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A one-shot imaging system for neutron track counting

Paolo Ferrari*, Francesca Mariotti, Lorenzo Campani

ENEA – IRP Radiation Protection Institute, 4 Via Martiri di Monte Sole, 40129, Bologna (BO), Italy

HIGHLIGHTS

- The system, based on a CCD camera, acquires a one-shot image of an etched dosemeter.
- A Labview program determines the corresponding dose, distinguishing false positives.
- The system is fast and it shows a good reproducibility and stability.

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ABSTRACT

The Individual Monitoring Service of ENEA Radiation Protection Institute supplies thousands of dosemeters for fast neutron dosimetry per year to a series of national laboratories and hospitals. A PADC (poly allyl diglycol carbonate) sheet is used to detect neutron tracks through a chemical etching process. A track reader has been developed with the main idea of employing a CCD camera to get one-shot image acquisition of the etched dosemeter for the track counting. The digital image, that can be visually inspected on the video by the operator during the acquisition, is analyzed through a Labview program, that controls all the phases of the procedure and produces a report containing the evaluated doses and the results of the basic image quality analysis performed. The developed system showed a good reproducibility and stability and its accuracy was judged adequate for our radiation monitoring needs.

1. Introduction

The Individual Monitoring Service of ENEA Radiation Protection Institute supplies thousands of dosemeters for fast neutron dosimetry per year to a series of national laboratories and hospitals (Morelli et al., 1999). A PADC (poly allyl diglycol carbonate) sheet, known for its dosimetric properties(Cartwright et al., 1978), is used to detect neutron tracks, produced by recoil protons of the material hit by primary neutron radiation. The current ENEA fast neutron dosemeter consists of a 2.5 cm × 3.5 cm × 0.14 cm PADC track detector produced by TASTRAK©. Tracks are magnified through a chemical etching with KOH (6.25 N) for 2 h 50' at 85 °C (Assenmacher et al., 2016).

The system previously employed consisted in an optical microscope equipped with a camera linked to a PC through a National Instruments image acquisition board (Bedogni, 2003). Because the field of view of the optical system (camera and microscope) was about 0.23 cm^2, the 1.15 cm^2 desired scanning area was obtained moving the PADC sample below the microscope through the a micrometric stepper. A new project, named CONAn (CCD Camera One-shot Nuclear track Analysis system), was developed with the aim of perform a fast image acquisition and a track counting based on track density distribution on the evaluated sample, analogously to what proposed by (Steele et al., 1999) and (Bàtor et al., 2015) that used a commercial scanner. In this work the CCD camera was employed with the aim of guaranteeing a field of view of the order of 1 cm^2 and a spatial resolution apt to detect etched neutron tracks. The possibility of a direct visual inspection of the etched dosemeter elaborated regions allows the operator to detect immediately the possible source of anomalies, confirming the results of the automatic analysis or performing further investigations.

2. Materials and methods

All the material employed was preliminary checked through a quality test procedure that allowed to select PADC sheets showing a comparable sensitivity (Fantuzzi et al., 2002).

A survey was performed on available commercial optical systems having characteristics that could assure the desired performances. The chosen device is a 35 mm CCD (6576 × 4384 pixels),

* Corresponding author.
E-mail address: paolo.ferrari@enea.it (P. Ferrari).

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Vieworks VA-29MG2-M/C2 (www.vieworks.com) Giga-Ethernet camera, equipped with a Makro Schneider component. The best optical combination available allows a spatial resolution of 1.9 μm per pixel with a FoV of 12.9 × 8.6 mm^2, that can be modified changing the camera working distance. In the present study it was decided to downgrade the spatial resolution to 2.4 μm per pixel, obtaining a larger FoV (15.5 × 10.3 mm^2) with a Schneider Apo-Componon 2,8/40, a Makro-Unifoc 12 and a 50 mm extension tube, allowing the acquisition of a larger part of the dosemeter surface in one-shot. That resolution was considered appropriate to detect tracks with dimensions of the order of few microns and because the obtained Field of View (FoV), no movement is required during the image acquisition. The system is connected to a National Instrument chassis, NI PXIe-1071, supplied with a Vision Board. A dedicated software was developed in Labview 2010©. The developed software controls all the phases of the reading procedure, from the image acquisition to the final dose reporting (see Fig. 1).

2.1. The image acquisition

The system has a fixed focus, defined by the selected working distance. The tracks are made visible through the reflection of the light source on the pits walls, produced by the etching of tracks in the material, on a dark back side (as in Tsankov et al., 2005). Employing the CCD camera, the Labview program acquires a one-shot image of central part of the etched dosemeter with the dimension of the settled FoV. A thresholding filter is used to distinguish the tracks. A bimodal distribution, peaked on the two maxima representing respectively the background (black) and the etched tracks (white), is assumed. Tracks are identified as group of pixels that have a grey level higher than a fixed value T_p (in this case $T_p = 128$). The image is made binary and used for the subsequent elaboration, whilst the original one is saved in the database.

