

# **X-ray detectors made of self-standing epitaxial GaAs**

**G.C. Sun, N. Mañez, J.C. Bourgoïn**

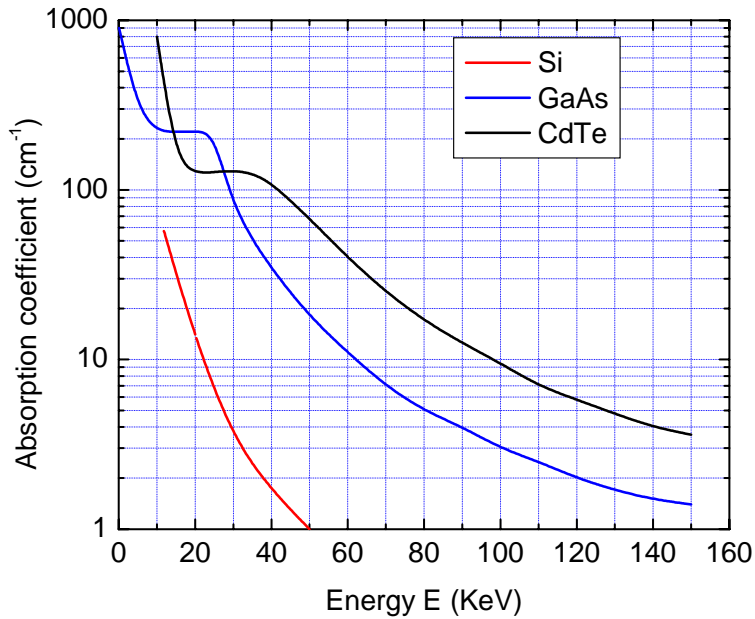
IMPMC and LISIT, Université Pierre et Marie Curie (Paris 6)

GESEC R&D

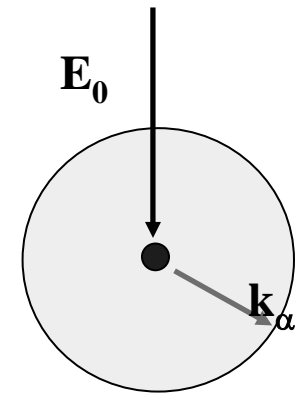
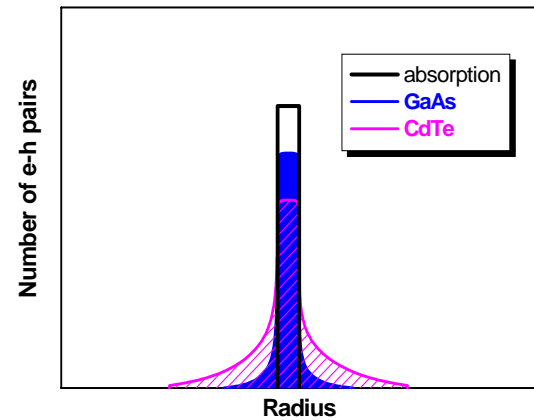
# Requirements for X-ray imaging

1) Large – low Z

Large Z → high absorption



Large Z → strong fluorescence



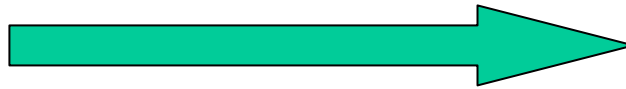
	Z	$k_{\alpha 2}$ (keV)	$k_{\alpha 1}$ (keV)	$\omega_k$	Absorption of $k_\alpha$ (cm <sup>-1</sup> )
GaAs	Ga: 31	9.22	9.25	46%	220
	As: 33	10.51	10.54	52%	
CdTe	Cd: 48	22.98	23.17	82%	127
	Te: 52	27.20	27.47	86%	

