The Modelling and Optimisation of P-type Diodes for Dosimetry in External Beam Radiotherapy

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This thesis is an investigation into some of the factors that affect p-type semiconductor diodes used as dosimeters. The work employs two major computational techniques: Monte Carlo simulations for radiation transport calculations, which were conducted in an attempt to identify the optimum construction parameter in terms of radiation interactions; and the finite element method, which is used to simulate the collection efficiency of the device and to study the effect of contact layout upon it. Work is also presented in which diode performance is investigated through measurement, in order to validate some of the computational predictions and to study the effect of total dose on some of the dosimetric parameters, namely sensitivity and dose-per-pulse dependence.

The transport simulation work has shown that, in order to have a significant effect on the energy response, a substantial amount of metal must be added to the diode, as this can lead to a reduction in over-response to a value as low as 2.6 times that of the response at 1 MeV. The addition of large amounts of metal to the diode results in the prediction not only that there will be an improvement in the energy response of the diode but also that there will be an increase in sensitivity by a factor of 2. It also shows that the thickness of the diode will have an impact on the diodes angular response.

The device simulation suggests that there is no improvement to be gained from the choice of contact position when dose rates are in the range of those applicable to radiotherapy. It also shows that there is a difference between the predictioned gain from the simulation codes Apsys and PISCES IIb, with experiment indicating the Apsys prediction to be correct. In the experimental section of this work it is shown that a bottom contact arrangement gives a more desirable dose-per-pulse response with a measured dose-per-pulse dependence (DPPD) of 0 ±2% for the bottom contact and 6±2% for the top contact arrangement.

Taken as a whole, the work shows that it is possible to tailor the response of the diode dosimeter for a given application, allowing energy and angle response to be altered. Collection efficiency, stability and dose-per-pulse dependence are shown to be correlated with total dose, and so it is possible to decide which is of the greatest importance for the application under consideration.