High Resolution Low Energy X-ray Microradiography Using Single Crystal Scintillators

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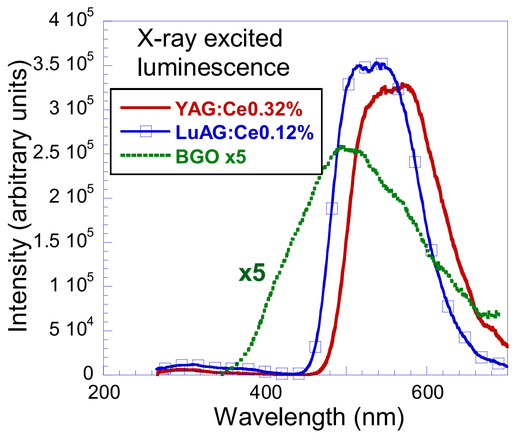
High resolution X-ray camera for micro-radiography based on CCD detector and precise thin YAG:Ce or LuAG:Ce single crystalline screens and its different applications are described and presented. YAG:Ce or LuAG:Ce inorganic crystal scintillators are characterized by good mechanical and chemical stability, non-hygroscopicity, high scintillation efficiency and fast decays [1]. Screens prepared from these crystals can be used in equipments for detection of different kinds of radiation and particles (UV, VUV, electrons or ions or their beams, X- or gamma rays). The resolution achieved is about 1 micrometer at low energy X-rays.

Scintillation Materials for Imaging Screens

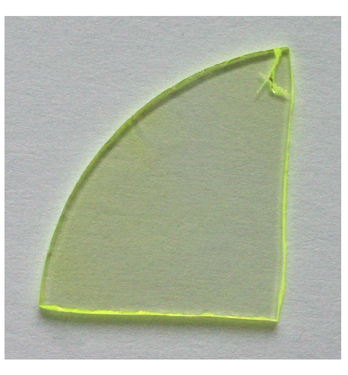


YAG:Ce ($Y_3Al_5O_{12}$) Yttrium aluminum garnet
LuAG:Ce ($Lu_3Al_5O_{12}$) Lutetium aluminum garnet

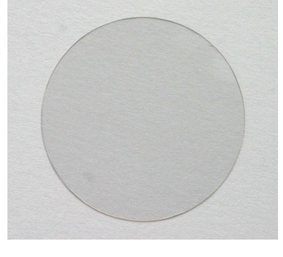
Czochralski or Liquid Phase Epitaxy grown

Screen thickness down to several micrometers

5 m thin YAG:Ce screen



LPE LuAG:Ce sample



LPE LuAG:Eu screen

Thin YAG:Ce screen on FOP

Yttrium aluminum garnet activated by cerium is a fast scintillator with excellent mechanical and chemical resistance. YAG:Ce scintillation detectors are the preferred choice for electron microscopy, beta and X-ray counting, as well as for electron and X-ray imaging screens.

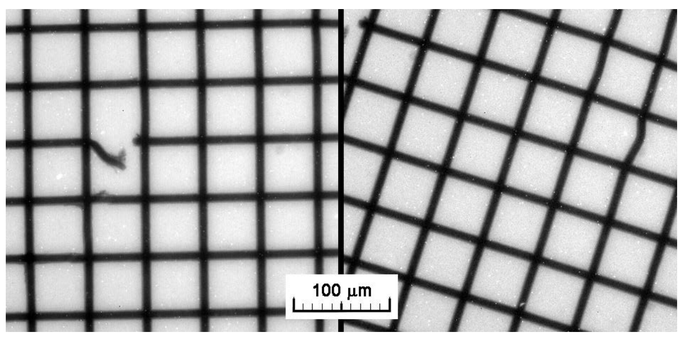
Lutetium aluminum garnet activated by cerium or europium is a scintillator with a high absorption to X-ray radiation and excellent mechanical and chemical resistance. LuAG:Ce scintillation detectors are the preferred choice for X-ray radiography imaging screens.

High Spatial Resolution Imaging Systems

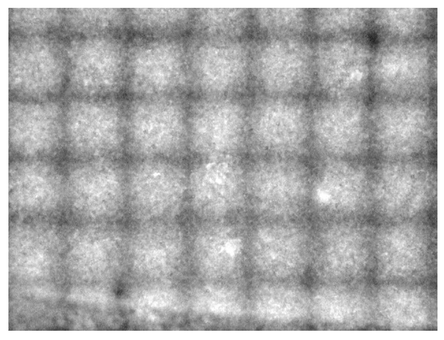
High-resolution X-ray imaging digital camera

The X-ray CCD camera was tested either with several small biological objects (insect or small animals) or with special grids. The 2D-spatial resolution achieved in the images was about 1 micrometer [2].

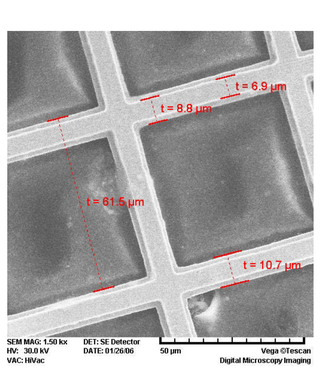
High resolution imaging system is a combination of a high sensitive digital CCD camera and an optical system with a thin scintillator imaging screen.
Very thin (down to 5 microns) screens of YAG:Ce were developed for imaging applications requiring high spatial resolution [2]. The 2D-spatial resolution of an X-ray or other ionizing radiation imaging systems is one of the critical parameters in non-destructive micro-radiography and radiation beam inspection.