# Application to mammography

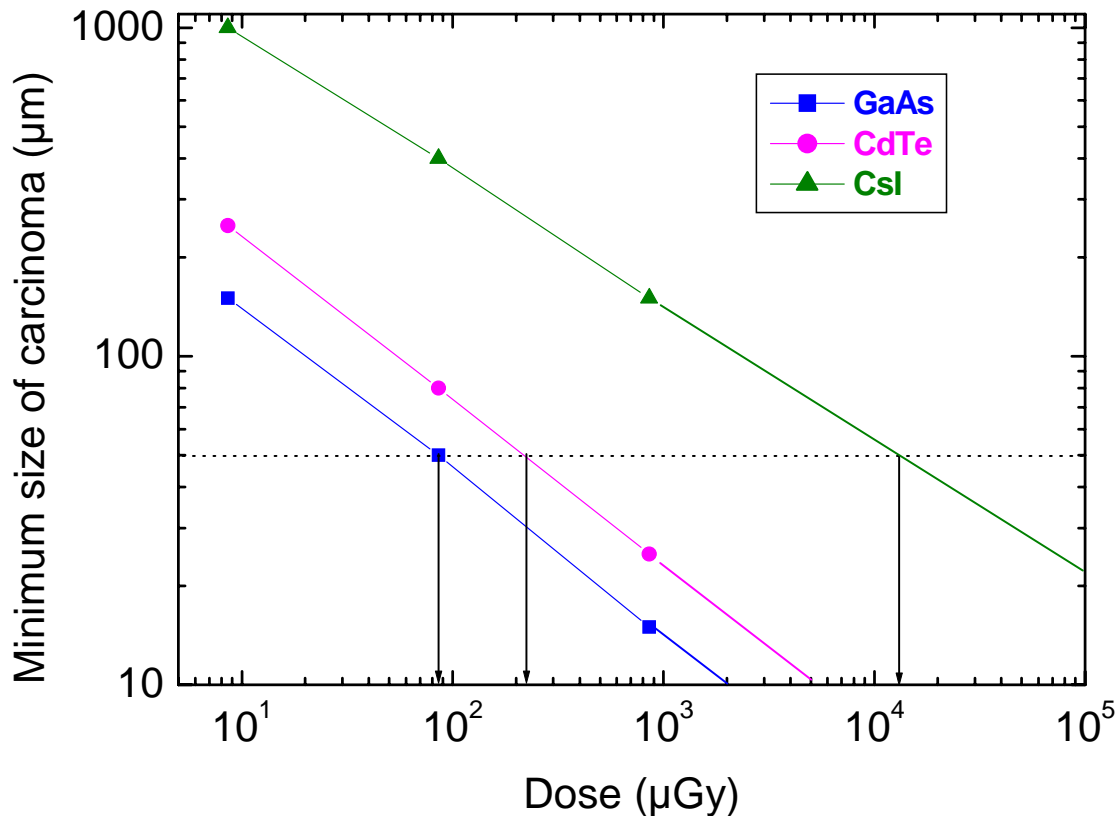
Minimum size of carcinoma

Dose ~ 100  $\mu\text{Gy}$

Pixel size: 100  $\mu\text{m}$



GaAs	CdTe	CsI
50 $\mu\text{m}$	100 $\mu\text{m}$	500 $\mu\text{m}$



Carcinoma size ~ 50  $\mu\text{m}$