2.2. Track counting

A grid of 15 regions of interest (RoI), partially overlapping, is automatically drawn on the binary image, excluding the margins of the FoV. All the RoIs are rectangular and cover an area of 0.1788 cm^2. For each RoI the number of tracks is automatically counted, c_i. The mean of the 15 c_i, c_m, (1) together with its associated standard deviation, s_m, is assumed to be representative of the track density (tracks/cm) on the dosemeter surface.

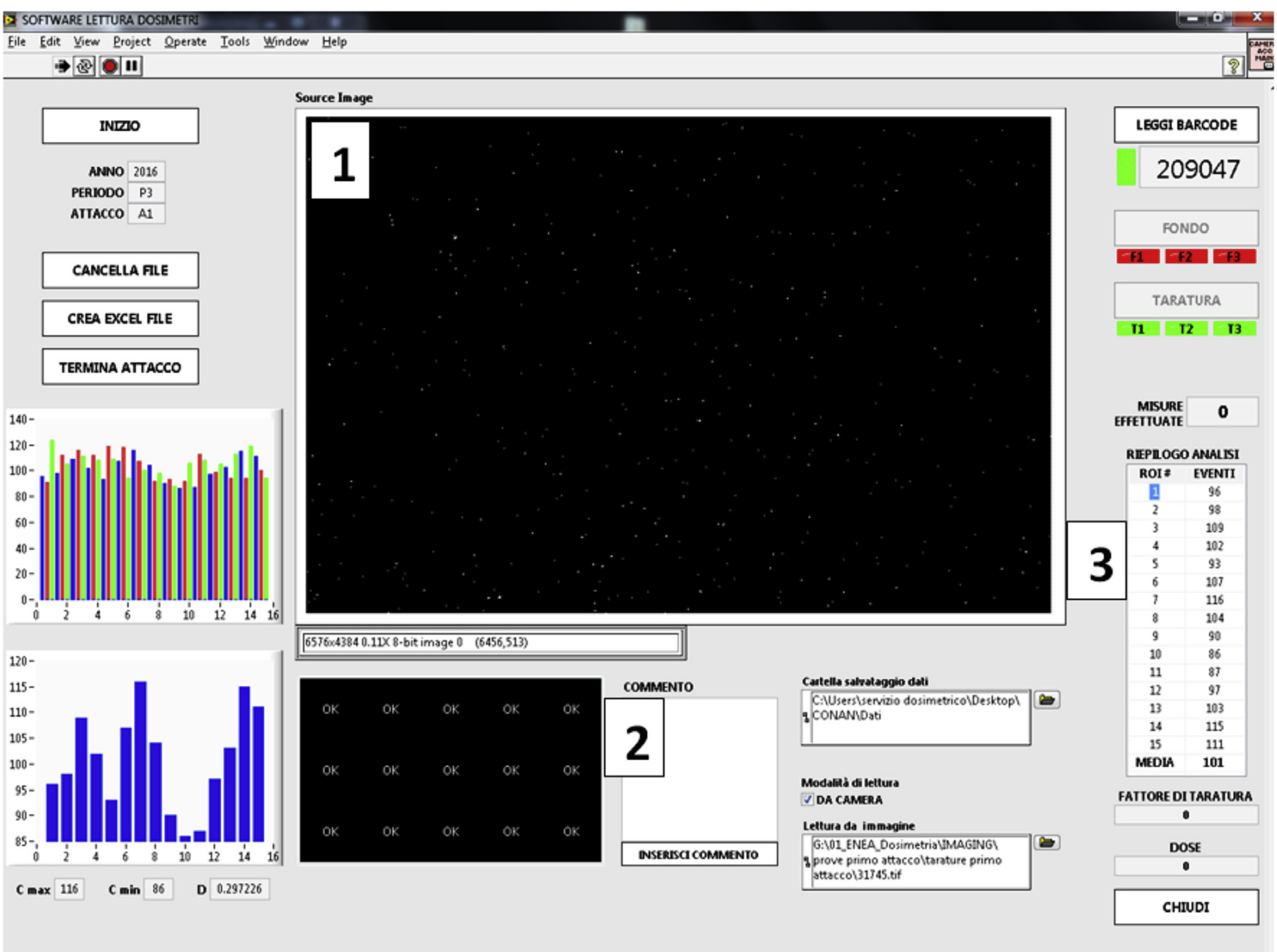

Fig. 1. The developed software console. (1) the image of the investigated dosemeter region (produced by the one-shot acquisition); (2) part of the homogeneity analysis of the 15 acquired image RoIs; (3) the counted tracks in the 15 acquired image RoIs.

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