



CRYTUR Ltd.

*Crytur Single Crystal
Scintillator Screens*

Jan Touš, Karel Blažek

02/2011

Outline



- Company Profile
- Different Scintillators Production
- Single Crystal Scintillators
- YAG:Ce and LuAG:Ce Imaging Screens
- Quality Inspection
- Applications

CRYTUR Company

Czech Republic

80 km by highway from Prague, 600 km from GSI



CRYTUR Ltd.



- 60 Employees
- 2500 m2

CRYTUR Company Profile



68 Years Crystal Growth Tradition

- Crystal growth
- Grinding and polishing
- Laser rods and laser components
- Coating, sputtering
- Sapphire profiles
- Scintillation materials and detectors
 - - for High and Low Energies

Scintillators Production

Different Scintillators

- Single Crystal Scintillators
- Powder Scintillator Screens
- Plastic Scintillator Screens
- LPE Grown Scintillator Screens

Materials

- YAG:Ce, LuAG:Ce, CaF:Eu
- YAP:Ce, BGO, CsI:TI, LYSO
- CdWO₄, P43

Screens

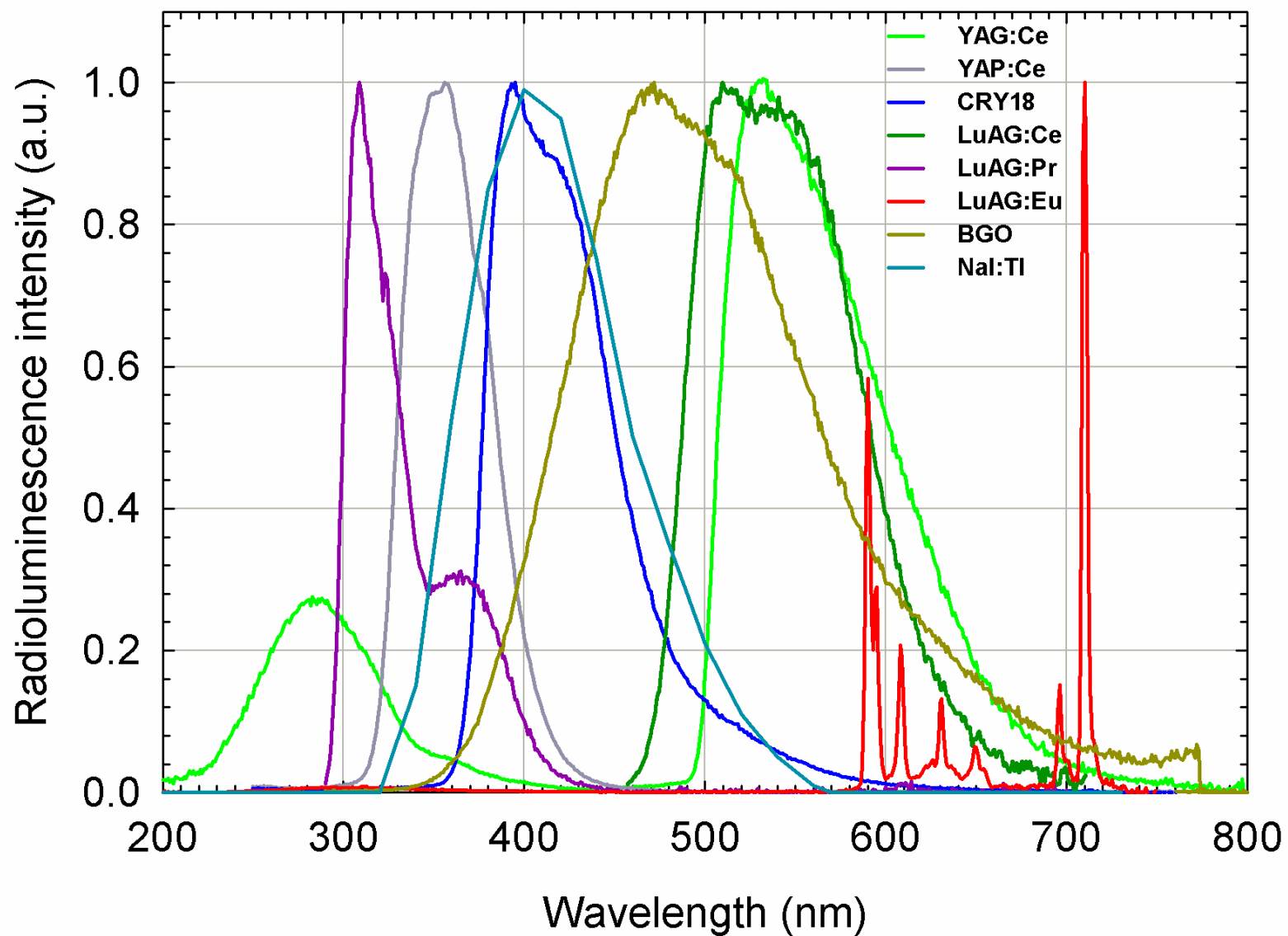
- On Substrates (BK7, Quartz, ...)
- On Fiber Optics (FOP, Tapers)
- Free Standing (on Rings)

Different Scintillators

Scintillator abbreviation	Emission wavelength [nm]	Density [gcm^{-3}]	Cleavage/Hygroscopic	Photon Yield [ph/keV]	Decay [ns]
YAG:Ce	550	4.55	No/No	35	70
LuAG:Ce	500-545	6.73	No/No	20	60
YAP:Ce	370	5.37	No/No	25	25
LYSO:Ce	420	7.1	No/No	32	41
GSO:Ce	440	6.71	Yes/No	8-10	30-60
CsI:Tl	565	4.51	No/Yes	54	>1000
GOS:Tb	544	7.34	-/No	60	10^6
CaF:Eu	435	3.18	Yes/No	23	940
CWO	475	7.9	Yes/No	12-15	5000
BGO	480	7.13	No/No	8-10	300

- Application Depends on Physical Properties
- YAG and LuAG Single Crystal Screens are the Best Choice for Low Energy High Resolution Imaging

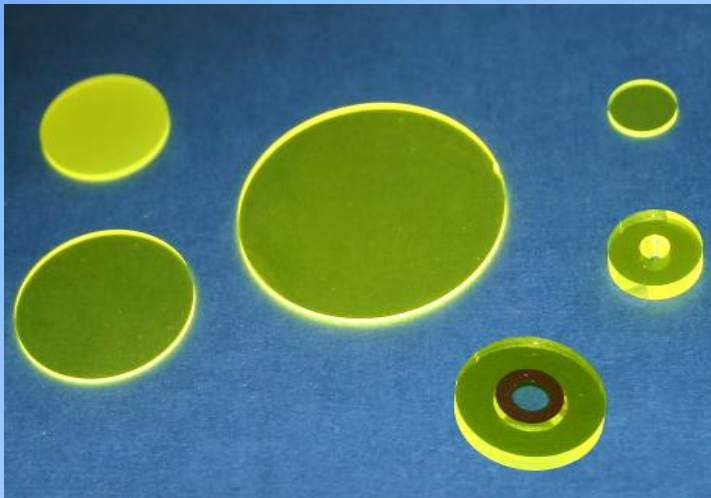
Single Crystal Scintillators



Single Crystal Scintillators

Application in

- Electron Microscopy,
- Alfa, Beta, and Gamma Radiation Detectors,
- Proton and Electron Beam Imaging Screens,
- X-Rays, UV and XUV Imaging Screens