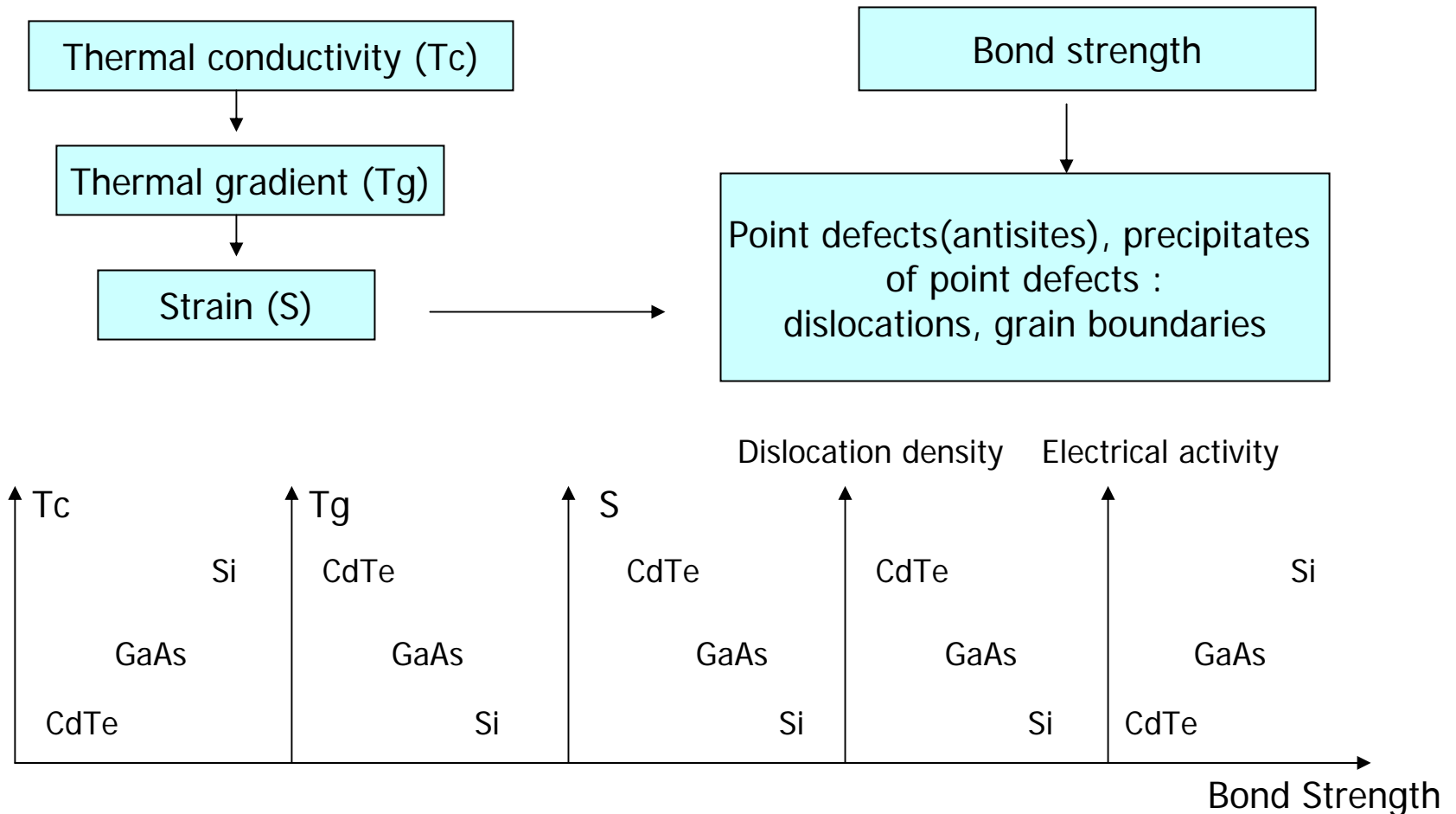
Dose reduction:

$$\frac{\text{GaAs}}{\text{CdTe}} = \frac{1}{2}$$

$$\frac{\text{GaAs}}{\text{CsI}} = \frac{1}{100}$$

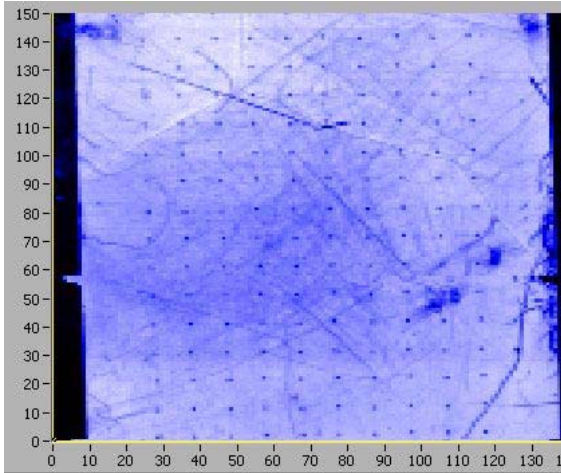
## 2) Defects: low concentration and homogeneity

