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REAL-TIME AUTOMATIC EVALUATION OF SOLID STATE NUCLEAR TRACK DETECTORS WITH AN ON-LINE TV-DEVICE*

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An on-line TV-system for real time analysis of two-dimensional images is described which is being used for automatic evaluation of track detectors, histological cell analysis, and a number of other purposes. Results are reported for applications commonly encountered in dielectric track detector evaluation problems; namely determination of the integral track density, of the spatial distribution of tracks, and of statistical distributions of geometrical features of tracks. Special emphasis is given to the region of low track densities.

1. Introduction

In basic and in applied research with solid state nuclear track detectors (SSNTDs), one frequently encounters the necessity to evaluate many detectors rapidly and accurately with respect to certain properties. In neutron- or radon-dosimetry, e.g. the integral density of tracks has to be determined. In auto-radiography, e.g., often the spatial distribution of radioactive elements is needed, and thus, the differential density or the coordinates of etched particle tracks must be derived from microscope image. For particle identification or for calibration purposes finally, information on the geometrical shape of single tracks and on the statistical distribution of relevant geometrical features is necessary. In all these cases, one should like to have available an automatic system with which such measurements can be performed with sufficient speed and accuracy.

For determination of the integral number of tracks, especially on large areas of thin detectors, and for densities below, say, 10 tracks/mm^2, spark counters can be used[1]. However, it is known that the results obtained with this instrument are sensitive to the reproducibility of the detector material and of environmental and etching conditions. The influence of these parameters is considerably reduced by using microscopic evaluation, because optical recognition and counting of tracks is less dependent on track geometry than is electrical sparking. The problem of long evaluation times when using optical systems can be reduced by using fast hardware and software, and detector foils with high contrast. Such a fast optical system for automatic evaluation of track detectors with respect to various features is described below and its performance demonstrated in selected, typical measurement situations.

2. Method

The automatic image analysis system consists of a Plumbicon (to be substituted by a Chalnicon) TV-camera which is mounted on a Leitz Ortholux microscope. The microscope is equipped with a x–y-stage driven by step motors with 10 μm steps at a maximum rate of 200 Hz. The grey-level signal of the TV-camera is converted into a binary signal by a thresholding logic. Camera, thresholding logic, and step motors are Camac interfaced and controlled by a Siemens 330 computer (fig. 1). The computer has a 128 kbyte memory and a cycle time of 1 μs.

With this system a binary TV-image of 256×256 points is fed on-line into the computer memory within 1/25 s, stored in 8 kbyte of the memory, and then evaluated by software. The binary image is "cleaned" from background noises,

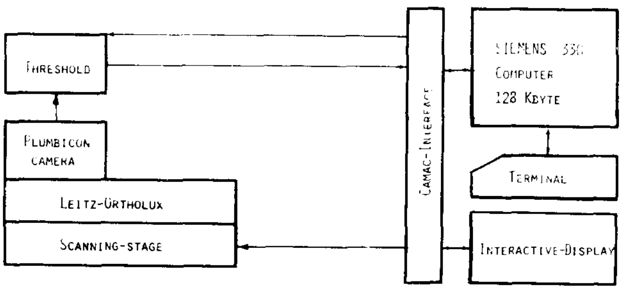

Fig. 1. Block diagram of the automatic evaluation system.

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scratches, etc., and track features of interest are determined by non-linear parallel array processing and by sequential point processing operations. Non-linear array processing operations are preferentially used for global image processing. Sequential point processing operations are employed to process discrete areas in the image, i.e. to separate single objects in the image, and to determine track features. For this purpose, the Siemens 330 computer is especially qualified because it allows addressing and access to a single bit within only 1.5 μs.

For determination of track features like area, circumference, diameter, coordinates of mid-point, and different kinds of other shape parameters, an Assembler programme was developed which works like recursive procedures known from Algol programming. Each bit of an object is checked for its four neighbours and then erased to find the connectivity in the binary image and to select relevant single objects.

In the case of automatic low density track counting, fast image evaluation and fast frame transportation is necessary since most images do not show tracks. Applying, for instance, such a microscopic magnification that the quadratic image frame has a width of about 0.4 mm, mechanical moving to the attaching new frame takes about 1 s (including some waiting time for damping of vibratory movements of the scanning stage). Also software evaluation of a picture needs basically somewhat less than 1 sec for an empty image.

Since both operations are performed parallelly, an empty detector area of 1 cm^2 is evaluated in about 10 min. This time increases only negligibly

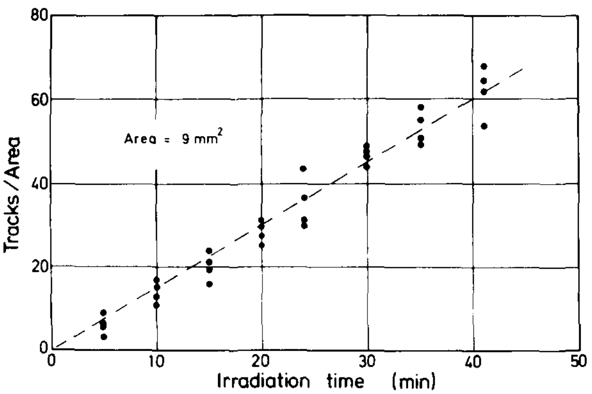

Fig. 2. Integral track density determination of LR-115 foils irradiated for various times by alpha particles from radon daughter products.

by the presence of tracks, e.g. by only 1.5 sec per 100 tracks. Regarding the high precision of this optical method, this evaluation time is acceptable for many routine measurements. However, an improvement in speed by a factor of 4 is still possible.

