Radiation Physics and Chemistry 130 (2017) 154–157

Contents lists available at ScienceDirect

Radiation Physics and Chemistry

journal homepage: www.elsevier.com/locate/radphyschem

In-laboratory development of an automatic track counting system for solid state nuclear track detectors

Sefa Kemal Uzun *, Işık Demiröz, İzzet Ulus

Sarayköy Nuclear Research and Training Center/Turkish Atomic Energy Authority, Atom Street No: 27 Saray, Kazan, Ankara, Turkey

HIGHLIGHTS

- Automatic track counting system was developed for SSNTDs in laboratory.
- The developed system was tested for radon detectors.
- The developed system is introduced for radon measurement service.
- The developed system can be easily adapted for other SSNTD applications.

ARTICLE INFO

Article history:
Received 22 February 2016
Received in revised form
21 July 2016
Accepted 11 August 2016
Available online 16 August 2016

Keywords:
SSNTD
Radon
CR-39
Track counting
Image processing

ABSTRACT

In this study, an automatic track counting system was developed for solid state nuclear track detectors (SSNTD). Firstly the specifications of required hardware components were determined, and accordingly the CCD camera, microscope and stage motor table was supplied and integrated. The system was completed by developing parametric software with VB.Net language. Finally a set of test intended for radon activity concentration measurement was applied. According to the test results, the system was enabled for routine radon measurement. Whether the parameters of system are adjusted for another SSNTD application, it could be used for other fields of SSNTD like neutron dosimetry or heavy charged particle detection.

1. Introduction

Solid state nuclear track detectors (SSNTD) are widely used for radon activity concentration measurements at indoors around the world. Besides, there are also other application fields of SSNTDs like neutron dosimetry, heavy ion detection. Operation of the solid-state nuclear track detector is based on the fact that a heavy charged particle causes extensive ionization of the material when it passes through a medium. Nikezic and K.Y. (2004) This ionization generates a latent track on detector surface. Because of track formation potential and low fading rate, SSNTD materials are selected from polymer based materials like CR-39, Lexan. By applying chemical or electro-chemical etching process, the tracks are enlarged until they become countable under an optical microscope. The measured quantity (activity concentration, dose, etc.) can be calculated from track number with an appropriate calibration factor. The counting of tracks with eye under microscope is very cumbersome and also counting with eye have large uncertainty. Therefore track counting process is generally done by automatic track counting systems. In this study, an automatic track counting system has been developed that it is consisting of stage motor table, microscope, camera and software. The software of the system was designed and written specially. The validation of the track counting system for radon measurement was done by the repeatability, linearity and proficiency tests and the system was introduced as track counting system for radon detectors.

2. Material and method

The main concern of the developed system is counting of the charged particle (protons, alphas, ions) tracks clearly by distinguishing from noisy images (dirt, scratch etc.). If it is considered that the dimensions of etched tracks are in the order of micrometers, to count the tracks distinctly, the image of the SSTND detector should be magnified by a microscope. The minimum required magnification rate depends on track size and track size

* Corresponding author.
E-mail addresses: sefakemal.uzun@taek.gov.tr (S.K. Uzun), isik.as@taek.gov.tr (I. Demiröz), izzet.ulus@taek.gov.tr (İ. Ulus).

http://dx.doi.org/10.1016/j.radphyschem.2016.08.009

depends on charged particle type, etching conditions. When the image of the SSNTD surface is magnified, only a portion of the SSNTD will be screened so the SSTND surface should be scanned step by step thus, in the system, stage motor table which mounted on microscope was used for scanning detector surface. Another component of the system is the CCD camera that is attached on microscope. By the camera, the image of the SSNTD is transferred to the PC for track counting. Beyond the hardware components, a software should be to manage the system and to count the tracks by image processing. For this purpose, a specific software was developed on Visual Studio Express platform.

2.1. Hardware specifications

The microscope is the main component of the system so the choice of the microscope type is important. Firstly, the optical magnification should be enough to distinguish the tracks from dirt or scratches. Another required feature of the microscope is that the frame of the microscope should be stable while motorized table is moving. Otherwise, moving of the frame would bring a large uncertainty. Besides microscope should be suitable for mounting the stage motorized table and CCD camera. In the system, Nikon® Eclipse LV100ND type microscope was used that meets the all of the required criteria. The microscope includes two objective lenses which have 5×, 10× magnification rates. The microscope has also ocular lens which has 10× magnification rate. Maximum 100× optical magnification can be obtained by these lenses. The illumination of the microscope is carried out by 12 V, 50 W halogen lamp which is placed at the bottom of the stage motorized table.

