INTRODUCTION

The feasibility of a solid state microdosimeter based on a monolithic silicon telescope was proposed and investigated in literature [1,2]. The standard configuration of the device is constituted by a thin ΔE stage (about 2 μm in thickness) and a residual energy measurement stage E (about 500 μm in thickness) made out of a single silicon wafer. The sensitive volume of the ΔE stage (the stage studied as a microdosimeter) was a rectangular parallelepiped, 1 x 1 mm² in sensitive area.

Recently, a new silicon device with a ΔE stage consisting of a matrix of micrometric diodes was designed and tested [3]. The aim was to develop a silicon detector with sensitive volume dimensions of the order of a few micrometers, similar to those simulated by a TEPC. Preliminary measurements were performed by coupling this new detector to different plastic converters [4]. The results of a systematic comparison between the lineal energy spectra of monoenergetic neutron fields derived with the silicon telescope and those obtained with a cylindrical TEPC are presented.

IRRADIATIONS WITH LOW-ENERGY NEUTRONS

The new device (Figure 1) is constituted by a ΔE stage segmented in a matrix of cylindrical diodes (about 2 μm in thickness and 9 μm in diameter) and a single E stage (500 μm in thickness). The detector was coupled to a tissue-equivalent plastic (A150) and irradiated with monoenergetic neutrons of energy 0.64, 0.96, 1.27, 1.58, 1.89 and 2.30 MeV.

Neutrons were produced via the ⁷Li(p,n)⁷Be reaction by bombarding a LiF target 700 μg cm⁻² in thickness with protons generated by the Van de Graaff CN accelerator of the INFN-LNL. The spectra of the energy deposited in the protons generated by the ⁷Li(p,n)⁷Be reaction by bombarding a LiF target 700 μg cm⁻² in thickness with protons generated by the Van de Graaff CN accelerator of the INFN-LNL. The spectra of the energy deposited in the silicon-based system, a reference TEPC was also irradiated in the same experimental conditions. The gas pressure of the TEPC was set so as to simulate a site 2 μm in diameter and was placed within the neutron fields with its axis normal to the neutron direction of incidence.

![Fig. 1. Sketch of the segmented telescope constituted by a matrix of ΔE elements.](image)

![Fig. 2. Comparison between the microdosimetric spectra measured with the silicon telescope and those obtained through a cylindrical TEPC which simulates a tissue site 2 μm in diameter at different neutron energies.](image)

In order to derive the lineal energy distributions within a
tissue site, the energy imparted in the silicon $\Delta E$ elements was corrected for tissue-equivalence by adopting an optimized procedure. Moreover, in order to compare the spectra measured by the silicon microdosimeter with those acquired with a cylindrical TEPC, a shape-equivalence correction was also applied [3,4].

The lineal energy distributions measured with the segmented telescope at different neutron energies is shown in figure 2 (solid grey line). This figure shows also the lineal energy distributions obtained with the cylindrical TEPC (solid black curve). These spectra were truncated at a value corresponding to the energy threshold of the silicon-based system (about 6 keV $\mu$m$^{-1}$) in order to normalize properly and compare directly the results derived with the two different systems. Anyhow, figure 2 illustrates also the non-normalized complete microdosimetric spectra measured with the TEPC (dashed black lines). The lineal energy spectra measured with the silicon device are limited to a minimum value of about 6 keV $\mu$m$^{-1}$ which is imposed by the electronic noise. This limit hinders to measure the lower-LET events due to secondary electrons generated by photons associated to the neutron field. Nevertheless, at lineal energies higher than the threshold, the agreement between the distributions is satisfactory. At lineal energies around the proton edge (100 - 150 keV $\mu$m$^{-1}$) the spectra measured with the silicon device differ from those of the TEPC. This is mainly due to differences in the cord length distribution in the sensitive volume of the two detectors.

The experimental results shown in figure 2 were processed in order to calculate the dose-mean lineal energy at each impinging neutron energy. In particular, the values derived through the TEPC were calculated by truncating the distribution at 6 keV $\mu$m$^{-1}$, therefore by using the distributions shown in figure 2 with a solid black line. As it can be observed in figure 3, the trend of the two data set is similar. The dose-mean lineal energy values derived by the silicon telescope overestimate those obtained through the TEPC of about 7% for all the neutron energies considered. This systematic difference is due to the mentioned above discrepancy between the spectra at lineal energies around 100 keV $\mu$m$^{-1}$. Anyway, by considering the uncertainties associated to the experimental data (about 8% for those referring to the silicon-based system and about 5% for those derived with the TEPC) the agreement between the results is fairly good.

![Fig. 3. Dose-mean lineal energy measured at different neutron energies $E_n$ with the segmented silicon telescope and by the cylindrical TEPC which simulates a site 2 $\mu$m in diameter.](image)

**CONCLUSIONS**

A new silicon device based on the monolithic silicon telescope technology was studied as a solid state microdosimeter. The device was coupled to a A150 plastic converter and irradiated with mono-energetic neutrons at different energies. In order to perform a direct comparison with a reference technique, a cylindrical TEPC was also irradiated in the same experimental conditions. The lineal energy distributions measured with the silicon-based system were limited to lineal energies higher than about 6 keV $\mu$m$^{-1}$ owing to the electronic noise. At $y$-values higher than this detection threshold, the agreement between the microdosimetric distributions measured with the silicon device and those obtained with the cylindrical TEPC is satisfactory. An improved set-up characterized by a lower electronic noise is necessary, together with a further comparison at neutron energies higher than 2.3 MeV. This will be the matter of a future work.