YAG:Ce and LuAG:Ce

YAG:Ce and LuAG:Ce Single Crystals



LuAG:Ce ($\text{Lu}_3\text{Al}_5\text{O}_{12}$) Single Crystal

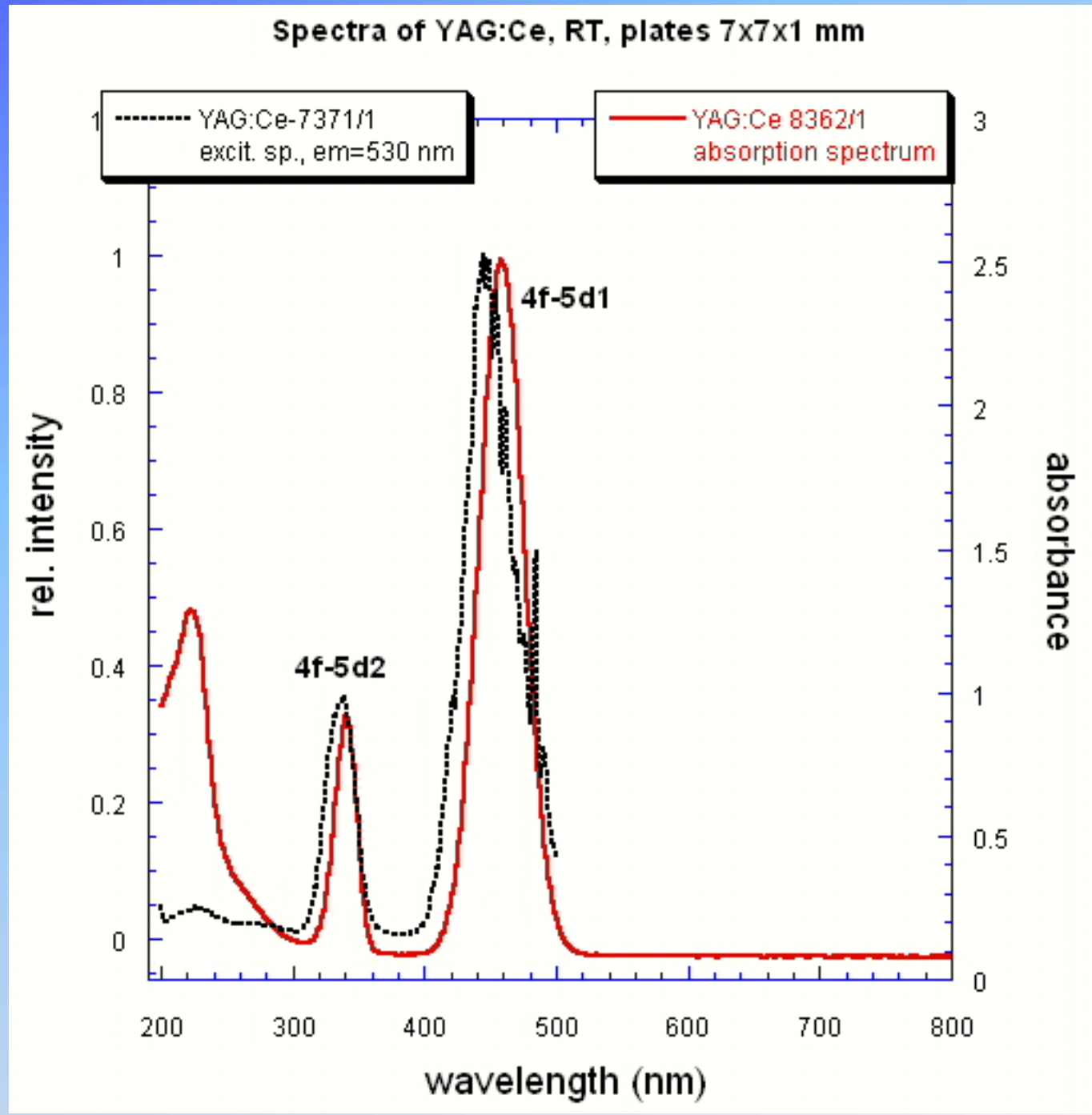
YAG:Ce and LuAG:Ce Single Crystals Have the Optimal Properties for High Resolution Imaging

- Czochralski Technique Grown
- High Radiation Hardness $\sim 10^{14}$ Gy
- High Chemical and Mechanical Stability
- Good Physical Properties
- Long Lifetime, etc.

