

HIGH REPETITIVE X-RAY PINHOLE CAMERA BASED ON CCD AND ITS APPLICATION IN PLASMA X-RAY SOURCE

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Abstract. Based on CCD Camera and Computer technology, a high repetitive x-ray pinhole camera system has been developed and successfully used in our plasma x-ray source for capturing the X-ray pinhole images. This pinhole camera system can be operated in repetition rate of up to 10 Hz. The repetition rate can be preset. The x-ray pinhole images are captured and stored in computer automatically. For synchronization, the pulsed plasma focus x-ray source and pinhole camera system are controlled (triggered) by the same computer, the software is written in C language.

1. Introduction

We have developed a high repetition (16Hz), high power (300W) plasma focus soft x-ray source for microelectronic lithography [1,2]. Because the size of the point-like soft x-ray source is one of the limiting factors to the lithography resolution, we have developed a high repetition rate pinhole camera based on CCD (Charged Coupled Device) for studying the variation of sizes of this point-like soft x-ray source. This pinhole camera system can be operated at a repetition rate of up to 10 Hz. The repetition rate can be preset in the range of 0.01Hz to 10Hz and the number of images to be taken in one burst (or for pulsed soft x-ray source --- plasma focus device how many shots to be fired in one burst) can be preset with the computer. The x-ray pinhole image are captured and stored in the computer automatically. For synchronization, the plasma focus device and pinhole camera systems are controlled (triggered) by the same computer, the software is written in C language. The soft x-ray pinhole images can be analyzed in the computer either singly or by overlaying several images together. This pinhole camera system has been successfully used in our plasma focus x-ray source.

2. Experimental setup

This pinhole camera system has been developed based on CCD and computer. It consists of easily obtained components which includes: a CCD (the glass cover was removed), a video card for computer, and a personal computer as well a program written in C language. The block diagram of pinhole camera system and plasma soft x-ray source is shown in Figure 1.

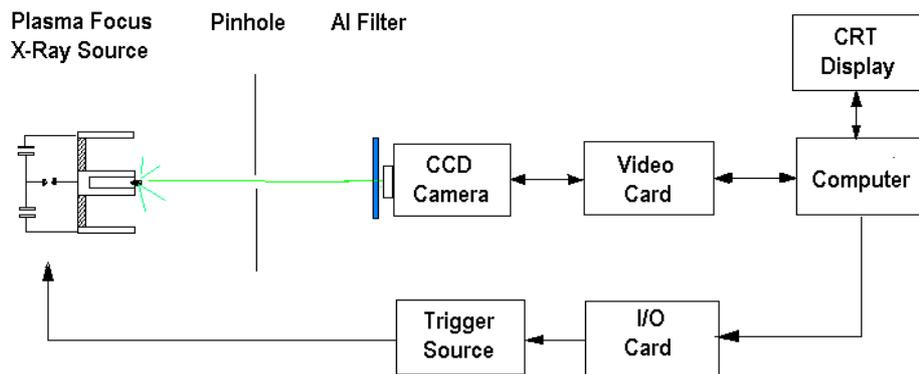


Fig 1. Block Diagram of Pinhole camera system based on CCD and Plasma x-ray source

The CCD camera used in this experiment was a Pulnix TM 6EX which has a high-resolution (756×574 pixels, pixel size $8.3 \mu\text{m} \times 8.39 \mu\text{m}$) silicon based 1/3 inch format CCD chip. The glass cover of the CCD was replaced with $25 \mu\text{m}$ Al filter. The transmission of the Al filter is given in Figure 2. The spectra of x-ray emitted from our Plasma x-ray source are given in Figure 3. Image processing routines were then carried out on the stored

