Measurement of Phosphor Persistence in X-ray Image Intensifiers

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An X-ray image intensifier is an area X-ray detector with high sensitivity. The front window for X-rays is made of beryllium or aluminum and the back is a layer of phosphor which converts X-rays to visible light. The light is then converted to electrons by a photocathode on the surface of the phosphor. The electrons are accelerated by an electric field and hit a phosphor in the back window which emits visible light again. Thus an X-ray image intensifier converts X-rays to visible light using two phosphors. The X-ray distribution on the input window is converted to an image on the back window which is viewed by a video or CCD camera.

Since an X-ray image intensifier has high sensitivity, it is often used in combination with a fast camera for time-resolved experiments [1]. However, at a time resolution of milliseconds, persistence in the phosphor often makes it difficult to observe fast variation of X-ray intensity. Thus we studied dependence of time-response of an X-ray image intensifier on phosphor.

The X-ray image intensifier used in the present study had a 6-inch beryllium window (V5445P, Hamamatsu Photonics). The phosphor in the front window is CsI:Na^+ in the form of needle-shaped crystals. As a phosphor in the back window, P20 (ZnS:Ag^+) and P43 ($Gd_2O_2S:Tb^{3+}$) were compared. The experiments were made at the small-angle station of RIKEN beamline BL45XU in SPring-8. An X-ray shutter with a solenoid interrupted the beam (about 0.6 mm horizontally, 0.2 mm vertically) completely within 1.5 msec. A fast CCD camera (C4880-82, Hamamatsu Photonics) was used with the X-ray image intensifier. This camera works at a framing rate of 28 frames/sec with a full frame (656 by 494 pixels) readout. The number of frames per second can be increased by reducing the number of scan lines.

Figure 1 is a time-response of X-ray image intensifier with P20. The vertical spikes indicate beginning of each frame in the CCD recording, showing that each frame was about 10 msec. The continuous plot is an X-ray flux measured with an ionization chamber which shows that the shutter was closed at the end of the 5th frame. However, the integrated intensity of the X-ray beam measured with the X-ray image intensifier (thick line with points) has about 15 % intensity after the closing of the shutter. This is due to persistence in the P20 phosphor.

Figure 2 is a recording of a time-response of an X-ray image intensifier with P43. Each frame was 1.9 msec. Even with this high frame rate, only less than 10 % persistence was observed in the frame following the closing of shutter.

These results show that the persistence in P43 is about one order shorter than that in P20. The X-ray image intensifier with P43 will be useful in time-resolved experiments in the range of a few milliseconds.

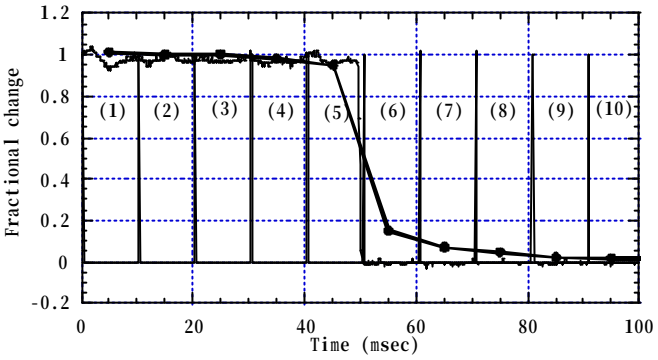

Fig. 1. Time-response of X-ray image intensifier with P20.

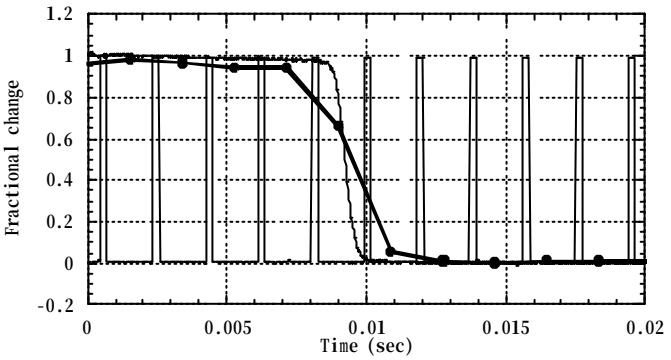

Fig. 2. Time-response of an X-ray image intensifier with P43.

References

[1] Amemiya *et al.*, Rev. Sci. Instrum. **66** (1995) 2290-2294.