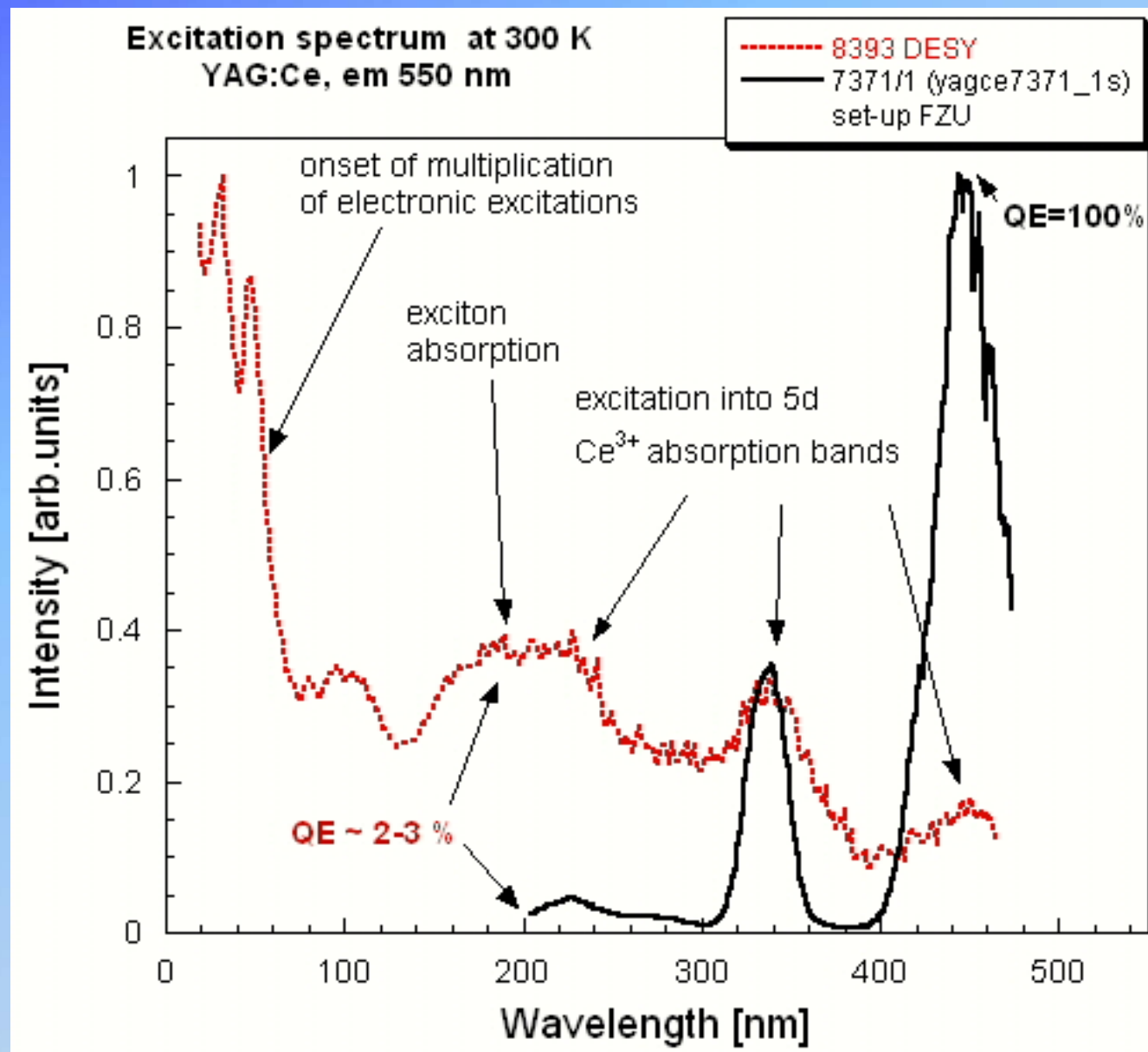


YAG:Ce ($\text{Y}_3\text{Al}_5\text{O}_{12}$)
Single Crystal

YAG:Ce Excitation and Absorption Spectra in UV-Visible Region

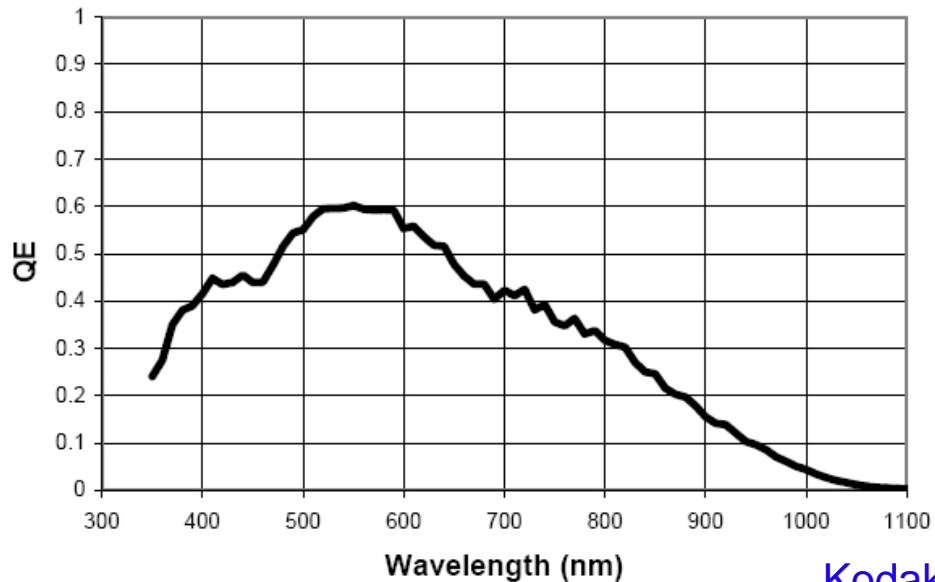
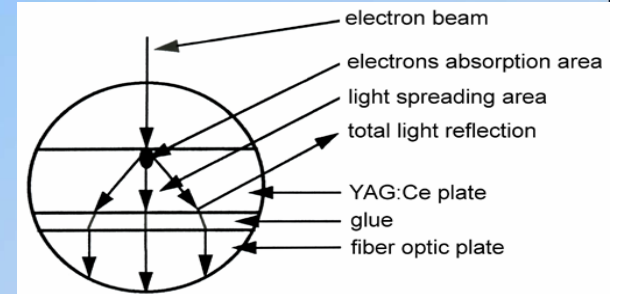
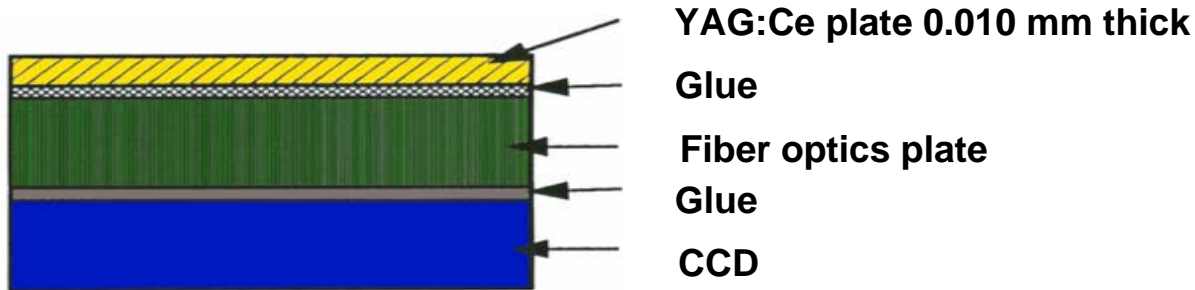


