Selenium?

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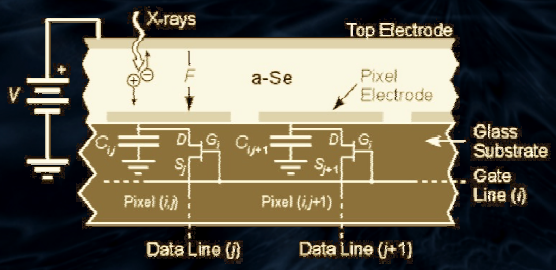
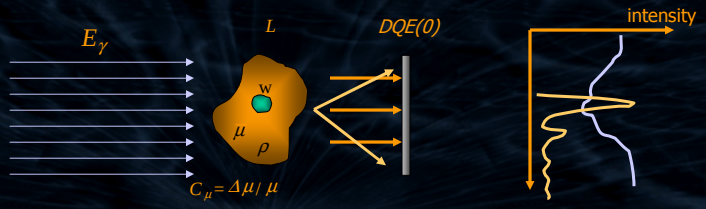


V~ 10V/µm

Dose considerations for imaging detectors



Direct Imaging (absorption)

$$D_{skin} = \frac{2 \cdot L \cdot e^{\mu \cdot L} \cdot SNR_{out}^2}{DQE(f) \cdot \mu^2 \cdot w^4 \cdot C_\mu^2} \cdot E_\gamma \cdot \left(\frac{\mu}{\rho}\right)$$

$$D_{sample} = \frac{\mu \cdot P \cdot h \cdot \nu}{DQE(f) \cdot \rho^2 \cdot w^4 \cdot \lambda^2 \cdot r_e^2}$$

Indirect imaging (scattering)

$$\approx \frac{1}{w^4 \cdot DQE(f)}$$

1 – DQE is what destroys the sample or patient and does not increase SNR

Simple model of spatial frequency DQE

Integrating detectors

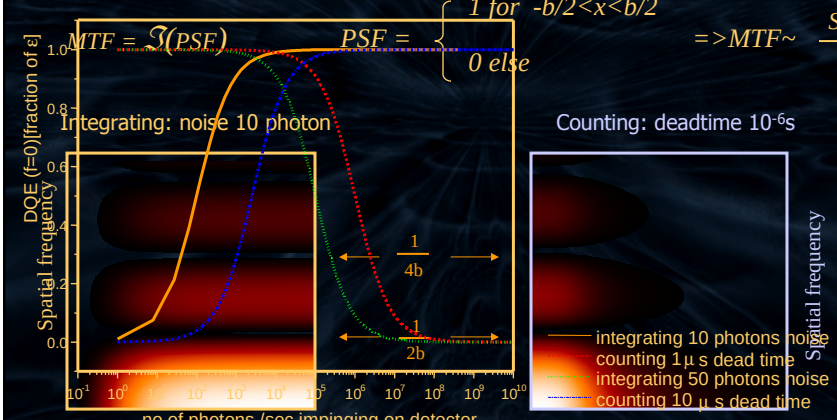
$$DQE = \frac{\varepsilon}{1+\frac{\sigma_{add}^2}{\varepsilon \cdot N}} \cdot |MTF|^2$$

$SNR^2_{measure} = DQE \cdot SNR^2_{Poisson}$

Counting detectors

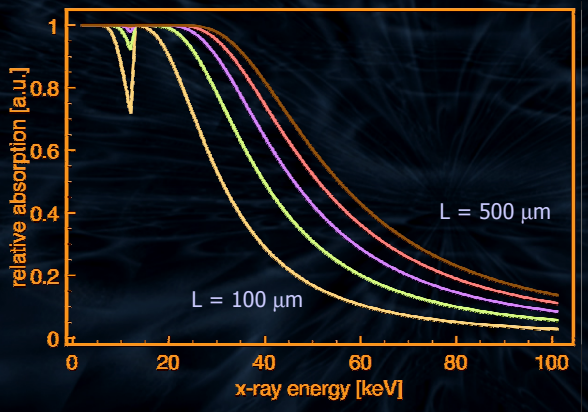
$$DQE = \frac{\varepsilon}{1+R \cdot \tau} \cdot |MTF|^2$$

$MTF = \Im(PSF)$ $\quad PSF = \begin{cases} 1 \text{ for } -b/2<x<b/2 \\ 0 \text{ else} \end{cases}$ $\quad => MTF \sim \frac{Sin(x)}{x}$



Why Selenium?

