ENEEP Member: The Slovak University of Technology Bratislava

Shortlist of novel education and training activities

February 2024

Contents

1. Neutron personal dosimetry

Basic information

Main topic: Radiation Physics
Subtopic: Personal dosimetry, radiation protection and shielding

Level of exercise Basic ☛Advanced ☛Complex
Level of education ☛BSc ☛MSc ☛PhD
Keywords: Passive detectors, neutron dosimetry, etching, artificial intelligence, machine learning

1.1. Purpose of experiment

The purpose of the experiment is to demonstrate the main phenomena in radiation protection and the basics of work of personnel in controlled radiation area. The purpose of the experiment is to demonstrate the utilization of passive neutron track detectors for radiation protection. The experiment consists of irradiation of detector samples, their etching, evaluation of latent track produced as result of neutron induced damage as well as the determination of a map of effective doses based on the evaluation of the used detectors either manually or by using artificial intelligence and machine learning principles.

1.2. What you will learn

Students will become familiar with solid state neutron track detector, mechanisms of the conversion of radiation induced damage to radiation quantities, such as effective dose or neutron flux and neutron flux distribution/attenuation in complicated geometries.

1.3. Pre-knowledge required

- Dosimetry units and limits,
- radiation protection and interaction of neutrons with matter,
- types of radiation,
- basics in chemistry,
- radiation shielding,

- basics in image processing and IT.

1.4. Facilities and instruments

For performance of the experiment a neutron/reactor physics laboratory is required. Radioisotope neutron souce and neutron shielding blocks are required.

Required instruments for exercise:

- solid state neutron track detector,
- Mini Labyrinth experiment,
- etching apparatus,
- digital microscope,
- evaluation software.

1.5. Experimental procedure

The exercise starts with the installation of the solid state neutron track detectors in the Mini Labyrinth experiment on positions selected by the students. Then the radioisotope neutron source is loaded using the remote source loading mechanism to the required position and irradiation takes place. During the irradiation, students prepare the etching bath. The etching time and concentration of the NaOH solution is selected by the students, based on the provided tables and literature survey performed before the exercise. The irradiation is completed after one hour and the specimens are placed to the etching bath. The etched detectors are then evaluated using digital microscope. A sufficient area of the detector is scanned and saved in a form of digital images for subsequent analysis and for determination of the number of latent tracks or defects. During the exercise, the digital images are manually analysed to define latent tracks and damages induced by neutrons. The students will be therefore able to distinguish between exposure from different particles and neglect possible gamma tracks during evaluation of neutron exposure. Subsequently the images are evaluated by the software utilizing artificial intelligence and machine learning principles to identify, localize and count the defined defects. When the number of tracks and damages are determined, the students are able to determine the neutron track density, convert it to an effective dose based on the defined conversion factors and to prepare the dose map of the Mini Labyrinth experiment.

1.6. Additional information

1.6..1 Limitations

The AI based evaluation software is currently under development by the partner institute. If the software was not available, student would evaluate the images manually.

1.6..2 Procedure to sign up for experiment

For more information please contact the institute through the form at: http://www.ujfi.fei.stuba.sk/kontakt.php. No special procedure is needed.

2. Solid state neutron track detectors in radiation measurement

Basic information

Main topic: Radiation Physics
Subtopic: Nuclear Instrumentation and Methods

Level of exercise Basic ☛Advanced ☛Complex
Level of education ☛BSc ☛MSc ☛PhD
Keywords: Passive detector, neutron measurement, etching, artificial intelligence, machine learning

2.1. Purpose of experiment

The purpose of the experiment is the measurement of the neutron field by accumulation of defects in solid state neutron track detectors. The determination of the neutron flux or dosimetry quantities induced by neutrons at the level of natural background is accompanied with high uncertainty, especially when active detectors are used. In these situations passive detectors can offer cheap and versatile solution to monitor areas of interest when long term measurement is desired.

2.2. What you will learn

Students will become familiar with solid state neutron track detectors, damage effect of different particles of ionizing radiation (alfa, gamma and neutrons) in polymer structures and mechanism of the conversion of radiation induced damage to radiation quantities, such as effective dose or neutron flux.

2.3. Pre-knowledge required

- Types of radiation,
- dosimetry units,
- radiation protection and interaction of particles with matter,
- basics in chemistry,
- basics in digital image processing and IT.

2.4. Facilities and instruments

For performance of the experiment laboratory of reactor physics with external neutron, gamma and alpha source is required.

Required instruments for exercise:

- solid state neutron track detectors,
- etching apparatus,
- digital microscope,
- evaluation software.

2.5. Experimental procedure

The exercise starts with the installation of the solid state neutron track detectors in the proximity of the source of neutron, gamma or alpha particles. After sufficient time, damage from the radioactive sources is accumulated in the detectors and can be evaluated. The specimens of the detectors are placed to the etching bath. The etching time and concentration of the NaOH solution is determined by the students at the beginning of the exercise based on the provided tables and literature search prior to the experiment. The etched detectors are then evaluated using digital microscope. The representative area is scanned and saved as digital image for subsequent analysis and determination of the number of latent tracks or defects. Based on the three types of particles used during experiment, different effect on size of the track or defect will be demonstrated. The students will be then able to distinguish between exposure from different particles and neglect alfa and gamma tracks during evaluation of neutron exposure. The digital images can be also evaluated by the software utilizing artificial intelligence to identify localize and count the defined defects.

2.6. Additional information

2.6..1 Limitations

The Evaluation software is currently under development by the partner institute. If the software was not available, the student would evaluate the figures manually.

2.6..2 Procedure to sign up for experiment

For more information please contact the institute through the form at: http://www.ujfi.fei.stuba.sk/kontakt.php. No special procedure is needed.