Excitation spectra
YAG:Ce, RT,
em = 530-550 nm

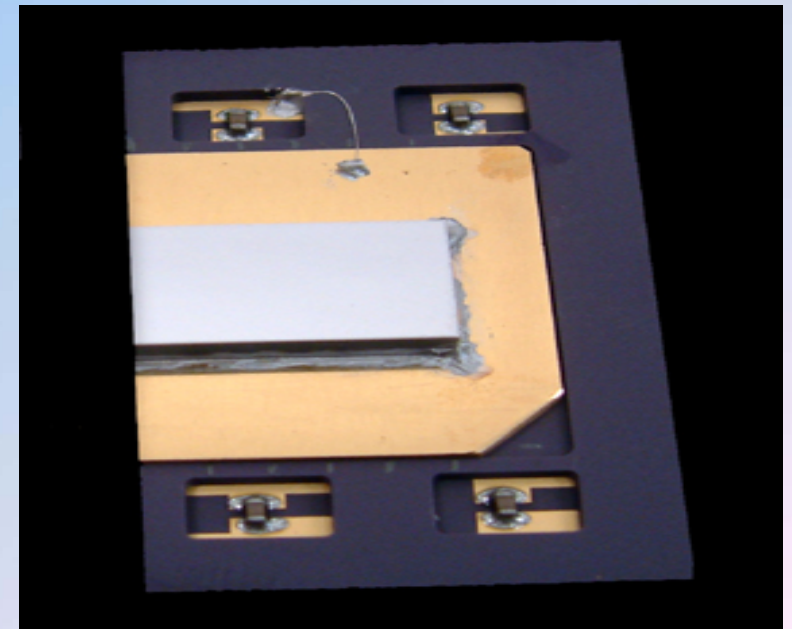


YAG:Ce on FOP and CCD

- Imaging System for X-Rays, VUV, UV and Electrons



Kodak CCD



Scintillator Screens

... on Substrates



YAG:Ce 5 Microns Thick



LuAG:Ce 20 Microns Thick

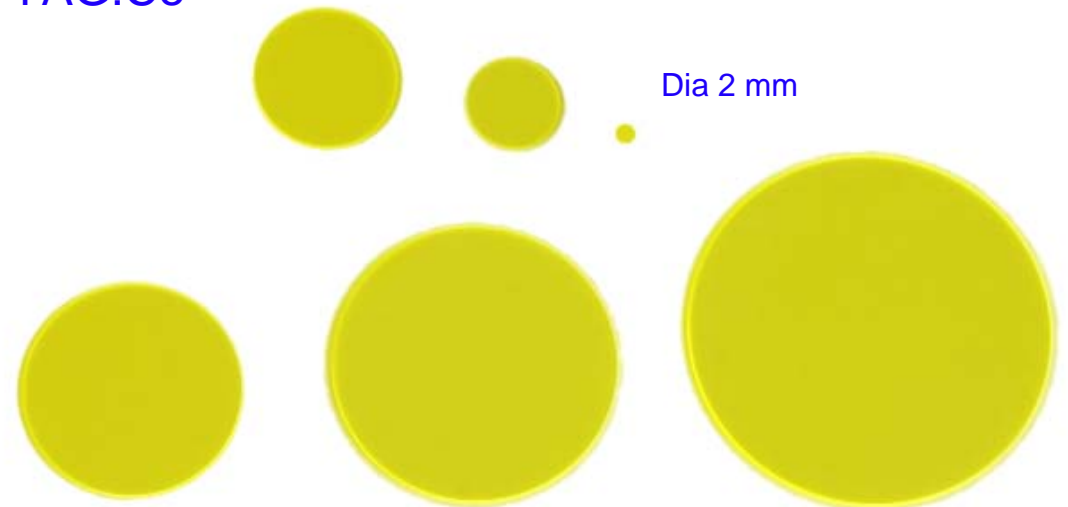


Free Standing 25 Microns



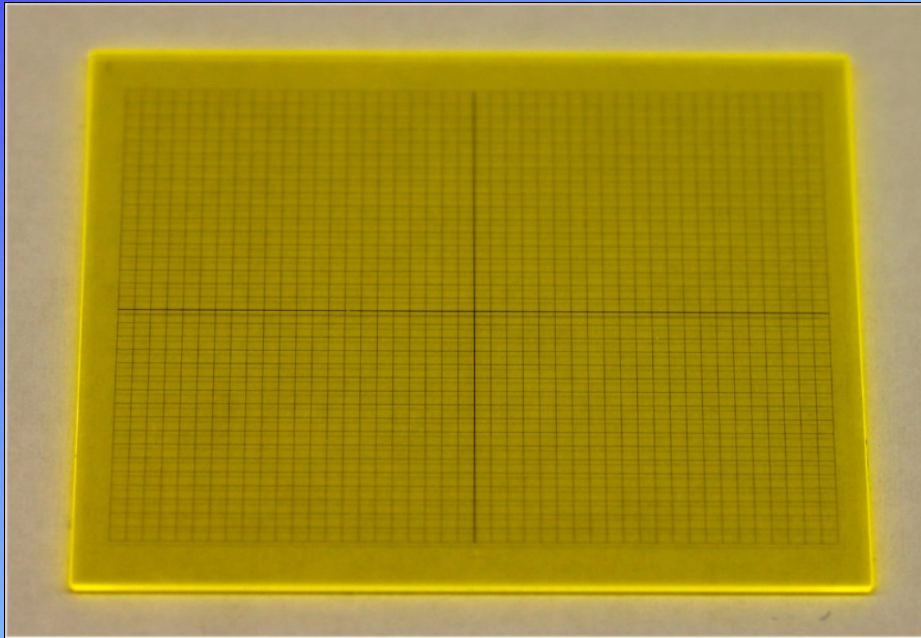
... on Taper

YAG:Ce

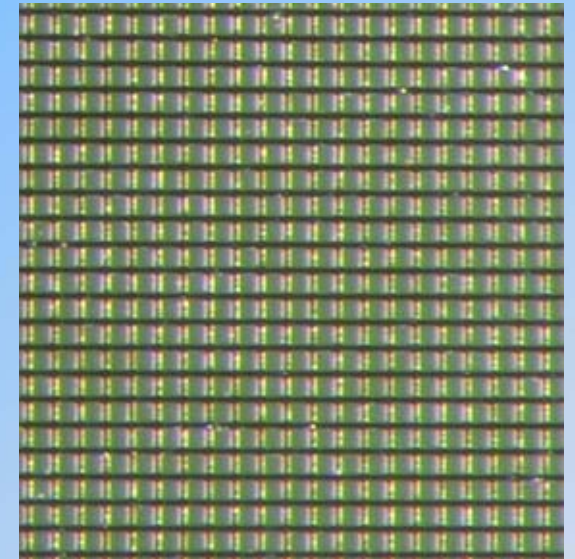


Dia 50 mm

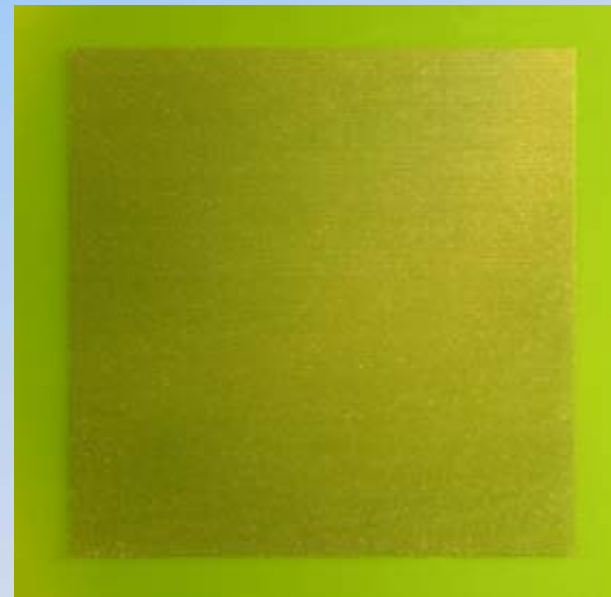
Scintillation screens



YAG:Ce with a Grid



Detail



LuAG:Ce with a Grid

Screen Surface Layers

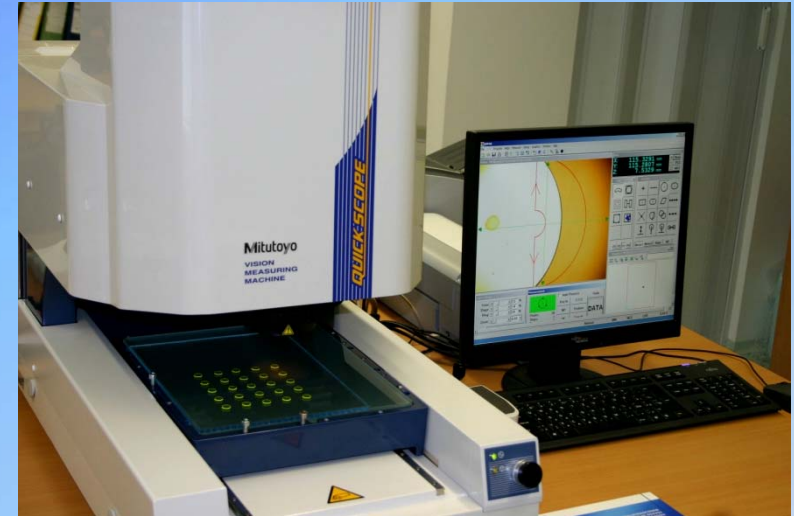
- Anti-Reflection Layers
- Reflection Layers
- Conductive Layers
- Different Compounds of Layers According the Application
- Optimized to Screens Emission Wavelength



Imaging Screens Quality Inspection

Quality Inspection

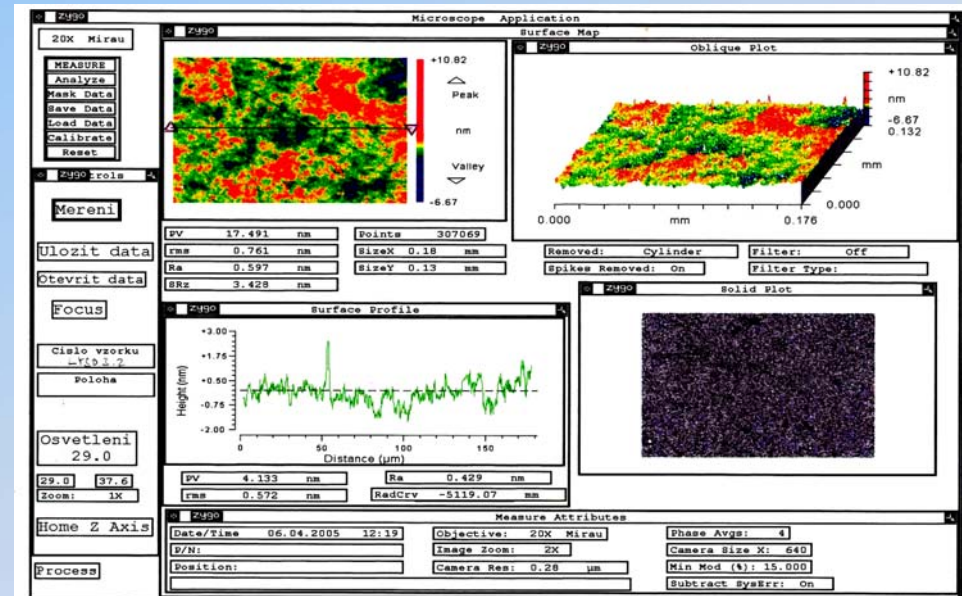
- Crystal Quality
- RLE – Relative Luminescence Efficiency
- Optical Quality
- Surface Quality