### Growth of Bulk materials

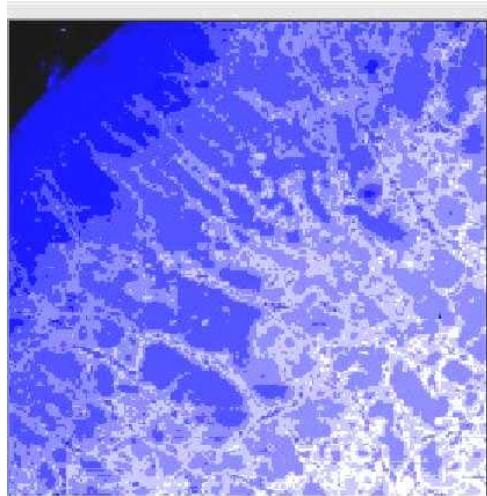


# Low defect concentration: epitaxy

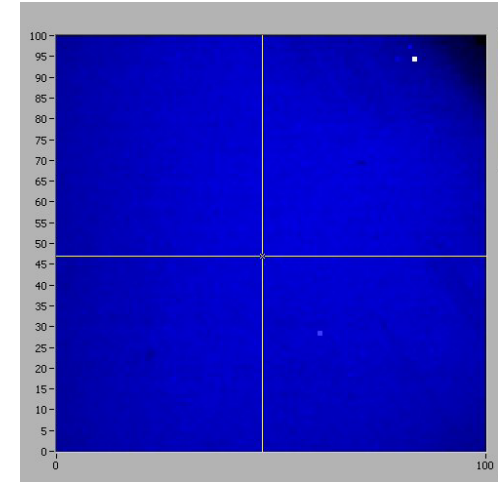
## Homogeneity: epitaxy



CdTe  
(area 1 cm<sup>2</sup>)



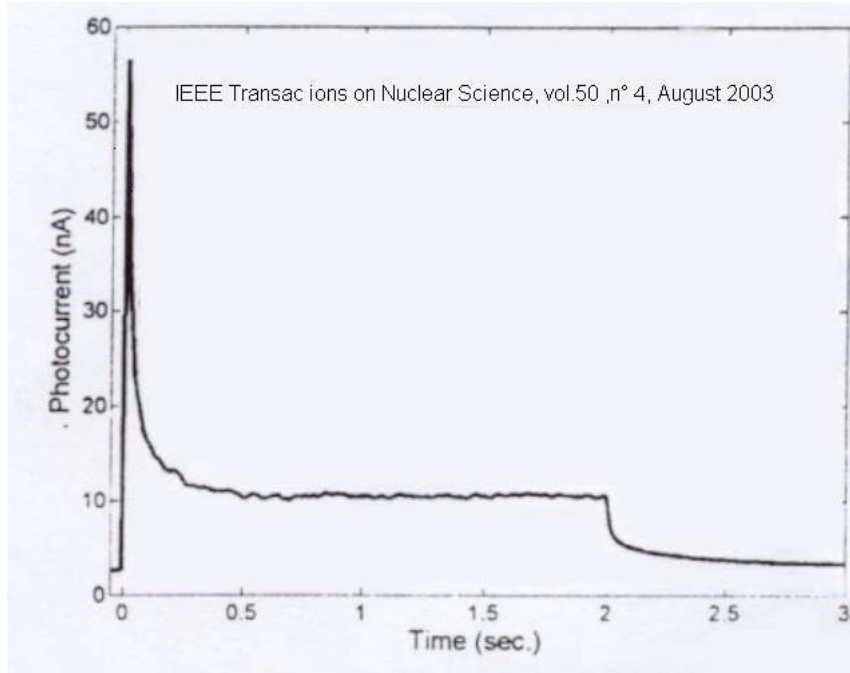
Bulk GaAs  
(1/4 of a 2 inches wafer)



Epitaxial GaAs  
(1/4 of a 4 inches layer)

