p-FET Derived Proton-Beam Dose-Depth Curves

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ABSTRACT: An array of four p-FETs was used to obtain a dose-depth curve for the 100 MeV proton beam at the Loma Linda Proton Therapy Facility. The p-FET dosimetry compares extremely well with ionization chamber results and tends to resolve the peak and distal edge region more sharply.

INTRODUCTION: The dose-depth curve for a high-energy proton beam has the unique shape, seen in Fig. 1 which makes it useful in proton therapy, for high dose is delivered at a distance from the beam entry into the absorbing medium. This reduces the dose delivered to the outer layers. The dose-depth curve is traditionally measured using an air ionization chamber as seen in Fig. 1. The chamber gas is air and the parallel plates are separated by 1-mm. The key feature of the curve is the dose at the peak relative to the entry dose and the rapid fall in dose at the distal edge. The objective of this effort is to evaluate the feasibility of using a p-FET dosimeter to obtain the proton dose-depth curve.

EXPERIMENT: In this study the p-FET dosimeter was the RADMON (Radiation Monitor) shown in Fig. 2. The chip was fabricated using a 1.2-um CMOS process brokered through MOSIS. The array of four p-FETs, labeled P0, P1, P2, and P7, are arranged in a square 50-mils on a side and addressed by a multiplexer [1]. The chip is housed in a 16-pin flat pack with a step shield lid. The KOVAR lid allows each FET to be individually shielded where P0 is unshielded, P1 has a 2-mil KOVAR shield, P2 has a 6-mil KOVAR shield, and P7 has a 10-mil KOVAR shield,

Polystyrene absorbers were used to simulate water and were placed in the proton beam line. The voltage across the p-FETs was measured after forcing a current at the temperature-independent point [2]. The FETs were measured before and after three 2-min irradiations from the proton beam. During the test the total dose received by the FETs was about 60 krads and thus the dose had to be corrected for trap filling effects [2, 3].

RESULTS: The results are shown in Fig. 3 whore the p-FET responses are compared to ion chamber results. The p-FET results have a very similar peak to entrance response and are contained within the ion chamber results. The p-FET results appear to resolve the peak region more sharply. This is due to differences in the mass thickness where the ion chamber is 1.3 E-4 g/cc and the p-FET is 4.6E-6 g/cc. The ion chamber is 1 mm thick; whereas, the p-FET oxide is 20 nm thick. The results are further displayed in Fig. 4 where it is seen that the Kovar lid broadens the peak. The unshielded p-FET results define the peak more sharply than the shielded p-FETs.

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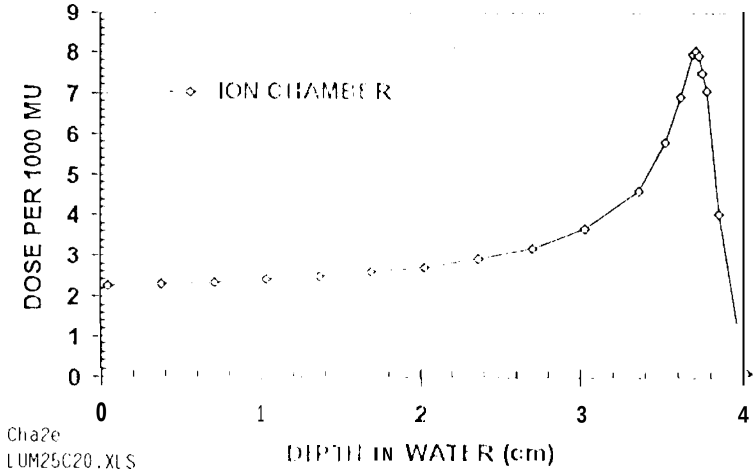

Figure 1. Air ion chamber response to a '100 MeV proton beam passing through water.