Automated Shape Inspection



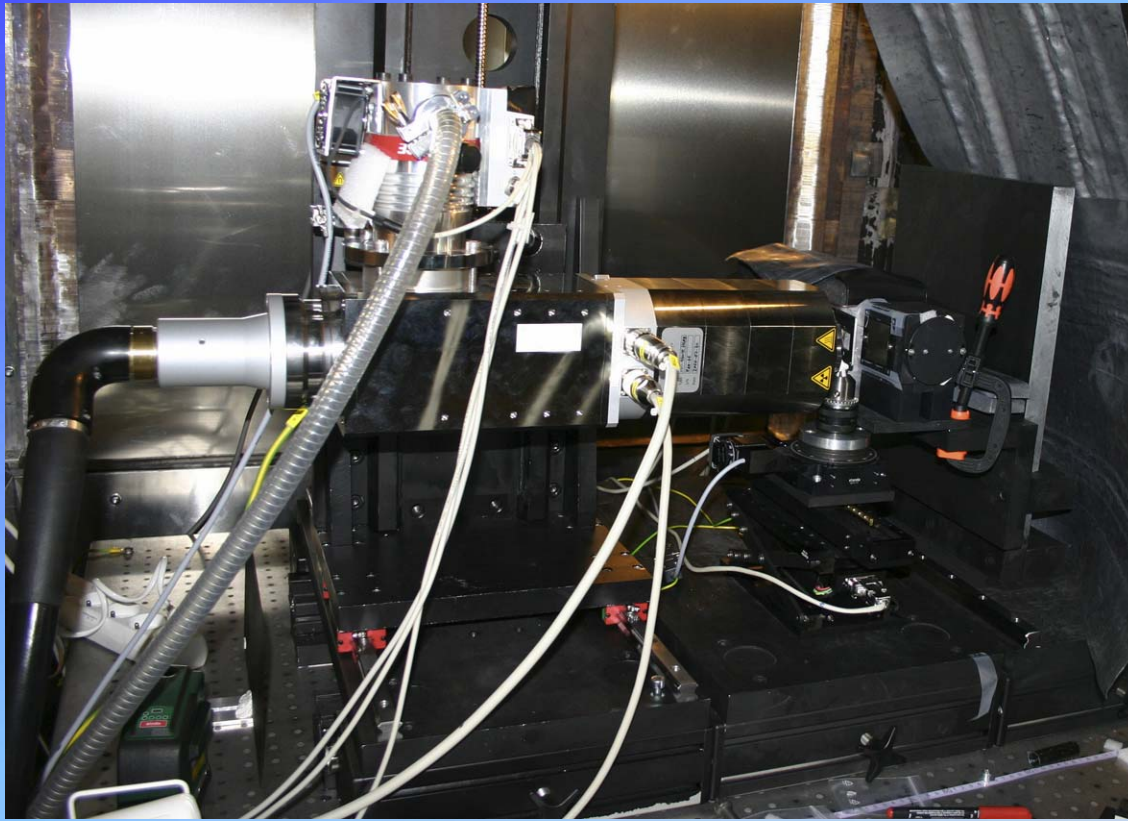
Clean Room Assembly



Surface Quality Inspection

Quality Inspection

Defects Detection



X-Rays Experimental Setup



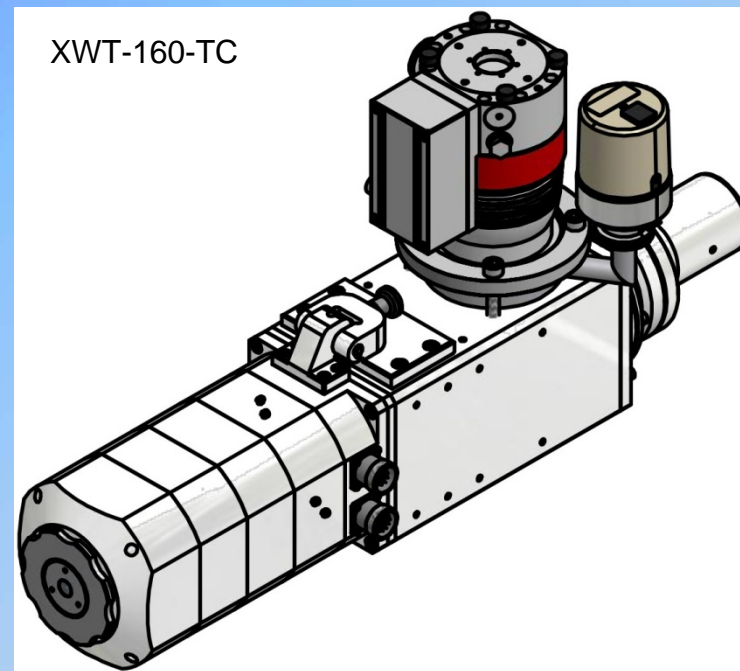
SEM Electron Microscope

- Microfocus X-Rays Source
- CCD High Resolution Cameras

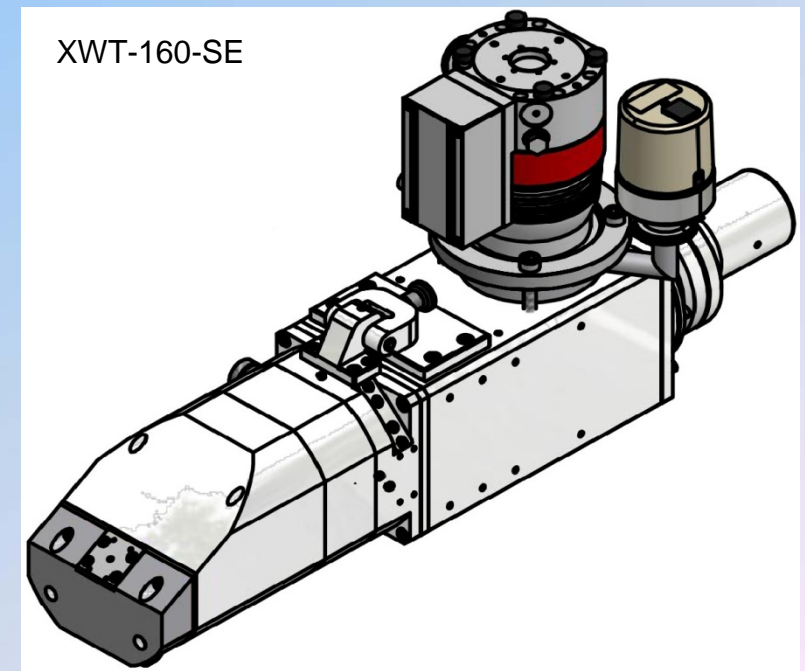
Inspection in X-Rays

X-Rays Source

- Microfocus Tube
 - 10 – 160 kV
 - Open Type
 - Different Anode Materials
- Transmission / Directional Tube
 - Spot Size < 1 μm / 5 μm
 - Target Power 25 W / 280 W
 - FOD ~ 0.25 mm / 4.7 mm



Transmission Tube

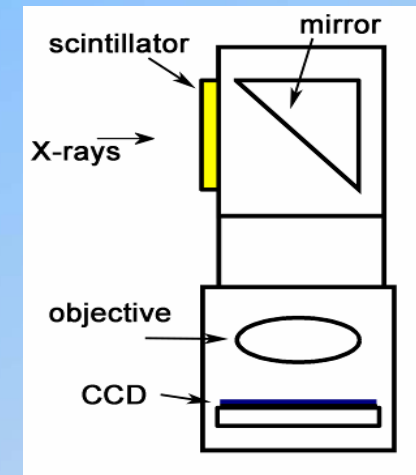
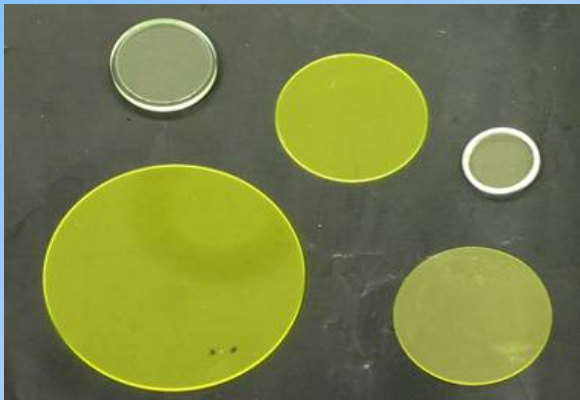


Directional Tube

Inspection in X-Rays

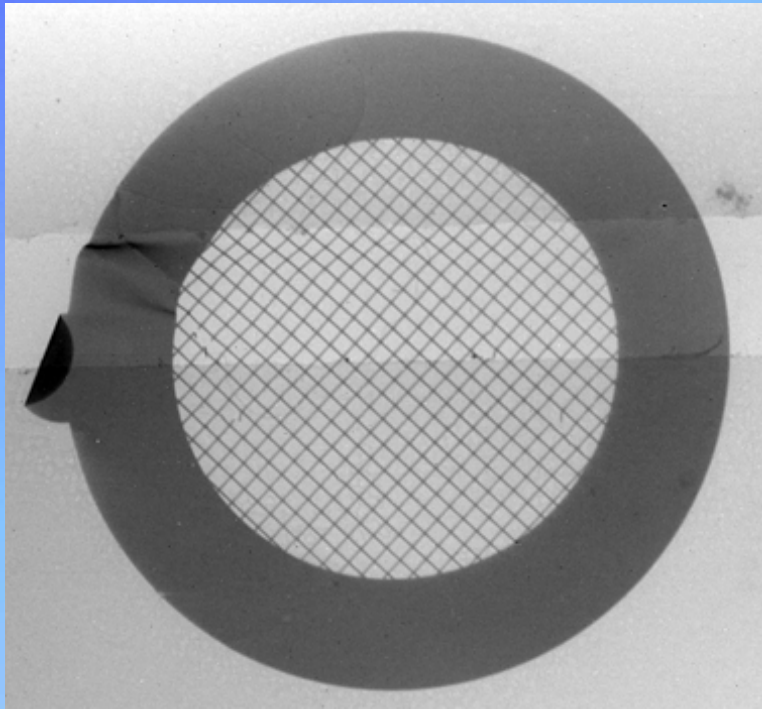
X-Rays Detector

- CCD Peltier Cooled Cameras
- Low Noise Electronics
- High Spatial Resolution
- Different CCD Sizes
- Up to 16 Mpix 36 mm x 36 mm
- Exchangeable Scintillators