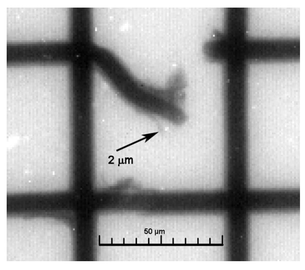
Radiographies of the 8-microns grid imaged by Czochralski LuAG:Ce (left) and YAG:Ce (right)thin plates



The grid imaged by P43 powder scintillator

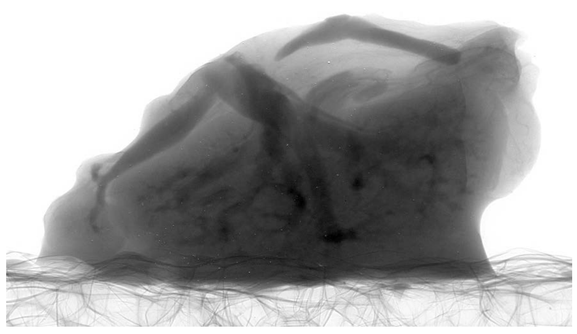


SEM image of the test grid

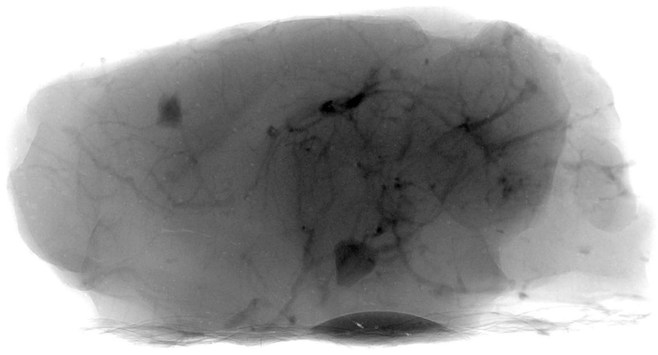


Detail of the broken wire

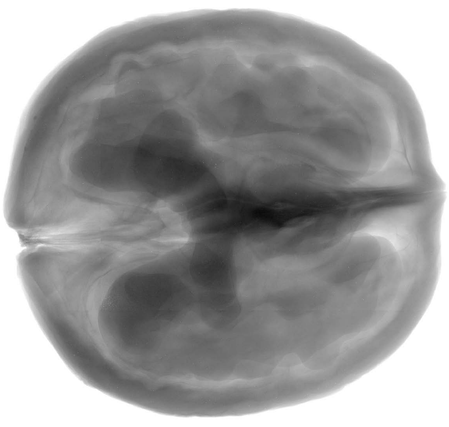
High Resolution Application in X-ray Radiography



X-ray radiography of a mouse kidney



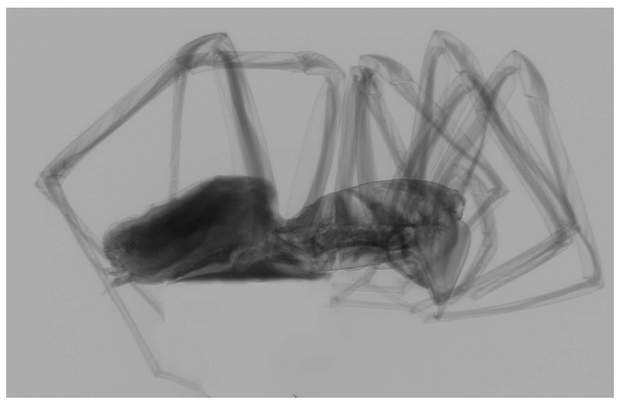
X-ray radiography of a mouse brain



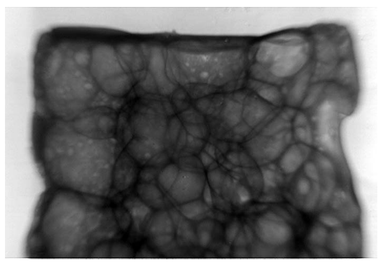
A walnut

The high resolution of the system with YAG:Ce thin screen is compared to a standard P43 phosphor screen using the same conditions. The objects is a gold grid with the wires 8 microns wide. The images were taken by using the 20 micrometers thick YAG:Ce imaging screen or 20 microns thick phosphor P43 (GADOX), both on quartz glass.

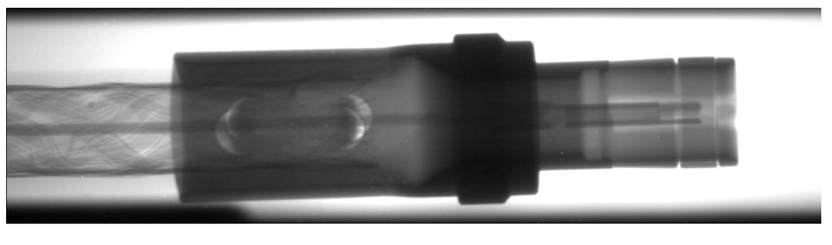
The images were taken using a microfocus X-ray tube with Cu anode@ 40kV/2mA



X-ray radiography of a spider



Aluminum foams



X-ray inspection of fine wires in a data cable

Other applications:
- *X-ray spectroscopy*
- *X-ray topography*
- *X-ray beam adjustment*
- *X-ray thin films diffraction*
- *X-ray optics adjustment*
- *X-ray microfocus spot measurement*
- *X-ray imaging in industry*
- *X-ray food inspection*

... and many others

[1] J.A. Mares, A. Beitlerova, M. Nikl, N. Solovieva, C. D'Ambrosio, K. Blazek, P. Maly, K. Nejezchleb and F. De Notaristefani, Rad. Measur. 38 (2004), 353-356.
[2] J. Tous, K. Blazek, L. Pina and B. Sopko, Rad. Meas. 42 (2007), 925-928.

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