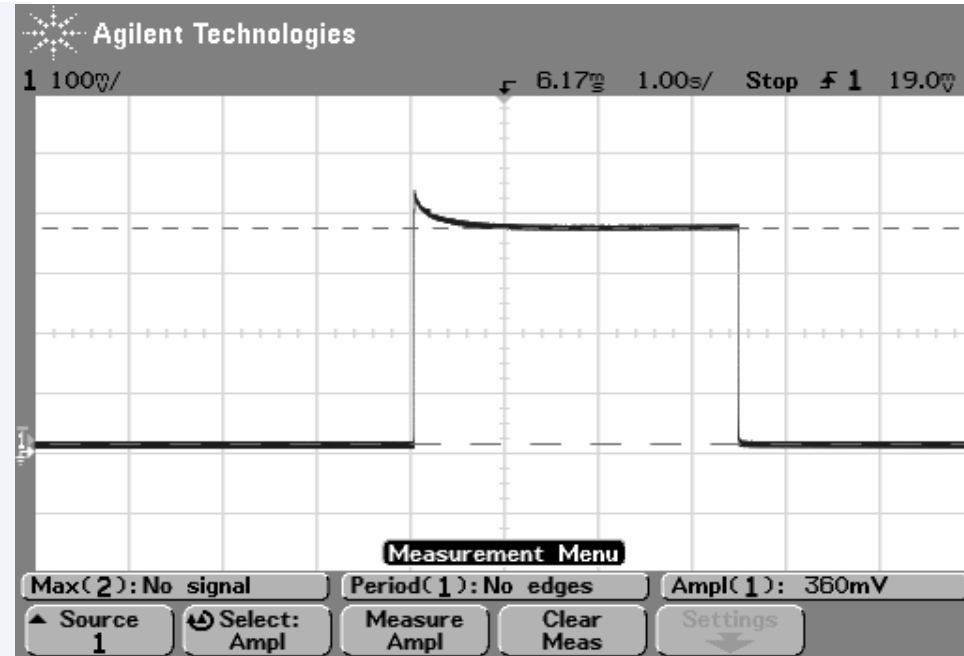
	Gap(eV)	Cost	Surface	Homogeneity	Technology
CdTe, CZT	1.56	High	Small	Very bad	Not mastered
Bulk GaAs	1.42	Low	Large	Very bad	Standard
<b>Epi GaAs</b>	<b>1.42</b>	<b>Low</b>	<b>Large</b>	<b>Very good</b>	<b>Standard</b>
Ge	0.66	Low	Large	Very good	Not easy
Si	1.12	Low	large	Very good	Standard

# Large concentration of defects : Afterglow



**CdTe**

Anode voltage 60kV, I=160mA, bias 200 V, thickness 3 mm, Photocurrent: 20 nA/mm<sup>2</sup>



**GaAs**

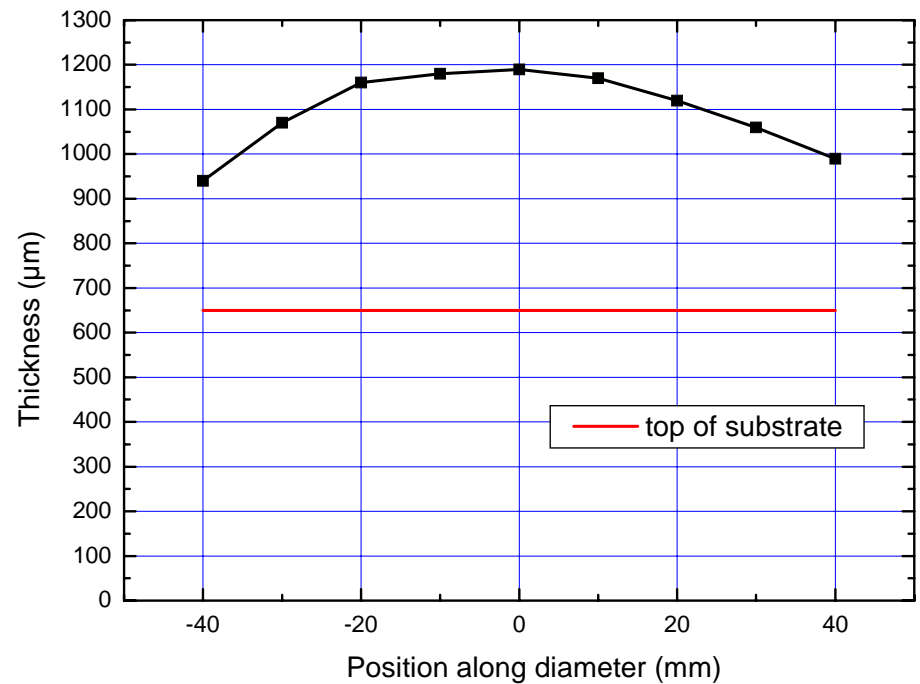
Anode voltage 40kV, I=50mA, distance 15 cm, bias 40 V, thickness 200  $\mu$ m,