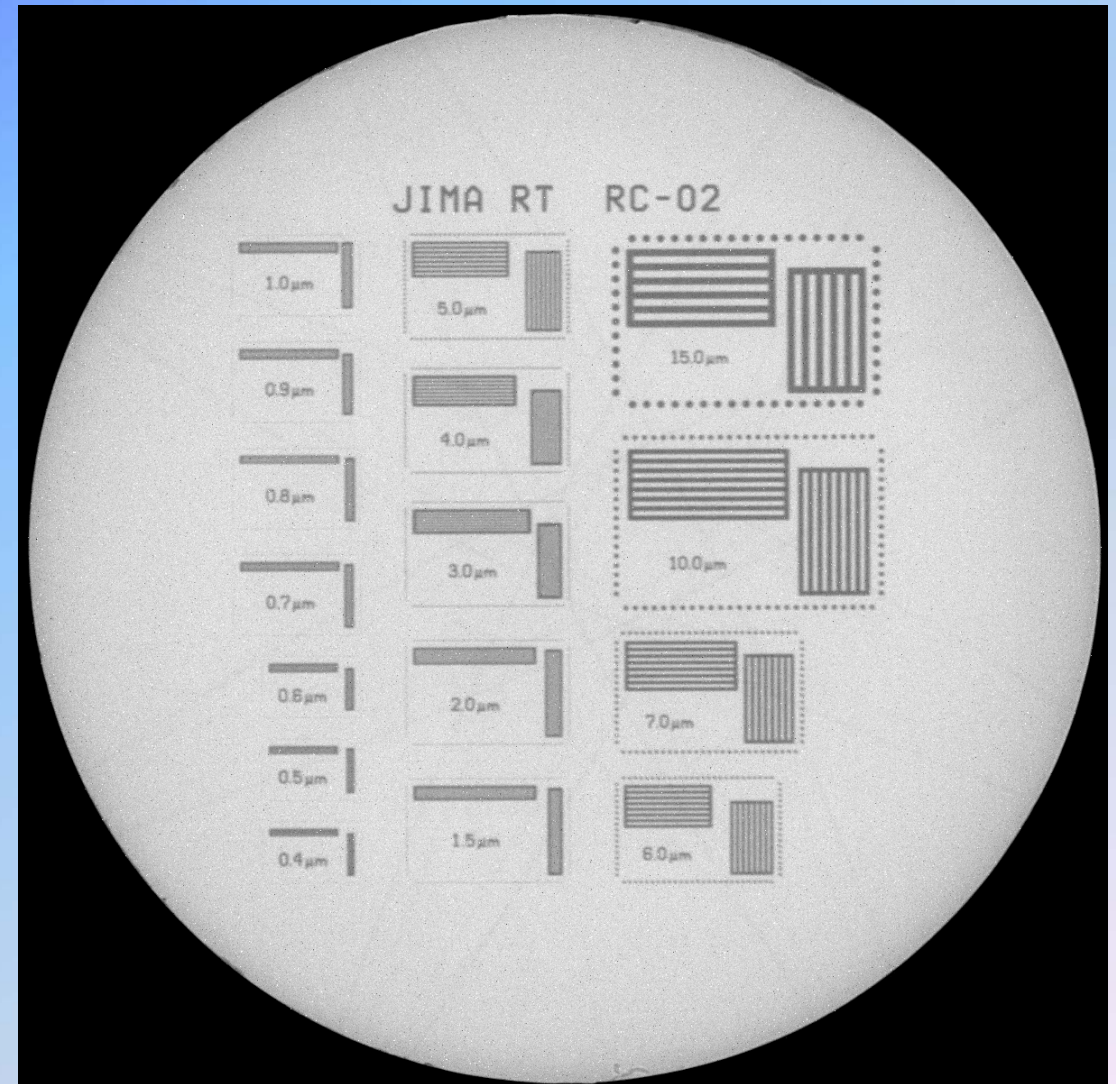


Screens Tests

- Golden Test Grid with 8 μm Wires
- JIMA Test Chart
- Tungsten Balls and Wires
- Carbon Fibers

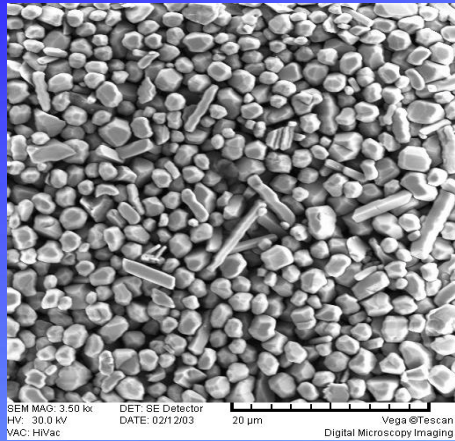


Golden Grid, YAG:Ce 50 μm , Cu
anode, 60keV

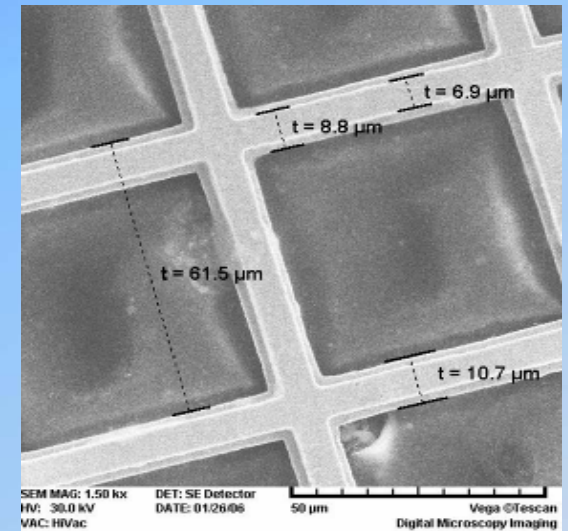


JIMA Test Chart, YAG:Ce 50 μm , Cu
Anode, 60keV

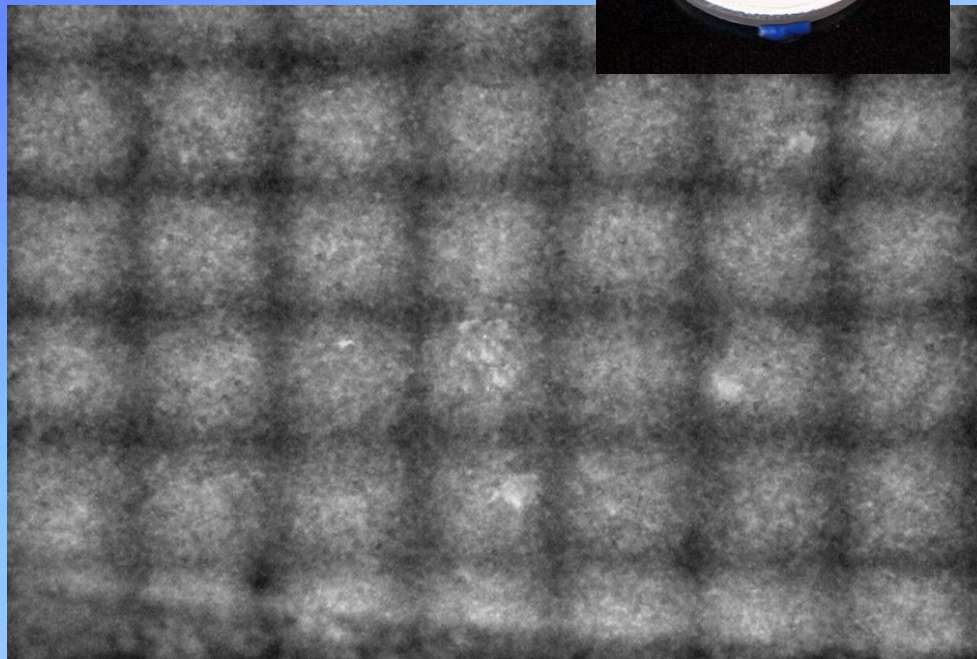
Screens Tests



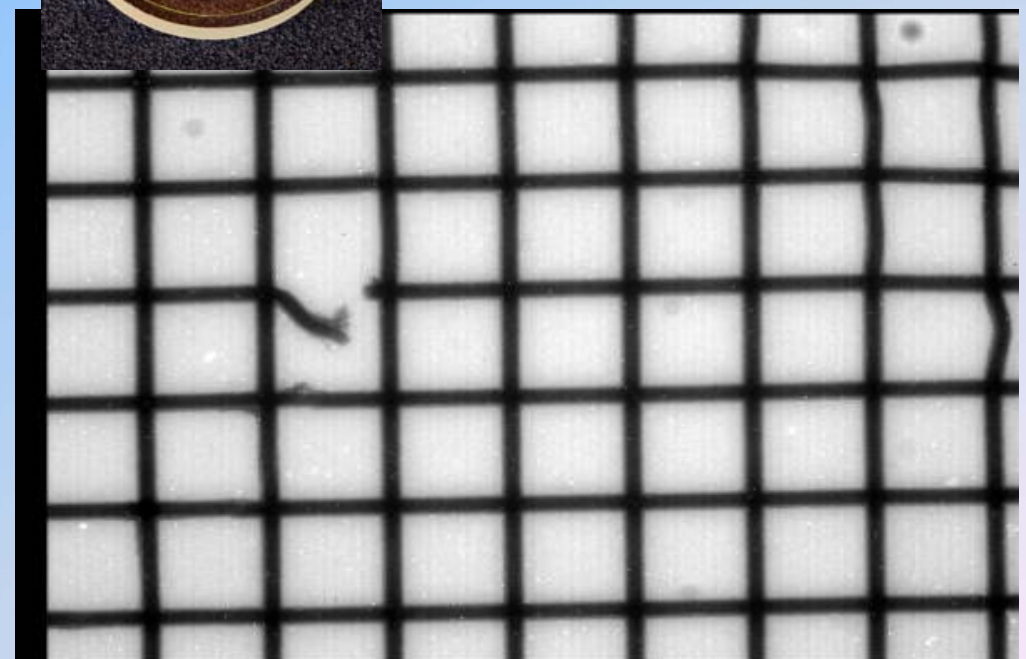
- Two Screens in Resolution Test
- GOS versus LuAG:Ce