In the high density range, the limiting factor is no longer the frame transportation speed but the software processing time because only a few images have to be evaluated for obtaining sufficient counting statistics. In this case, the evaluation time is approximately proportional to the track density. Additional statistical corrections have to be applied to account for loss due to track overlapping[2]). This results in total evaluation times of typically less than 3 min for 20 000 tracks.

3. Results

The performance of this automatic evaluation system will be demonstrated for some typical measurement problems, namely for the determination of integral and of differential track densities and of the statistical distribution of track diameters in plastic track detectors.

In neutron- and in radon surveillance dosimetry often track densities of 1–1000 tracks have to be determined on 1–10 cm^2 detector area. Since alpha particle tracks show less optical contrast than fragments from neutron induced fissions, the evaluation system was tested with low density tracks of alpha particles with a wide energy spectrum and incident from a solid angle of almost 2π. Cellulose nitrate foils (Kodak LR-115 type II) were irradiated by alpha particles emitted from radon daughter products deposited on a fibre filter. After 4 h of air in-take through the filter (at a rate of about 80 m^3/h) equilibrium was assumed, and the detectors were placed for various times at 2 cm distance above the filter.

Then the foils were etched for 150 min in 2.5 N NaOH at 60°C. This resulted in diameters of about 8 μm of those tracks which were etched through the thin red-dyed cellulose nitrate layer. The density of background tracks was only about 10 cm^{-2} since the detectors were annealed carefully before irradiation. For each foil three sets of 100 adjacent rectangular image frames of 0.3 mm width each were evaluated. The total time needed for stage movement and software analysis per 100 frames, i.e. per 0.09 cm^2 area was about 1 min. The results given in fig. 2 show only unavoidable

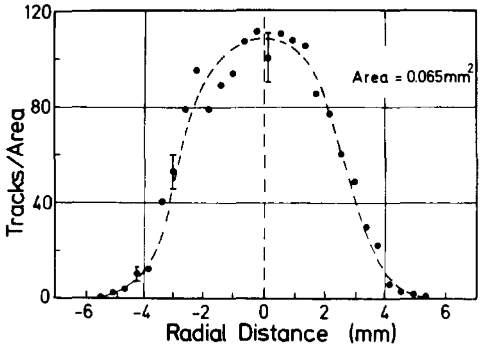

Fig. 3. Differential track density along a diameter of a thin circular ^{241}Am source. Evaluation time was about 2 min, width of image frame was 0.25 mm.

Poissonian fluctuations and thus indicate that such an optical system may well be used to evaluate neutron- or radon-dosimeter foils even with low track densities in acceptable short times and with good accuracy.

In autoradiographical applications of solid state nuclear track detectors often the microscopic track density as a function of position or the coordinates of tracks have to be determined. As an example for the solution of such evaluation problems with the automatic system described above, the differential track density across a thin ^{241}Am source was determined with LR-115 detectors using 20 μm Makrofol energy degrading foils (fig. 3). The width of the rectangular image frame was chosen to be 0.25 mm, and the total number of tracks per image was counted. The stage was positioned with an accuracy of better than about 1 μm.

If even higher spatial resolution should be necessary, the cartesian coordinates of the midpoints of particle tracks are determined relative to the boundaries of the image frames.

Finally, an example is shown in fig. 4 for the determination of geometric features of particle tracks. Such measurements are necessary e.g. for particle identification or for detector calibration. In this figure, the statistical frequency of track diameters is plotted for two groups of energy degraded ^{241}Am alpha particles which were vertically incident on LR-115 detector foils.

4. Conclusion

An on-line TV-system was described which can solve many problems encountered in basic and applied research with sufficient speed and accuracy.

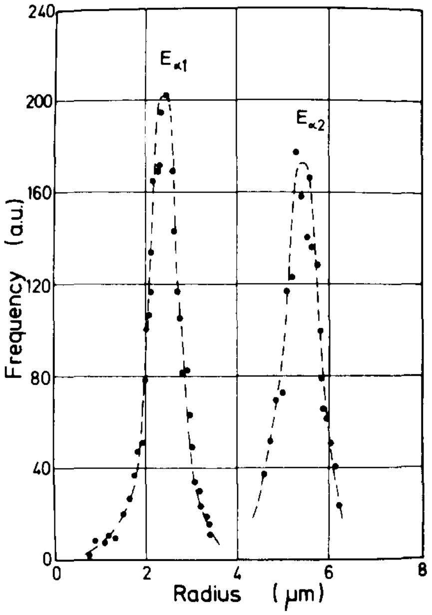

Fig. 4. Statistical frequencies of track diameters of two groups of alpha particles (3.3 and 4.2 MeV).

Even in the low density range, i.e. below 1000 tracks/cm^2, such an optical system can achieve statistically significant results in a reasonably short time. Thus it is worth consideration as an alternative to spark counter also for routine measurements.

Finally, commercially available hardware systems for automatic detector evaluation shall be compared to this software based system. With regard to integral track counting there is no essential difference since processing speed is limited by the scanning stage motor speed in both cases. For determinations of microscopic track densities and for evaluations of complicated track features, etc., software systems are superior because of their large versatility. They can easily be adapted to many other pattern recognition problems, as e.g. to problems of biomedical image processing.

References

[1]) W. G. Cross and L. Tommasino, Proc. 1st Symp. on *Neutron dosimetry in biology and medicine*, Neuherberg (1972) EUR 4896 d-f-e, p. 283.

[2]) W. Abmayr, G. Burger, P. Gais, H. G. Paretzke and H. Platzer, Proc. 8th Int. Conf. on *Nuclear photography and solid state track detectors*, Bucharest (1972) p. 425.