Photocurrent: 90 nA/mm<sup>2</sup>

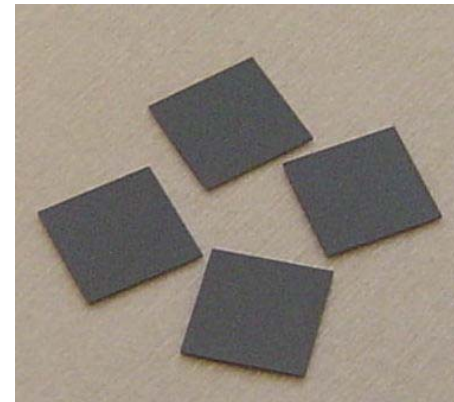
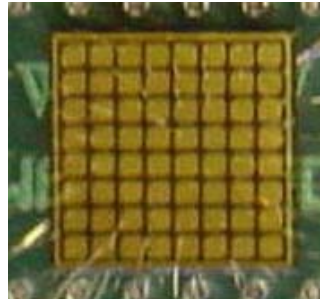
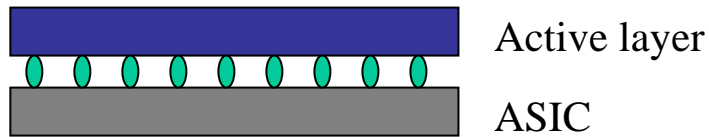
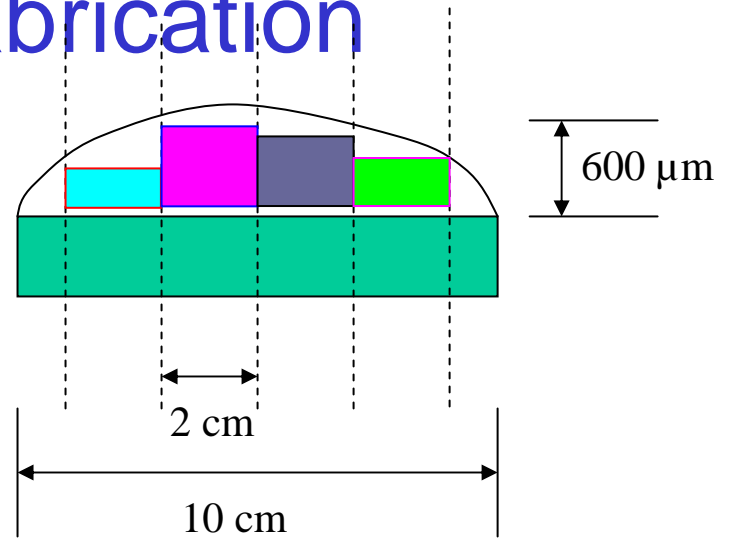
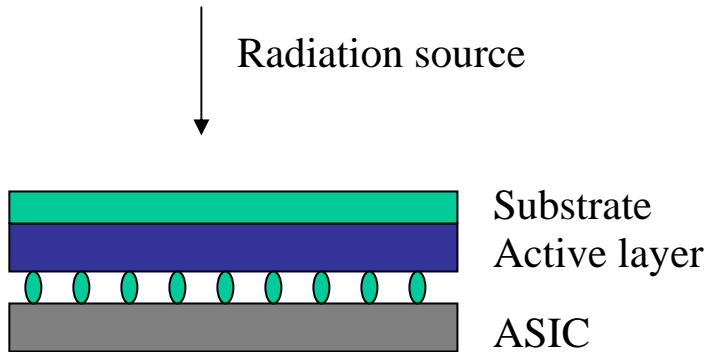
# Growth of epitaxial GaAs