Absorption efficiency ε



The easy approach

$$\varepsilon(E_\gamma) = 1 - e^{-\mu(E_\gamma)\cdot\rho\cdot\Delta L}$$

Looks good…. However does not describe the physics in detail

Drawbacks Selenium

$\varepsilon(E_\gamma) = 1 - e^{-\mu(E_\gamma)\cdot\rho\cdot\Delta L}$ Looks good…. However does not describe the physics in detail

More appropriate: Charge / energy efficiency

$$Q(E_\gamma) = \underbrace{\left(1 - e^{-\mu(E_\gamma)\cdot\rho\cdot\Delta L}\right)\eta(E_\gamma)}\cdot\frac{E_\gamma\cdot e}{W_{ion}}\cdot\underbrace{\Gamma\left(E_{depletion}\right)}$$

□energy efficiency □trapping / recombination

$$\eta(E_\gamma) = \frac{\langle E_{dep}\rangle}{E_\gamma} = \frac{\int_0^\infty n(E_\gamma)\cdot E_\gamma\cdot dE_\gamma}{E_\gamma\cdot\int_0^\infty n(E_\gamma)\cdot dE_\gamma} \qquad \Delta E_{dep} = \sqrt{\langle E_{dep}^2\rangle - \langle E_{dep}\rangle^2}$$

$$\langle E^2{}_{dep}\rangle = \frac{\int_0^\infty n(E_\gamma)\cdot E^2{}_\gamma\cdot dE_\gamma}{\int_0^\infty n(E_\gamma)\cdot dE_\gamma} \Rightarrow \Delta Q^2 = \frac{\langle E_{dep}\rangle^2}{W_{ion}}\cdot e^2\cdot\left(1+\left(\frac{\Delta E_{dep}}{\langle E_{dep}\rangle}\right)^2\right)$$

Problem: W_{ion} depends from $E_{depletion}$

More advanced model of spatial frequency DQE for a-Se

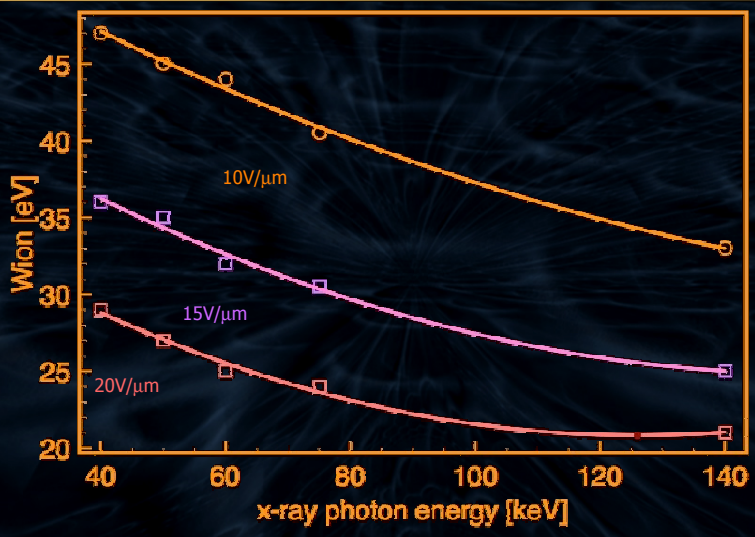
Integrating detectors

$$DQE = \frac{\varepsilon}{1+\dfrac{\sigma_{add}^2}{\varepsilon\cdot N\cdot\left(1+\left(\dfrac{\Delta E_{dep}}{\langle E_{dep}\rangle}\right)^2\cdot\left(\dfrac{e\cdot E_\gamma}{W_{ion}}\right)^2\right)}}\cdot|MTF|^2$$