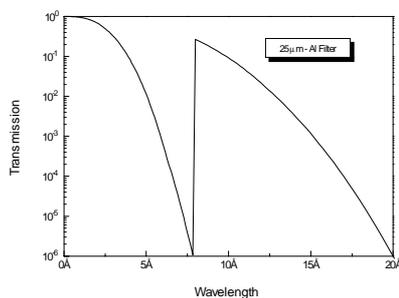


Fig. 2 Transmission of Al Filter

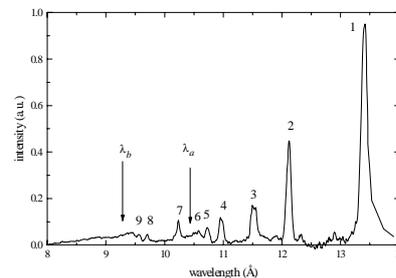


Fig. 3 X-ray emission spectrum of neon plasma

images to extract a variety of information such as pixel value for intensity information. The image captured by CCD is transferred to computer through the video capture card and

displayed on the monitor. The image data can be stored both in the memory of the image memory board and on the floppy disk or hard disk. The data are processed by a personal computer. This system permits flexible processing of the data and its presentation in various formats, such as overlay of many images, contour of image as well as a 3D display.

The pulsed plasmas focus x-ray source was triggered by the computer through a I/O card and trigger source.

3. Results and discussion

Some of pinhole images are presented in Figures 4 to 7. The images of single shot are shown in Figs. 4 and 5. In the Figure 4, one hot spot was found. Multi hot spot was found in Figure 5. Overlay of 20 images and 50 images are shown in Figs. 6 and 7, respectively.

