High resolution X-ray imaging based on single crystal films

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Single crystal films grown by Liquid Phase Epitaxy (LPE)

Figure 1: LPE laboratory at the ESRF and team

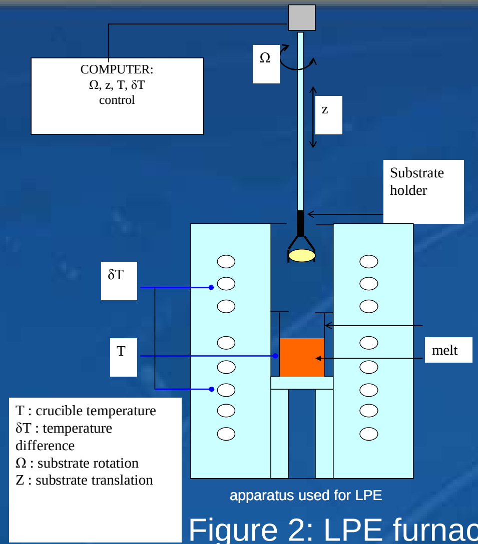

Figure 2: LPE furnace

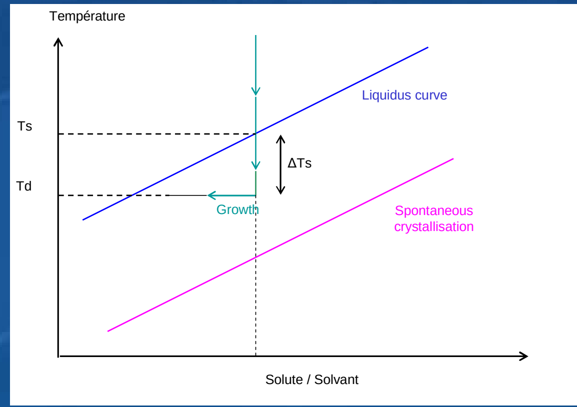

Figure 3: LPE principle

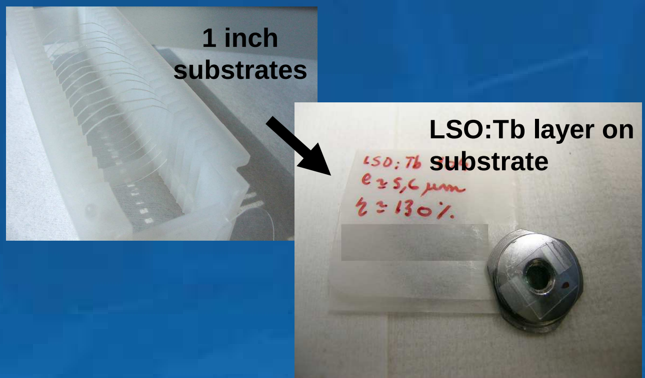

Figure 4: From substrate to final single crystal film ready for X-ray micro-imaging

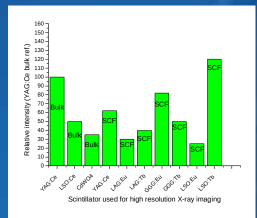

Figure 3: Comparison of the conversion efficiency of single crystal and single crystal film scintillators

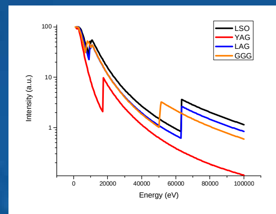

Figure 4: Comparison of the X-ray absorption efficiency of common single crystal films YAG, LAG, GGG and LSO. Note the different K-edge: 17keV for YAG, 50keV for GGG and 62keV for LAG and LSO.

Figure 5: Luminescence properties of single crystal films grown by LPE:

YAG:Ce/YAG

LAG:Eu/YAG

GGG:Eu/GGG

GGG:Tb/GGG

LSO:Tb/YbSO

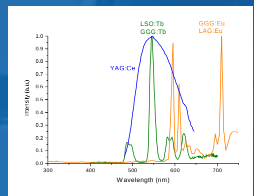

Figure 6: Emission spectra of the single crystal films covering the range [500nm;800nm].

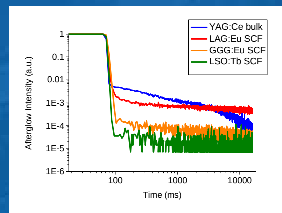

Figure 7: Afterglow of single crystal films following 1s exposure to 8keV X-rays (10^6ph/s/mm²)

High-resolution X-ray imaging at synchrotron: optimisation of X-ray imaging detector

European Synchrotron Radiation Facility

1)

