Exercise 12

Exercise 1: Particle detectors
Consider the interaction of a 50 keV X-ray photon with two different particle detectors:

a) **Direct detection**
Consider a thick a-Si:H nip diode particle detector with the following characteristics:

- diode thickness: 10 µm
- reverse bias: 100 V
- electron drift mobility: $1\,\mathrm{cm^2\,V^{-1}\,s^{-1}}$
- hole contribution is neglected (low drift mobility)
- number of created e^-/h^+ pairs: $100\,\mathrm{\mu m^{-1}}$

Estimate the current transient, i.e.

(a) the maximum pulse height
(b) the pulse length
(c) the pulse shape
(d) the total collected charge

for the case of

I) no space charge in the intrinsic layer of the diode (i.e. uniform field)
II) a uniform defect density of $2 \times 10^{16}\,\mathrm{cm^{-3}}$. Assume that all these dangling bonds are polarized in the space charge region.

b) **Indirect detection**
Consider a thin a-Si:H nip diode particle detector coupled with a scintillator layer with the following characteristics:

- diode thickness: 1 µm
- reverse bias: 5 V
- electron drift mobility: $1\,\mathrm{cm^2\,V^{-1}\,s^{-1}}$
- hole contribution is neglected (low drift mobility)
- light yield of the scintillator: 50 000 photon/MeV
- 20 % of the emitted photons are uniformly absorbed in the intrinsic layer of the diode

Estimate the current transient, i.e.

i) the maximum pulse height
ii) the pulse length
iii) the pulse shape
iv) the total collected charge

for the case of

I) no space charge in the intrinsic layer of the diode (i.e. uniform field), the photons are instantaneously absorbed in the intrinsic layer of the diode and
II) same as I) but taking into account that photo emission is spread uniformly over a 1 µm duration.

Exercise 2: Position sensitive detector

The device shown in the figure below is used for position detection. It consists of a a-Si:H diode in pin-structure biased at −1 V and detects the position of a laser spot. The current at the illuminated spot is thus dissipated (uniformly) at non illuminated places towards the side contacts. Calculate the fall-off of the current assuming a diode saturation current of $10 \times 10^{-10}\,\mathrm{A\,cm^{-2}}$ and a sheet resistance of $1000\,\Omega$. To restrict the problem to 1 dimension, assume the laser spot to be a line with the current dissipating perpendicular to it.
What is the largest device that can be built in order to have $V_{\mathrm{ph/T}} \geq \frac{V_{\mathrm{ph/T}}^{\mathrm{max}}}{100}$?