The grid in SEM



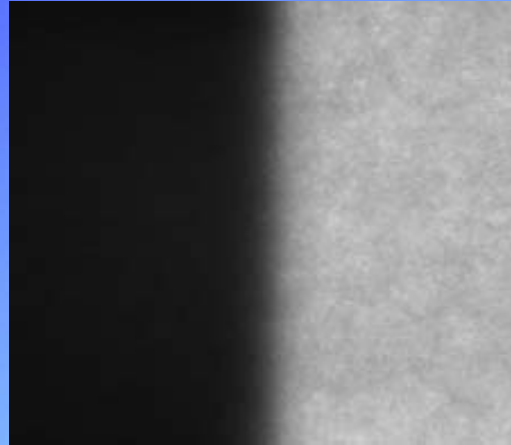
Using P43 (GOS) 20 μ m Thick Screen (2 μ m Grain Size), 40kV, Cu Anode



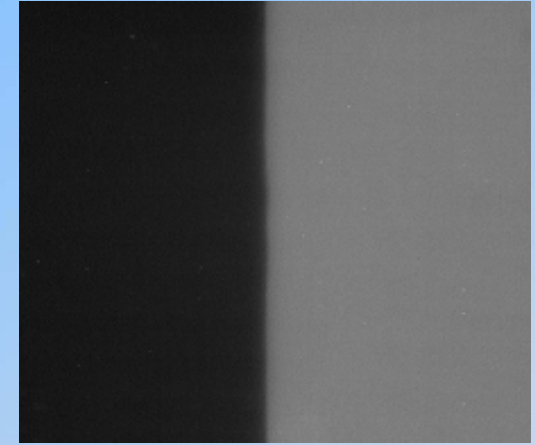
Using LuAG:Ce 20 μ m Thick Screen, 40kV, Cu Anode

Screens Tests

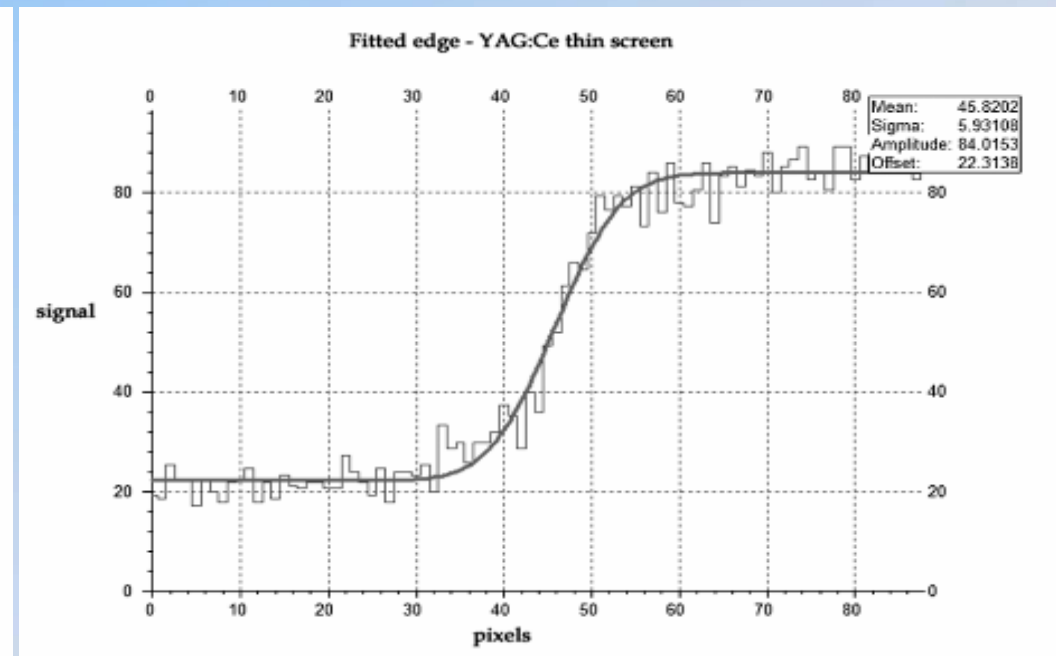
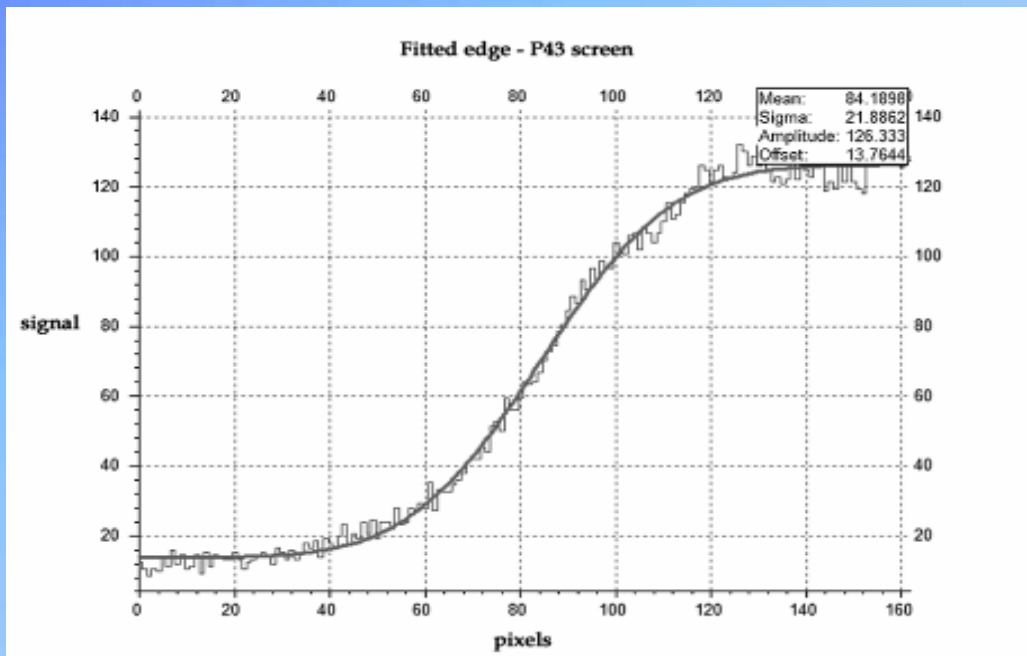
- Edge Test



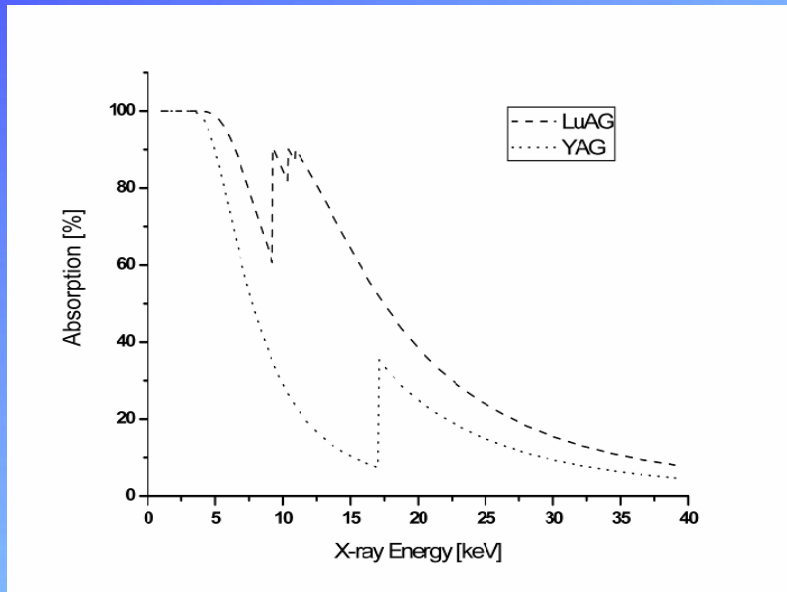
P43 (GOS) screen



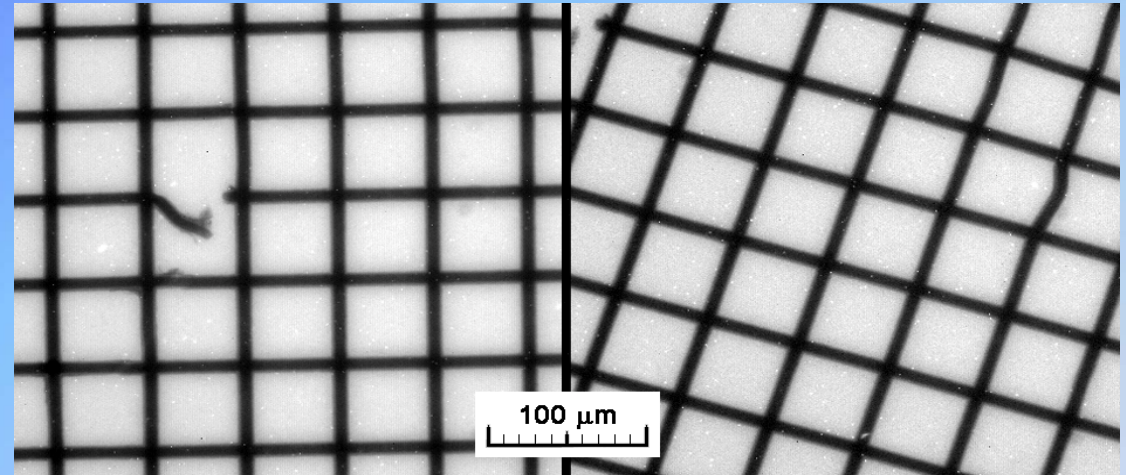
YAG:Ce screen



YAG:Ce or LuAG:Ce?