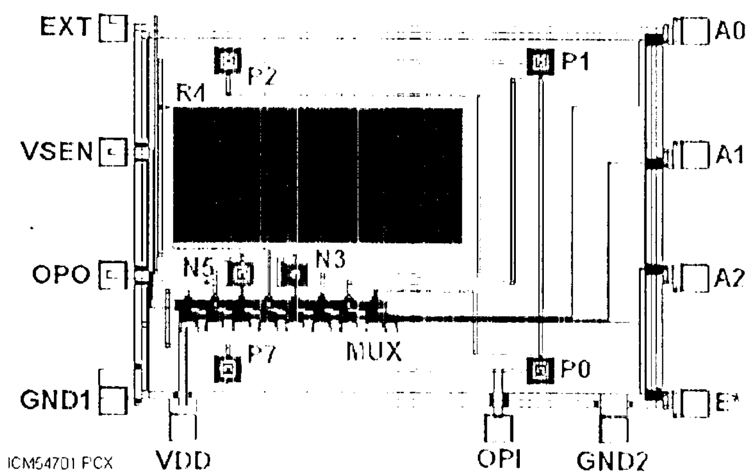

Figure 2. RADMON chip 2.5 mm x 1.8 mm. Chip consists of four p-FETS under test plus four other quality assurance components all addressed through a multiplexer (MUX) which is not affected by radiation [1].

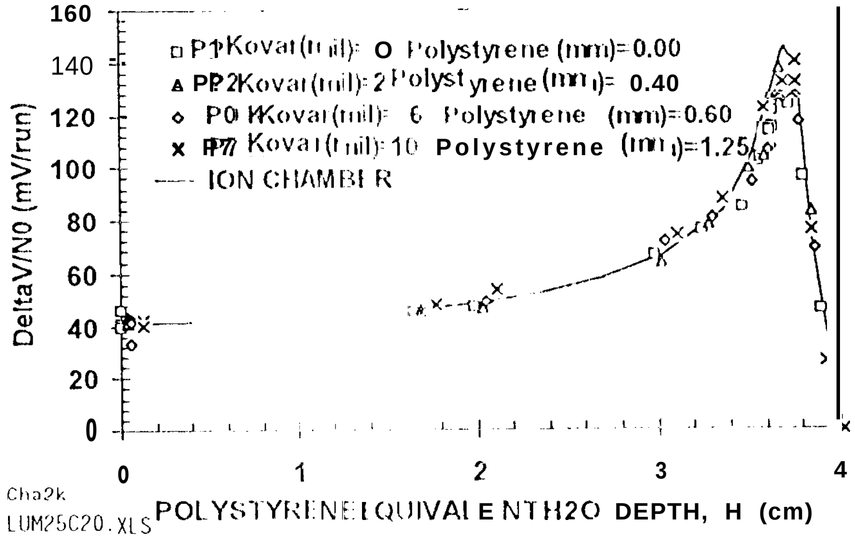

Figure 3. RADMON and ion chamber comparison where the RADMON data was corrected for gate-oxide trap filling and for step shield thicknesses. The RADMON was irradiated by the 100 MeV proton beam.

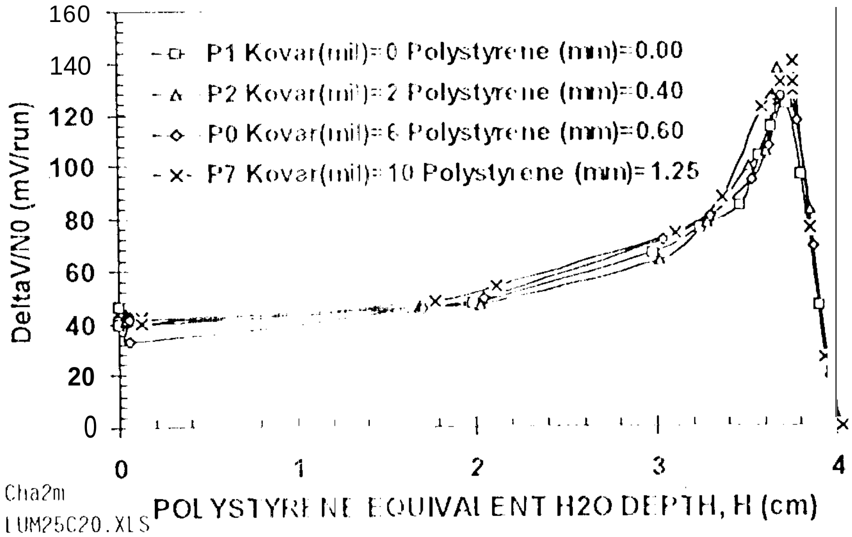

Figure 4. RADMON results showing the sharp definition of the peak region and the peak broadening caused by the Kovar lid.