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2. Electrical and CEE analyses
3. CEE at extreme radiation
4. Summary

3D-Trench_electrode detectors

The structure of array of 3D-Trench Electrode detector

Fig. 1 The structure of array of 3D-Trench Electrode detector

3. CEE at extreme radiation

MIP incident at different εc

Fig. 4c MIP incident at different εc

Ultra rad-hard up to 1x10^17 n/cm^2!!

Summary
◆ Micro/Nano 3D-Trench Electrode detectors with micron electrode spacing and nano size electrodes can be extremely rad-hard
◆ CEE can be more than 60% at 1x10^17 n/cm^2
◆ Only very small bias voltage is needed (as small as 10 volts)
◆ It is possible to fabricate with thin substrades and/or shallow etching (30 to 100 μm)

Electrical and CEE analysises

The electric field E(r) can be expressed as:

\[ E(r) = \begin{cases} \frac{\delta}{2}\left(\frac{\epsilon_0}{2}\frac{d^2}{4}\right)(r^2 + 1) & (r < 2d) \\ \frac{\epsilon_0 d^2}{2r^2} & (r \geq 2d) \end{cases} \]

(1)

Where \( \delta \) is the depletion depth at a voltage \( V_0 \) and \( \epsilon_0 \) is the detector full depletion voltage.

Not the factor 4 here, and electrode spacing \( R \) which is independent on the detector thickness.

The MIP induced current \( i_{m,h}(t) \) is:

\[ i_{m,h}(t) = \frac{Q_0}{\epsilon_0} \cdot \epsilon_0 \cdot E_n(r(t)) \cdot V_{m,h}(r(t)) \]

where \( v_{m,h}(r) \) is the carrier drift velocity for electrons (\( e \)) or holes (\( h \)).

\( Q_0 \) is the initial charge generated by incident particles. For minimum ionizing particles (MIP) \( Q_0 = 10 \text{ e}^{-}/\mu \text{m} \), \( r \) is the carrier trapping time constant.

\[ V_{m,h}(r) = \frac{\mu_{m,h} E_n(r(t))}{\mu_{m,h} E_n(r(t)) + \mu_{h,m} r} \]

as the carrier saturation velocity, \( E_n(r(t)) \) is the weighting field:

\[ E_n(r(t)) = \int r(t) dr(t) \]

As the position of a carrier at \( r(t) \), can be solved using all previously listed equations:

With this excel calculation sheet, we can calculate detector electrical and charge detector electrical and charge collection parameters. Those are induced electric and hole current shape.

References