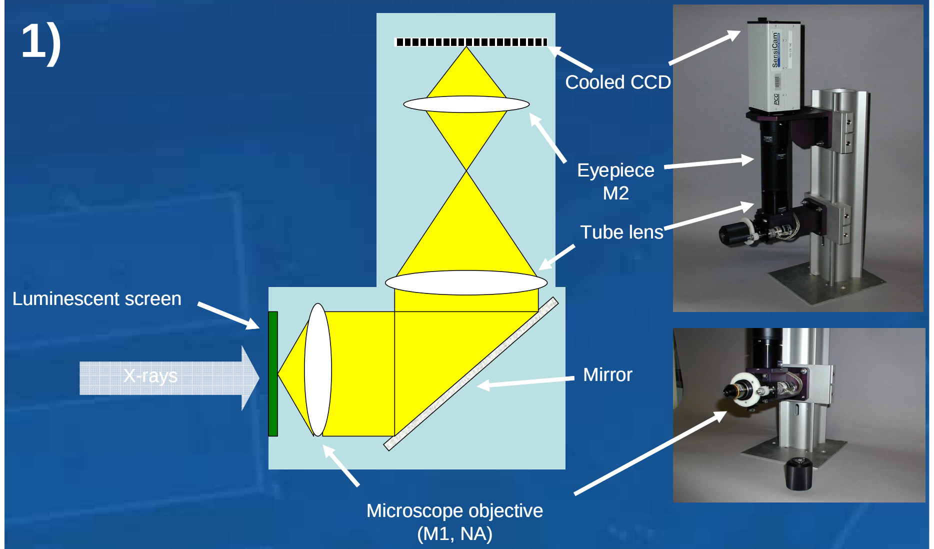

Figure 6: Principle of high-resolution X-ray imaging

2)

$$DQE = \eta_a \left[1 + \frac{1 + (1/SMF)}{\eta_{coll}(E_{Rx}/E_v)\eta_{x/v})} \right]^{-1}$$

At 0 spatial frequency:

DQE(0)

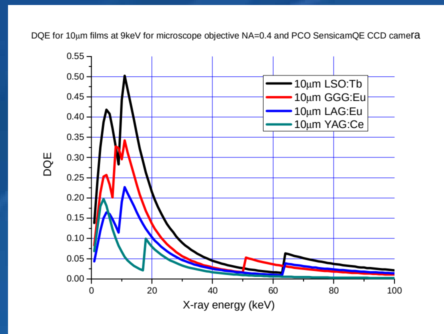

Figure 11: Comparison of DQE with detection system based on back-illuminated CCD and different SCF materials

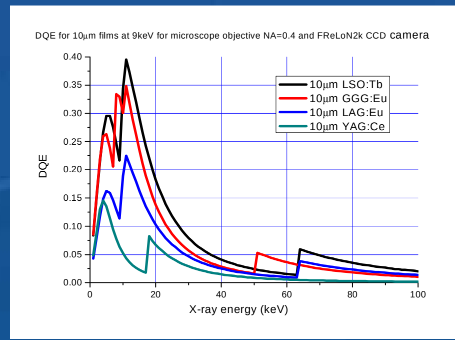

Figure 12: Comparison of DQE with detection system based on front-illuminated CCD and different SCF materials

3)

$$DQE = \frac{G.S.MTF^2(\nu)}{N.NPS(\nu)}$$

At spatial frequency ν:

DQE(ν)

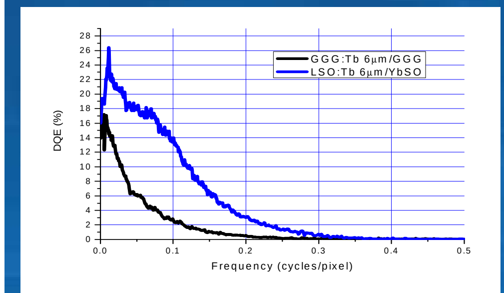

Figure 10: Comparison of 5µm thick GGG:Tb and LSO:Tb DQEs obtained with PCO2000 camera at 18keV, objective 5x (NA=0.25), eyepiece 2.5x. Note the decrease of contrast with GGG:Tb due to intrinsic luminescence of undoped GGG substrate. The effect is a loss in the MTF (and therfore in DQE) of the overall detection system. The substrate used for LSO:Tb (YbSO) presents no luminescence. At 18keV, the GGG substrate conversion efficiency is ~6% that of the GGG:Eu layer.

4)

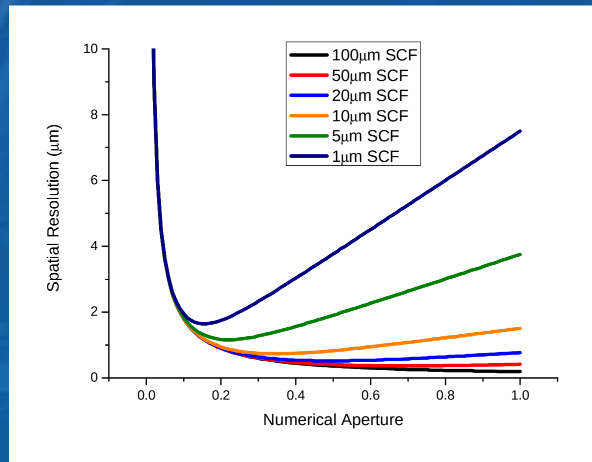

Figure 7: Influence of the SCF on the spatial resolution of the system

Aknowledgments

All members of the Detector Group at ESRF

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