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Introduction

We are studying a method of measuring neutron dose by counting the number of etch pits (or tracks) produced on CR-39 by neutron. Usually the numbers of the etch pits produced on CR-39 by neutron are counted visually with a microscope, but by this method it is difficult to scan a wide range, therefore it can not be expected to get a high sensitivity and accuracy. However by automatic counting technique, as reported here, using a TV camera, a computer and so on, it is expected to measure neutron dose with higher sensitivity and accuracy than visual counting technique.

Counting System

Fig. 1 shows the counting apparatus, in which the HP-85B is a personal computer and is used for the control of the LUZEX 450, the Stepping Motor Controller (SMC) and the PC9801m. A piece of CR-39 which was treated by chemical etching is mounted on the stage of the microscope and the image of the etch pits magnified with the microscope is transported to the LUZEX 450 via a video monitor which is set on the top of the microscope. The LUZEX 450 is a kind of image analyser and etched pits are counted for each diameter which is set in advance. The data counted are stored in the memory of the HP-85B for a time. On the other hand, the focusing of the microscope on etch pits is adjusted by the SMC connected to the HP-85B. The technique of automatic focusing is described in next section.

The area of the vision where the number of etch pits is counted at one time is about 0.1 mm^2. A field of the vision is changed by the SMC too. For obtaining high sensitivity and accuracy, we change the vision about 100 times and the counts on each vision are summed and stored in the HP-85B.

All of the stored data in the HP-85B are transported to the PC9801m computer and analysed there.

Method of Automated Focusing

We had two kinds of problems in automatic counting of the track (etch pit) density. One was automatic focusing, and another was the search and exclusion of abnormal data.

(1) Automatic focusing

We considered that the focusing on the etch pits of the CR-39 was attained if we could get a maximum track density at a distance (Z axis) between the CR-39 on the stage and the object lens. The change of measured track density with variation of Z axis is shown in Fig. 2. We can find in the figure a flat main peak with width of about 4 μm.

In this system we changed stepwise the distance between the CR-39 and the objective about 2.7 μm each in order to search a main peak. On the other hand, as there were a few subpeaks on the curve in Fig. 2, we had to avoid them and search the main peak. For this aim, we made mock etch pits on a part of CR-39 samples in advance, and first focused on them and then, before starting automatic focusing, we moved the vision to the part where real etch pits were found.

(2) The search and exclusion of abnormal data

In this system we decided to count etch pits over an area of about 10 mm^2. This means the vision of the field must be changed 100 times. In the treatment of the data, (i.e., the numbers of etch pits at each measurement), mean value (m) and the standard deviation (σ) among 100 measurements were calculated and the extreme values over $m+3\sigma$ were excluded from the data. This exclusion procedure was made twice, and then a mean value of the etch pits was obtained finally as the representative.

Results

The CR-39 samples irradiated with an Am-Be neutron source (5Ci) were etched chemically by 30% KOH solution at 65°C for 4 hours and then we counted the numbers of etch pits with this system. The result are shown in Fig. 3. We can find an almost linear relation between the track density and neutron dose. From the slope of this straight line and the standard deviation of the non-irradiated samples (background), we estimated the minimum limit of detection as about 130 mrem.

Some of the results obtained by focusing by eyes were also shown in Fig. 3. They were the data on the non-irradiated (background) samples and those irradiated as much as 1500 mrem. The values obtained by focusing by eyes for background samples agreed with those by automatic focusing. As for irradiated samples, however, the results of focusing by eyes were a little lower than those of the automatic, but two values agreed each other within 10%. We think the results might be brought by the fact that the measurements by focusing by eyes could detect and remove abnormal etch pits better than the automatic one.

Next, in order to investigate reproducibility, we measured the same samples (background and 1500 mrem-irradiated) ten times with this system. The results showed that the relative standard deviation was within about 5%. But we thought that this deviation might be mainly caused by the non-uniformity of the CR-39 samples.

It took about 23 minutes for this system to measure 100 vision fields (about 10 mm^2). This corresponds to about one half of the time needed if focusing is made by eyes.

Conclusion

1. In the automatic counting system, automatic focusing on the etch pits was attained by searching the maximum value of the number of etch pits counted.
2. The values measured with the automatic system agreed within 10% with those obtained by focusing by eyes.
3. The reproducibility was within about 5% as expressed in the relative standard deviation.
4. In the system the minimum limit of detection of neutron dose from the Am-Be source was about 130 mrem.
5. In the system, we could measure the number of etch pits in a given area in one half of the time expended if focusing was made by eyes.