To understand the DQE one has to measure W_{ion}

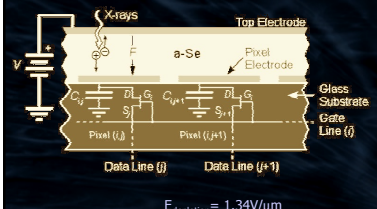
$$W_{ion} = \frac{\varepsilon\cdot\eta(E_\gamma)\cdot e\cdot E_\gamma\cdot\Gamma\left(E_{depletion}\right)}{Q}$$

Measured W_{ion}

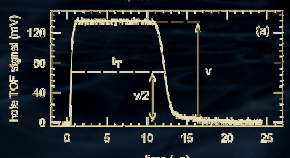


Stone et al.: X-ray sensitivity of amorphous selenium Medical Physics, Vol. 29, No. 3, March 2002

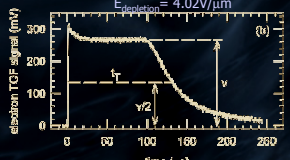
TOF measurement for mobility, capture time and recombination



$E_{depletion}$= 1.34V/μm



$E_{depletion}$= 4.02V/μm



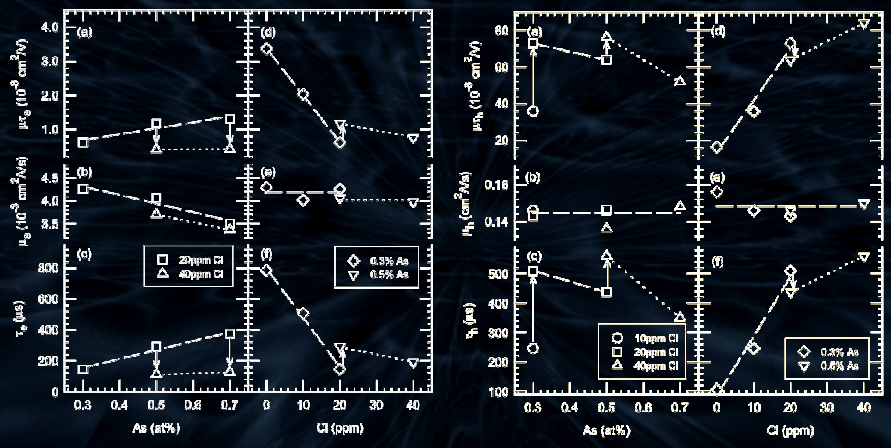
L = 224μm

$$\underbrace{\delta = \frac{1}{\mu}}_{\text{Absorption depth}} < \underbrace{L}_{\text{Thickness a-Se}} << \underbrace{\mu^{\pm} \cdot \tau \cdot E_{depletion}}_{\text{Schubweg}}$$

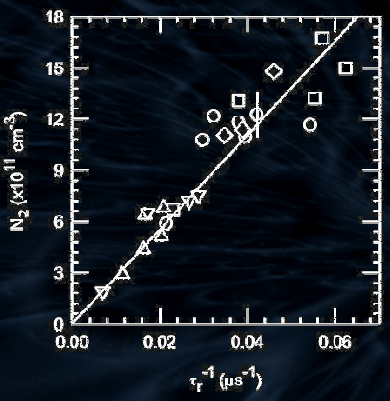
$$\mu^{\pm} = \frac{L^2}{V_{depletion} \cdot t_T}$$

$$\Gamma \approx \frac{e \cdot \mu}{t_T} = \frac{1}{N_2}$$

lifetime, mobility and range



Trapped electron concentration



Trapped electron concentration in the a-Se bulk versus inverse hole recombination lifetime at different depth

$$C = \frac{1}{\tau_t \cdot N_2}$$

C Langevin recombination coefficient