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Flat Panel Imaging of Thermal Neutrons

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Abstract

An initial investigation for the use of an amorphous silicon flat panel as an imaging detector for thermal neutrons is described. A dpiX Model SS2200 imaging panel was used with a Li-6 enriched, LiF-ZnS(Ag) scintillator screen for a thermal neutron imaging investigation using the Breazeale Nuclear Reactor and the neutron radiography facility at Penn State University's Radiation Science and Engineering Center. Good quality thermal neutron images were obtained at exposures in the range of 10^6 to 10^7n/cm^2, values that compare favorably with those normally required for a medium-speed film result. Spatial resolution observed was in the order of 2 line pairs/mm, a value consistent with the resolution limitation of the imaging screen. The neutron images showed excellent quality, as determined with radiographs of the modified Type A gage test piece, often used to evaluate thermal neutron radioscopic images. Fourteen consecutive holes in the "A" gage test piece were observed, an excellent result as compared to typical neutron radioscopic systems.

Summary

Electronic methods for x-ray image detection are exhibiting increased use, in order to take advantage of prompt response, digital processing, storage and retrieval and to minimize environmental problems in handling of film processing chemicals [1, 2]. Similarly, development efforts for electronic methods for detection of thermal neutron images are increasing rapidly. Reported work includes detection with scintillator screen-camera systems [3-5], photoluminescent storage phosphor screens [6, 7], and other semiconductor detectors [8]. Preliminary thermal neutron imaging work with an amorphous-silicon flat panel is reported here.

A dpiX Model SS2200 flat panel [2] was used, with a Li-6 enriched LiF-ZnS(Ag) screen. The 7 x 9 inch screen, as used in early scintillator-CCD camera studies, covered most of the active 8 x 10 inch imaging area of the flat panel. A previous MTF test of the imaging screen with film showed a resolution of about 2.5 lp/mm [9]. Tests of an improved neutron screen have shown an MTF of 6 lp/mm at 10% modulation [3], offering the prospect of achieving resolution limited by the flat panel pixel size of 127 microns [2]. The dpiX imaging software was used in these tests. The LLNL group developed the interface and trigger software, as part of their evaluation of flat panel imaging for x-rays and neutrons [10].

The thermal neutron radiography beam at the Breazeale Reactor at Pennsylvania State University was used for the tests. The neutron beam was directed inside a shielded enclosure, approximately 3.6 x 3.9 x 2 m in size. The characteristics of the reactor beam include a thermal neutron flux of 1.4 x 10^7n/cm^2-s at a reactor power of 500 kW, a gold cadmium ratio of 5 and an L/D of more than 150. Objects examined included a modified, large hole version of the ASTM E545-1975 Type A, double wedge acrylic gage, as has been used in early neutron radioscopy investigations [9, 11]. Also used was a cadmium hole gage. Flat panel thermal neutron images of both of these test objects are shown in Figures 1 and 2; thermal neutron exposure for these images was 10^7n/cm^2.

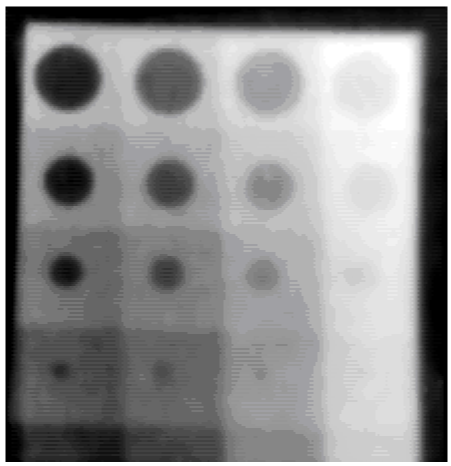

Figure 1. Thermal neutron, flat panel image of the modified, Type A test piece. Hole diameters in inches are 0.160, 0.120, .080 and .040. Step thicknesses for the through-hole wedge match the hole diameters. Steps are viewed through solid wedge steps of 0.031, 0.062, 0.125 and 0.250 inches. In the original neutron image, 14 consecutive holes were visible. This contrast enhanced image shows indications of 15 holes.

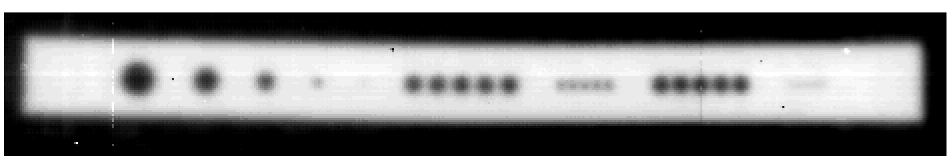

Figure 2. Flat panel neutron image of a 0.5mm thick cadmium test piece. Hole sizes include single hole diameters of 2, 1.5, 1, 0.5 and 0.25mm and groups of holes, as follows: 1mm dia., with 0.5mm spaces, 0.5mm dia., with 0.5mm spaces, 1mm dia., with 0.25mm spaces, and 0.25mm dia., with 0.25mm spaces. Hole separations of 0.25mm are detected, representing a spatial resolution of 2 lp/mm.

These results are encouraging. It is also recognized that the flat panel offers potential for sensitive, real-time imaging [12]. Additional flat panel tests are planned to obtain more data about resolution limits with an improved screen and about sensitivity and dynamic range.

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