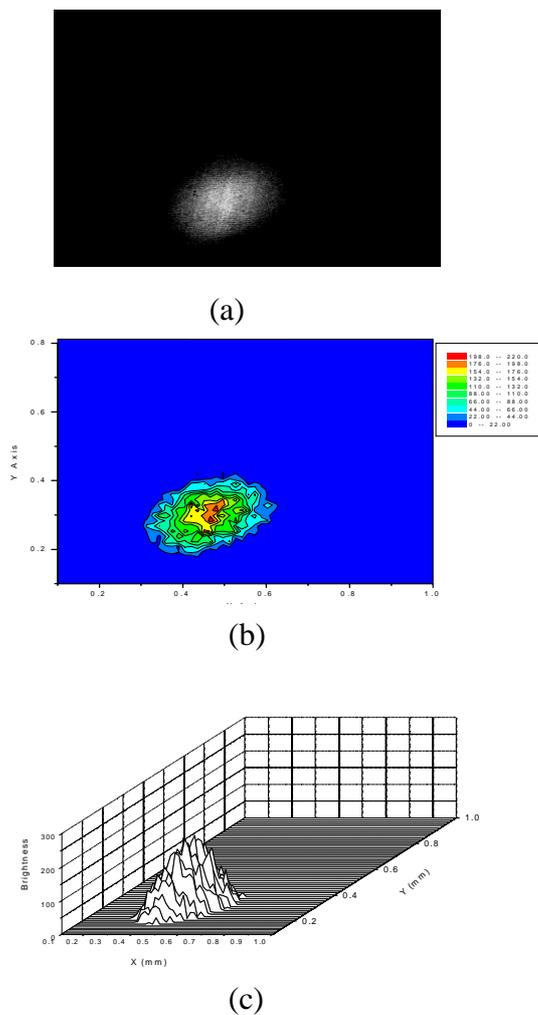


Fig.4 The pinhole image (single shot)
 (a) Image (b) Contour (c) 3D View

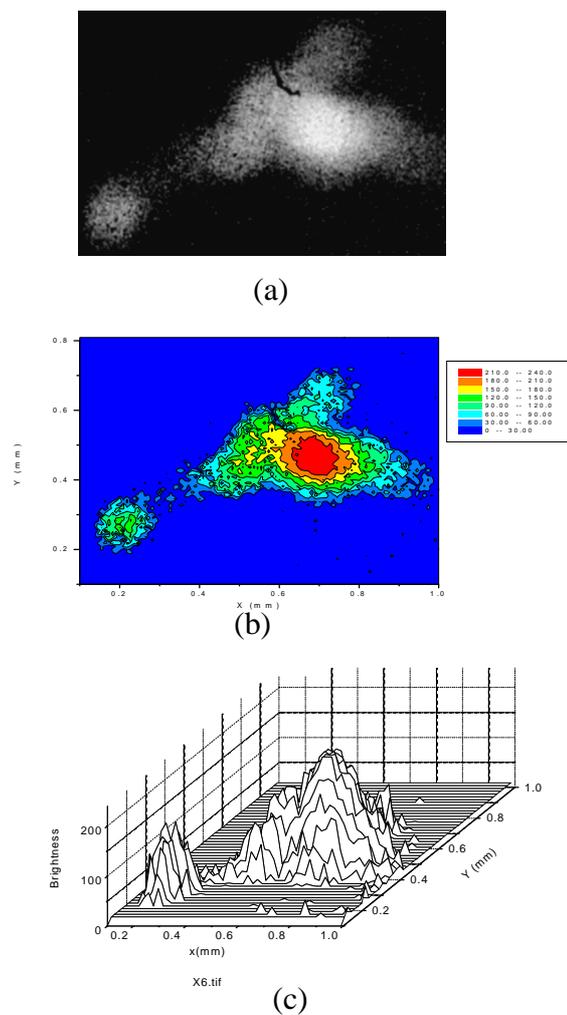
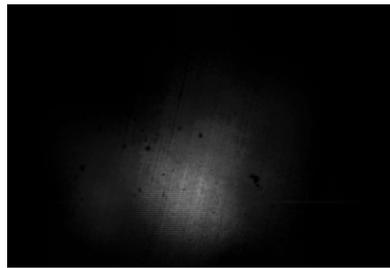
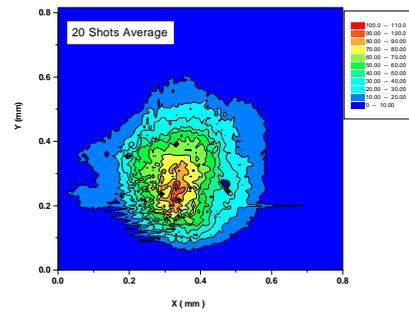


Fig.5 The pinhole Image (single shot)
 (a) Image (b) Contour (c) 3D View

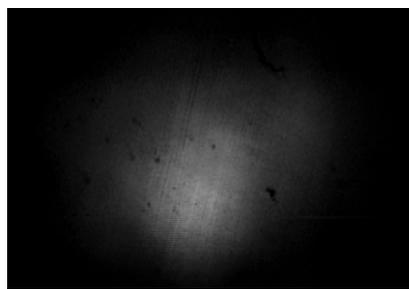


(a)

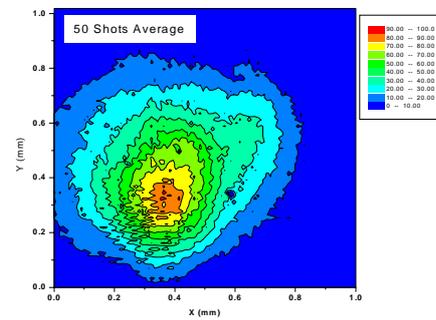


(b)

Fig. 6. X-ray Image (20 shots overlay) (a) Image (b) Contour



(a)



(b)

Fig. 7 X-ray Image (50 shots Overaly) (a) Image; (b) Contour

Compared to the traditional method, such as using the x-ray film to record the image, this pinhole camera based CCD is fast and more convenient, whether in recording the image or data processing.

References

- [1] S. Lee, P. Lee, G.X. Zhang, X. Feng, A. Serban, M.H. Liu, C. Selvan, T.K.S. Wong: SPIE on Microlithographic Techniques in IC Fabrication, Vol. 3183, 112 (1997)
- [2] S. Lee, P. Lee, G.X. Zhang, X. Feng, M.H. Liu, A. Serban, S.V. Springham, T.K.S. Wong, K. Wira and C. Selvan: SPIE on Microlithographic Techniques in IC Fabrication, Vol. 3183, 123 (1997)