, which is currently the best candidate with regards to medical imaging applications.

The suitability of epitaxial GaAs for use as a radiation detector was also studied. This material, with a thickness of 200 - 500 μs was produced at the Marie Curie University, Paris, using a novel growth technique. A sample of only 1.3×10^{14} cm^{-3} impurity concentration exhibited carrier lifetimes of up to 2 μs at room temperature. The depletion width at this temperature is only 20 μm at 10 V. Gamma measurements with 60 keV photons of the epitaxial material shows photopeaks with a charge collection efficiency of 80% at 90 V and energy resolution 4.9 %.