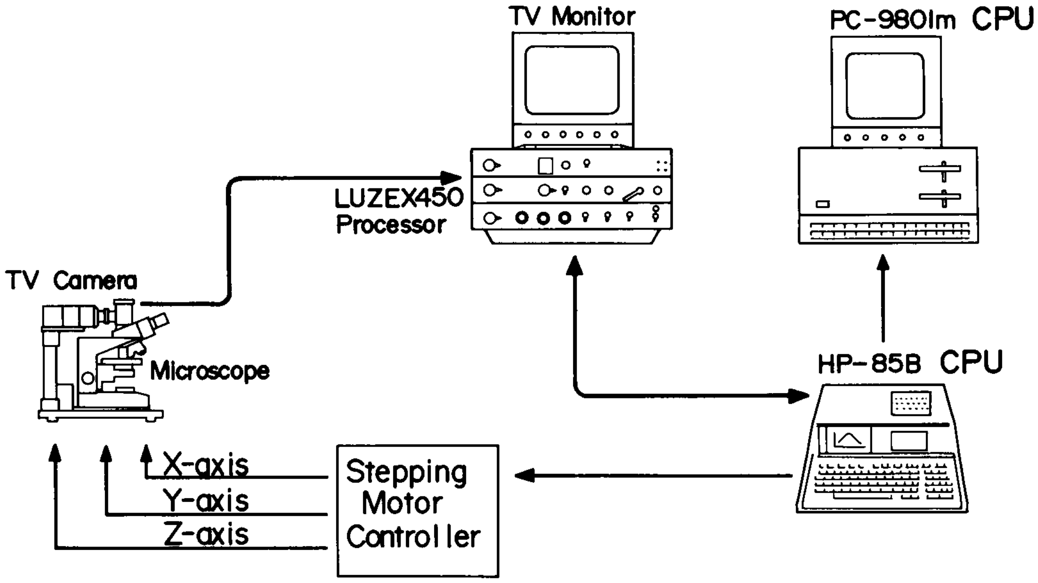

Fig. 1. Measuring equipment.

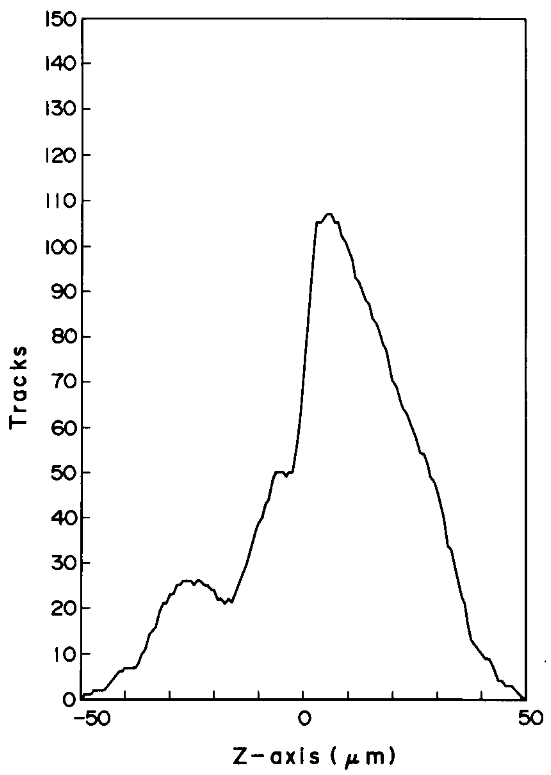

Fig. 2. Z-axis vs. tracks.

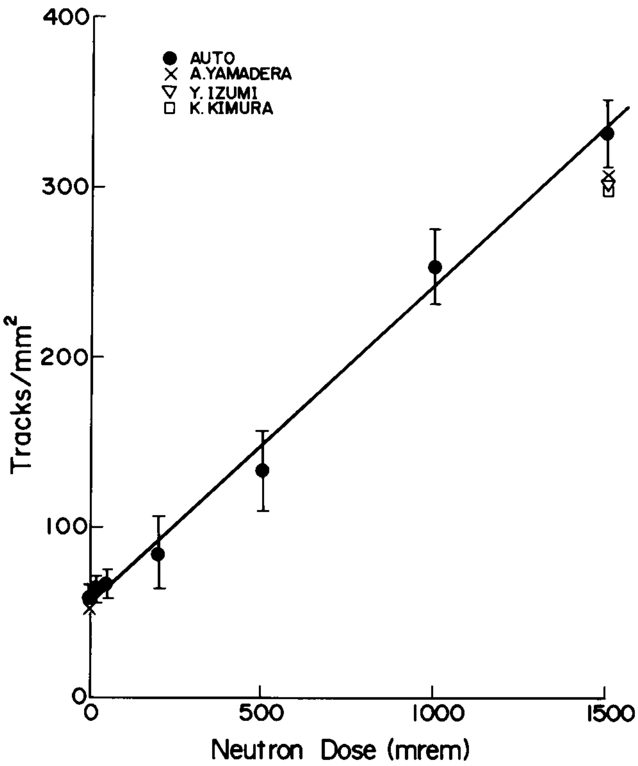

Fig. 3. Tracks vs. neutron dose.