# Measurement of dead layer thickness of double sided silicon strip detector

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Semiconductor materials are commonly used in radiation detection devices, especially for detecting charged particles and nowadays, these detectors are essential components of many widely used arrays in nuclear physics worldwide [1]. However, during the fabrication of these silicon detectors, a dead layer often forms on the surface to protect the active silicon wafer. The formation of the dead layer in a silicon strip detector is primarily influenced by the oxidation and metallization processes during the fabrication. In the metallization process, generally aluminum or gold conductive metal is deposited on the surface to form electrical contacts. The energy deposited by charged particles in this dead layer goes undetected, affecting the accuracy of charged-particle energy measurements. This layer is referred to as "dead" because it fails to produce a significant signal when a particle passes through, reducing the detector's sensitivity and efficiency. It mainly affects low-energy particles, which may deposit all their energy in this region without being detected. Experimentally measuring this dead layer is somewhat challenging, but it is crucial for experiment where low-energy light charged particles or heavy ion detection is required. In the present work, we reported an experimental measurement of the dead layer thickness of a high-resolution double-sided silicon strip detector using a radioactive source.

Thickness of the dead layer is measured from the basic principle of energy loss of the charged particle (in the present case alpha particle is used) while passing through a material [2]. Here, we have measured the dead layer thickness of the front surface of a double sided silicon strip detector of active area 50 mm by 50 mm and thickness ~ 1500 µm. Front side of the detector is divided into 16 vertical strips, each of dimension 3 mm by 50 mm. Back side of the detector is divided into 16 horizontal strips, mutually perpendicular in direction with respect to front strips, together it gives 256 pixels, each of 3 mm by 3 mm active area. Here, we assumed a uniform thickness of the dead layer on the surface of the strip detector. If a charged particle is incident on the detector surface at an angle θ with respect to the normal incident and 'T' is the dead layer thickness, then the particle will observe the thickness as T*secθ. So, the detected energy in the detector will be

$$E_d = E_0 - \frac{dE}{dx} * T * sec\theta \text{--------------(1)}$$

where, '$E_d$' is the detected energy, $E_0$ is the initial energy of the charged particle, dE/dx is the stopping power of the charged particle in dead layer at energy $E_0$. As the dead layer is extremely thin, the stopping power is assumed to remain constant. By measuring the relationship between the incident angle and the detected energy, the thickness of the detector's dead layer can be determined [3].

Experiment has been performed using the $^{241}$Am alpha source (energy 5.486 MeV) and a double sided silicon strip detector. The source was kept at a distance of 1 cm from the center of the strip detector inside a vacuum chamber. Here, we have considered the dead layer is silicon equivalent. A $^{229}$Th alpha source is positioned 10 cm from the center to achieve an almost parallel alpha beam, which optimizes the detection of incident alpha particles in the DSSD, (five various energies as 4.79 MeV, 5.82 MeV, 6.34 MeV, 7.07 MeV and 8.38 MeV) is used for energy calibration of the detector. While doing energy calibration, a uniform thickness of dead layer (0 and 1 micron) has been assumed for the detector and made the energy calibration. As the dead layer thickness is unknown, during fitting of equation-1 with the measured data, offset, $E_0$, and the slope of the line (dE/dx*T) were taken as free parameters, which takes care of the previous assumptions.

In the next step, the closest pixel was determined by identifying the pixel with the highest count out of the 256 available pixels. To identify the central pixel, i. e., the pixel close to the source, should have maximum counts due to large solid angle sustention. The counts of each pixel has been obtained by making a two dimensional plot between the front strip versus the back strip of the si-strip detector. A three dimensional plot has been made, between the front strip numbers, back strip numbers and the counts, as shown in Fig.1. The central pixel or the closest pixel has been identified as 8 × 9 (pixel between 8th front strip and 9th back strip). The angles of other pixels have been calculated with respect to the central pixel using the position information and the relation given by

$$Sec\theta = \sqrt{1 + \left(\frac{w}{d}\right)^2 \times \left[\left(E_{f0} - E_f\right)^2 + \left(E_{b0} - E_b\right)^2\right]}$$

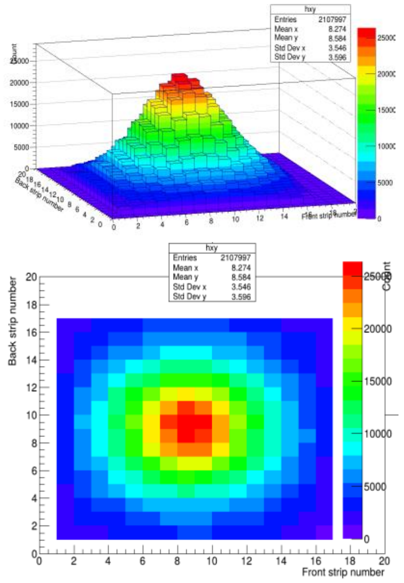

**Fig.1:** Positon identification in DSSD
(a) 3-dimensional. (b) 2-dimention map of 256 pixels.

where, *d* is the distance of source from the detector (1 cm), *w* is the strip width, $E_f$ and $E_b$ are the front and back strip numbers, $(E_{f0}, E_{b0})$ is the central position ($E_{f0}$ =8 and $E_{b0}$ =9 in our case). The energy of various pixels along 8th front strip is plotted with the sec θ is as shown in Fig.2 and Fig.3 for 0 µm and 1 µm dead layer assumption, respectively. The data, solid circles in Fig.2 and 3, have been fitted with the equation-1 (red solid line) for both the cases and obtained the dead layer thickness for the corresponding strip (8th front strip) for both the assumptions (0 µm and 1 µm) as 0.35 ±0.02 µm, the error considered here as fitting value only. Further analysis is going on to improve the calculation. This procedure has also been verified using the know thickness foil and a surface barrier detector. The details of which will be discussed during the symposium.

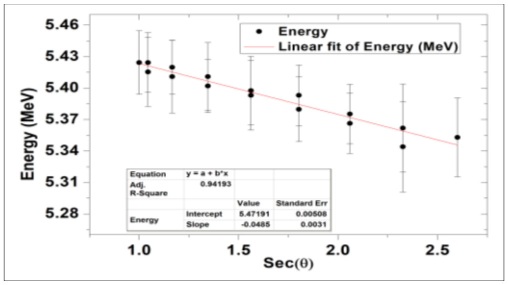

**Fig. 2:** Detected energy versus secθ of the 8th strip of DSSD, here dead layer assumption is of 0 µm.

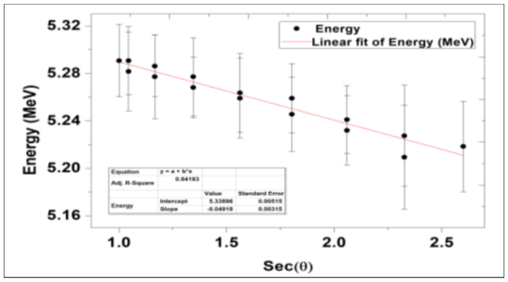

**Fig. 3:** Same as Fig.2 but dead layer assumption is 1 µm.

## References

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