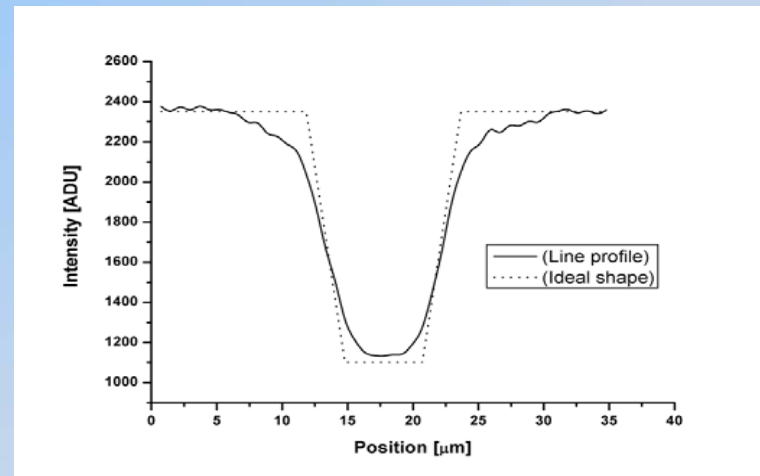


X-Rays Absorption in
YAG:Ce and LuAG:Ce



LuAG:Ce

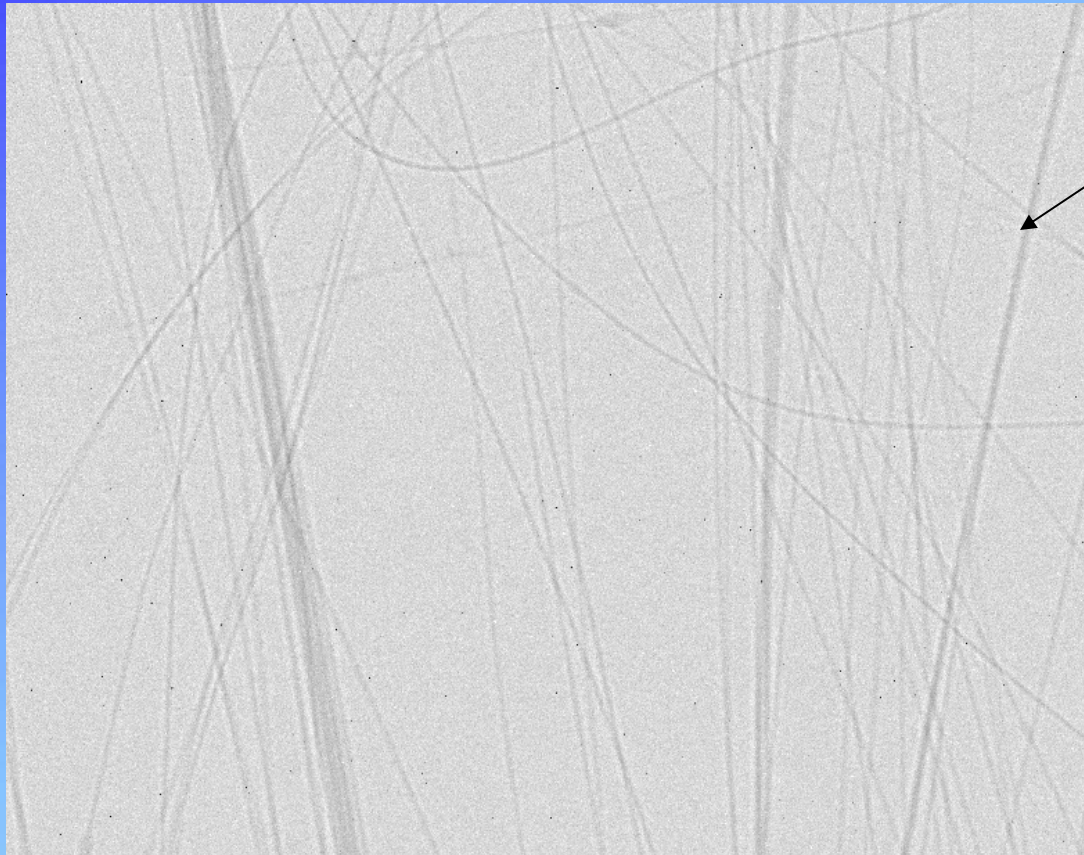
YAG:Ce



Line Profile

Low Energy X-Rays

- Light Weight Materials

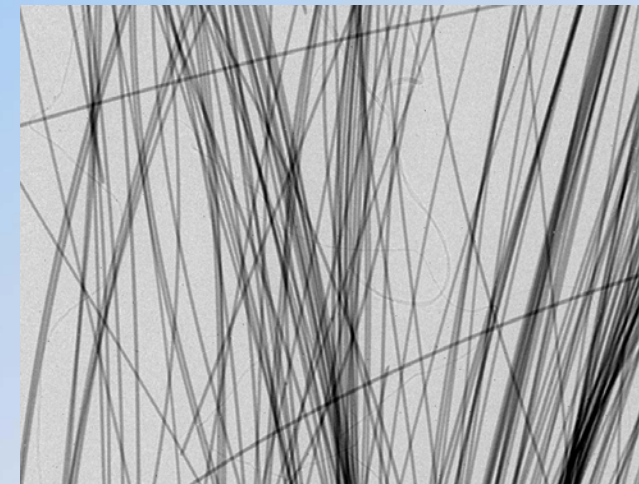


Carbon Fibers in X-Rays, Using 50 μ m Thick YAG:Ce Screen (Cu Anode 60kV/ 2W)



Carbon Fibers, 8 μ m (at Visible Light)

X-Rays Absorption in Carbon Fibers is Only 1% at 8 keV!

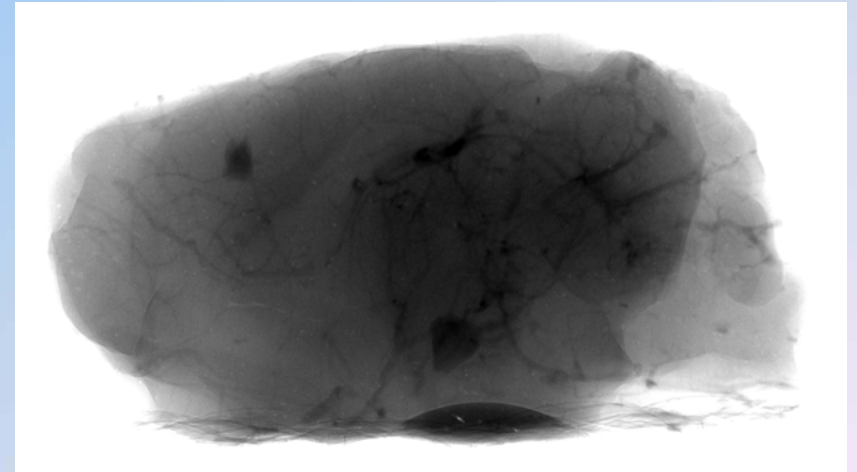


Polymer Fibers (the Same Settings)

Applications

YAG:Ce, LuAG:Ce Screens

- Low Energy Ionizing Radiation Detection and Imaging
- X-Rays, Electrons, XUV, UV, Photon Beams
- X-Rays Micro-Radiography
- NDT
- Science
- ...



Mouse Brain, YAG:Ce, 40kV, Cu Anode

Customers Support

We are ready to

- Help Customer with Detector Solution
- Design New Detectors
- Make the Detectors
- Cooperate in Projects
- Guarantee the Screen Quality



CRYTUR Ltd.

Thank you for your attention!

Visit us at our exhibition table for more information.

www.crytur.com

Results presentation

LUMDETR 2006

ISLNOM4 2006

EXRS 2006

IWORID 2007

IEEE 2007

IEEE 2008

LUMDETR 2009

CERN Physics for Health 2010

IWORID 2010

NDT Hamburg 2010