A 4 inch, 550  $\mu\text{m}$  thick layer

- Thickness profile

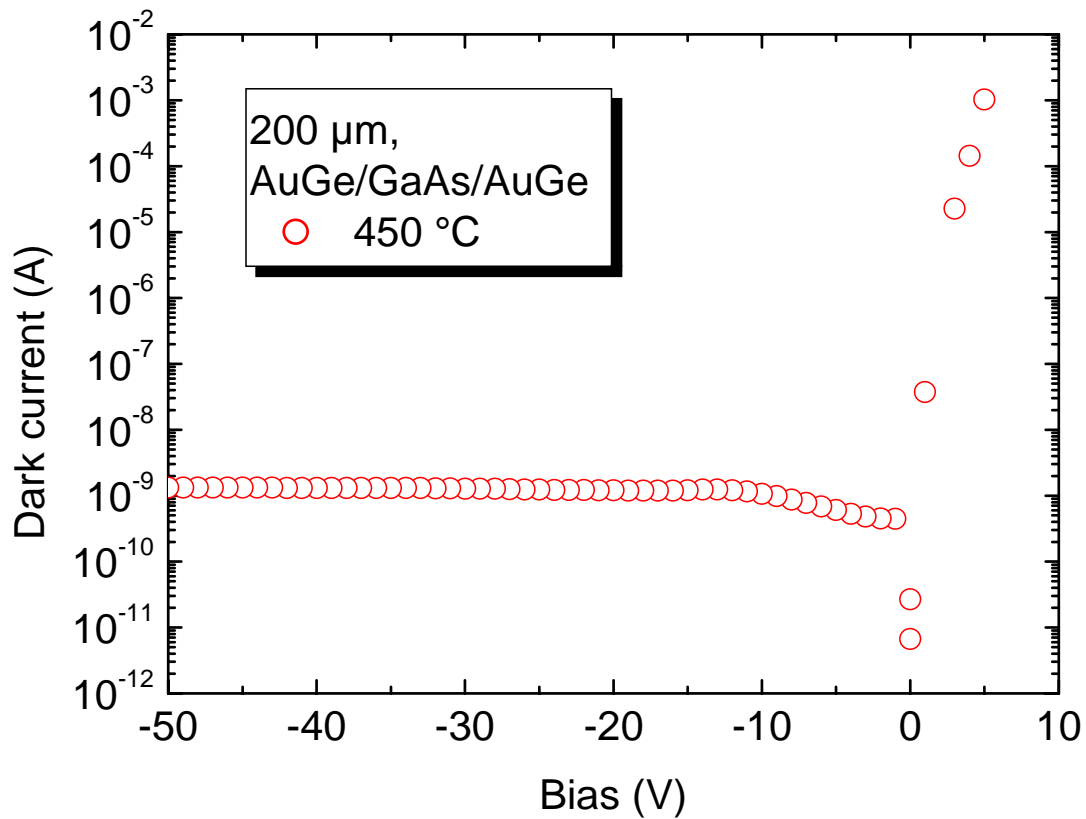


# Procedure of fabrication





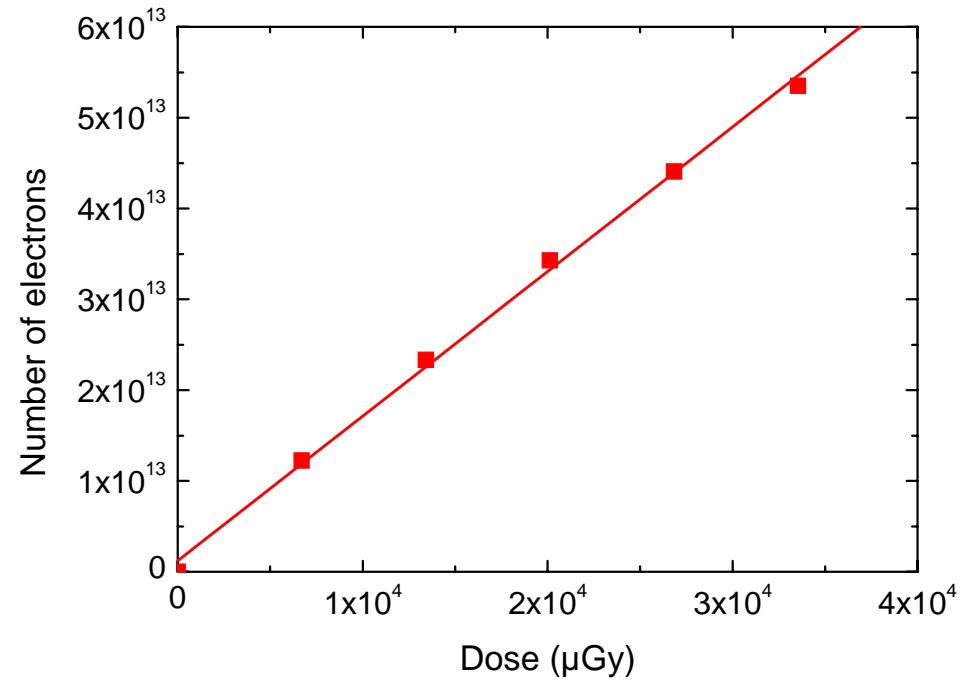
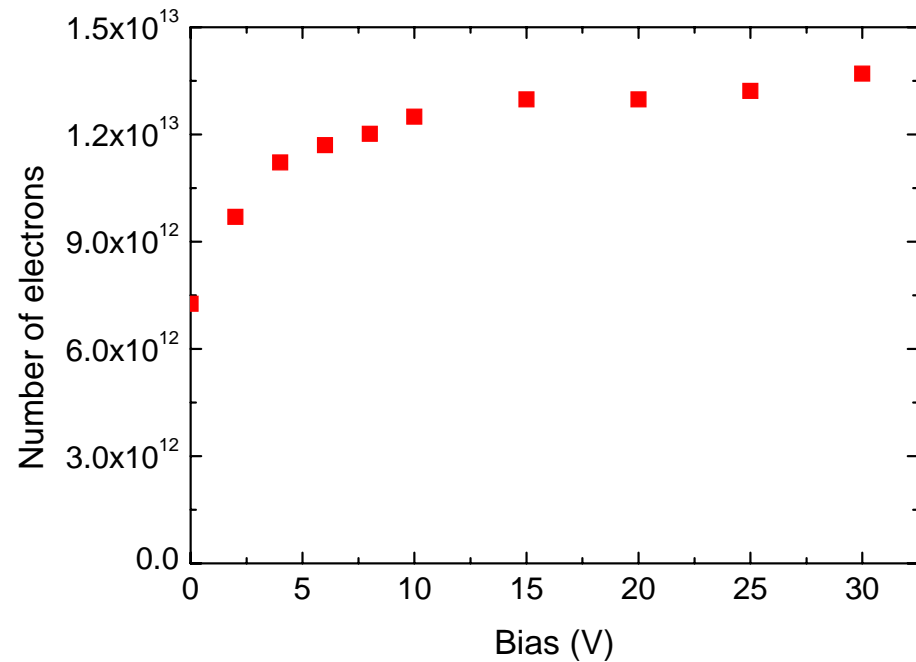
# Performance: dark current



# Performance: photocurrent

40 kV, 14 cm, 1 mm<sup>2</sup>, integration of 1 s, dose 708 μGy

40 kV, 14 cm, 1 mm<sup>2</sup>, integration of 1 S



Thickness : 200 μm

# Conclusions

## Requirements for X-ray imaging:

- 1) Optimisation of absorption and contrast/resolution: GaAs
- 2) Low defect concentration and homogeneity: epitaxial GaAs
- 3) Self-standing epitaxial GaAs available now (GESEC R&D)