Another component of the system is the stage motorized table that is used for scanning the detector surface precisely. The stage motorized table is controlled over the Tango controller. Wetzlar (2010) For this process, Marzhauser® (75 mm × 50 mm) stage motorized table was selected. Stage motorized table has a minimum 0.01 μm step size and ±3 μm positioning sensitivity. Furthermore, for automatic focusing another step motor is used and this motor is also controlled by same control unit. The stage motorized table and focusing motor is shown in Fig. 1 as number 1 and 3 respectively.

Track counting operation is done by image processing algorithm in the software of the system. The prerequisite of image processing is transferring the magnified image of the SSNTD to the computer by the camera. The camera should be attached the on microscope and it should send the image in a suitable format to the software. The CCD camera was used as shown in Fig. 1 with number 2.

2.2. Software Specifications

The software of the system was developed specially with VB. Net programming language. The software was classified into three modules which are image acquisition, image processing and motor control. The image acquisition module consists of the software development kit (SDK) of the camera which is used with some modifications. (Sensor Technologies America) By the modifications, the image is converted to monochrome and dimensions of the image are reduced to 1600 × 600 pixels. In this way, unnecessary usage of memory is prevented. In the motor control module, the commands are sent to stage motorized table for positioning by the functions of Tango library. (Wetzlar) On the other hand, the step motor for focusing is controlled by the same library thereby automatic focusing is done before counting of tracks for each detector. In the image processing module, for focusing, a numerical indicator was defined that shows the clearness of the image. This indicator is a ratio which is derived from division of diameter of the track to the center pixel color code of the track. While step motor is moving in z direction, the indicator is calculated for each z plane. The focus plane is selected according to the maximum value of the indicator. The image processing module is consisting of the core algorithm of track counting. By this algorithm, the tracks are counted according to the some defined parameters. The basic parameters for track counting are the minimum diameter, maximum diameter, darkness threshold and roundness. The dimensions of the captured images are 1600 × 600 pixels, this means that each captured image matrix have 960,000 elements. The pixels are the integer numbers that show the color of the points of the image. In the software, because of image is converted to monochrome, pixel has a one color code that is between 0 and 255. In the case of 0, it means that the pixel is full black, in the case of 255, the pixel is full white. By searching the pixel color codes that have smaller values than threshold value, the dark points are determined and by the circle equation they are tested whether a circle is occurring or not. With the roundness parameter, the pixels that are not forming an exact circle but forming a shape like a circle, they can be counted as a track. A sample magnified image of radon exposed SSNTD is given at Fig. 2. The counted tracks are marked with black circle. It is required scanning of detector surface step by step because of magnification, so the SSNTD surface is scanned 14 step in y direction, 7 step in x direction and 120 discrete (15 × 8) images are acquired and processed for each detector. The multi thread function of . Net framework is used to accelerate the image processing accordingly the image is divided four region and the algorithm is worked in four thread. By this way, the focusing and track counting time for whole detector surface (set of 120 images) is reduced to 90 s

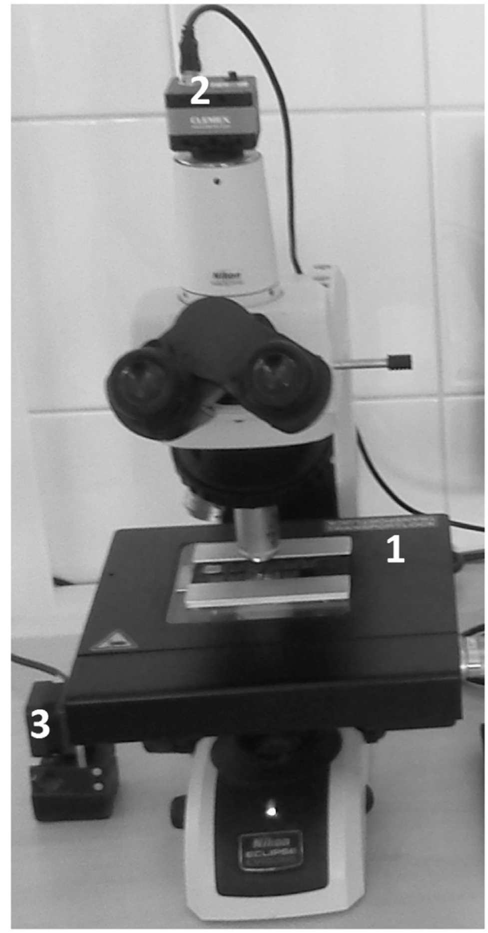

Fig. 1. Picture of track counting system.