UCRL- 86509
PREPRINT

UCRL--86509

DE82 012803

Developments in Solid State Detectors for Personnel Neutron Dosimetry

R. V. Griffith, K. J. Davidson, D. E. Miller
and K. E. Vindelov

8th DOE Personnel Neutron Dosimetry Workshop
Louisville, Kentucky

July 23, 1981

Lawrence Livermore Laboratory

DEVELOPMENTS IN SOLID STATE DETECTORS FOR PERSONNEL NEUTRON DOSIMETRY[a]

R. V. Griffith, K. J. Davidson, D. E. Miller
and K. E. Vindelov
Lawrence Livermore National Laboratory
Livermore, CA 94550

The personnel neutron exposure potential at the Lawrence Livermore National Laboratory is more diverse than at many other facilities, due to the wide range of neutron producing activities. It should be noted, incidentally, that our only reactor--a 3 MW pool type research reactor was shut down permanently in the spring of 1980. In spite of this diversity, our exposure levels are typically quite low. For this reason, the Hankins type albedo dosimeter is the workhorse of our personnel dosimetry program for the few tens of people that are monitored routinely. This dosimeter generally provides us with the sensitivity necessary for adequate dosimetry.

However, the albedo energy response problems in the face of the diversity of sources, and a concern about possible photon interferences with the neutron albedo response, have prompted us to pursue development of some additional dosimetry techniques to augment the personnel monitoring program. This work now consists of two programs--the dosimeter/spectrometer (DOSPEC) in which track etch detectors are added to the albedo badge to provide some energy evaluation and gamma insensitivity, and development of solid state thin film MOS detectors to provide a real time, gamma insensitive dosimeter.

DOSPEC

In principal, DOSPEC I involves two, three or four detectors with significantly different neutron energy responses, used in a combination that allows evaluation of dosimeter responses with improved accuracy, when the specific location or conditions of exposure are unknown. The selection of components is based on the character of the neutron fields, with a wider energy range calling for more detectors. We currently are investigating

(a) This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.

CC

CR-39, polycarbonate and LR115 track etch detectors used in addition to the low energy albedo component.

Somewhat arbitrarily, we have assigned energy thresholds of thermal to the albedo detector, 100 keV to the CR-39, 1.5 MeV to the polycarbonate and 6 MeV to the LR115 (Figure 1). The CR-39 and polycarbonate are etched electrochemically. In addition to the differential response of separate DOSPEC I components, we can obtain spectral information from the energy dependent ratio of chemical to electrochemical etch tracks in CR-39 (Figure 2). Moreover, the energy response of the CR-39 depends on the duration of pre-etch. Therefore. samples of CR-39 processed with different pre-etch times can be used as a third means of determining something about neutron energy.

Because the LR115 is primarily useful in accelerator (high energy) applications, we do not normally include that material in the dosimeters as issued. More detail on the use and energy response of these components is presented elsewhere.[1,2]

DOSPEC II is the designation for a single component dosimeter design concept which will have a rem response from thermal to a few MeV. This concept, which is represented in a DOE patent application, combines the relatively flat dose equivalent response of an albedo detector below 0.1 MeV with the natural response of CR-39 (when electrochemically etched) from 0.1 MeV to 5 MeV. The albedo response is represented by an n, alpha converter such as lithium tetraborate or borated plastic in contact with the CR-39 surface. The composition of the converter is adjusted to match the CR-39 response so that the composite energy response is proportional to the dose equivalent convernsion factors over the main range of interest in fission neutron producing environments (Figure 4). The magnitude of the peak in the CR-39 response at 2 MeV can be reduced by shorter pre-etching times (two hours rather than five). Through improved processing methods such as this, we believe the response match can be improved further. We expect that even alpha, n sources can be monitored with reasonable energy response accuracy (± 25%).

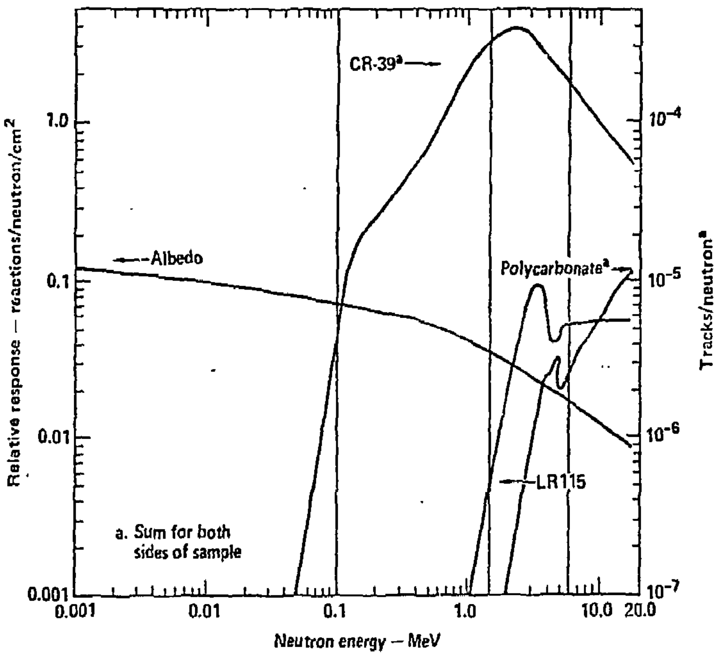

FIGURE 1. Energy Response of DOSPEC I Components

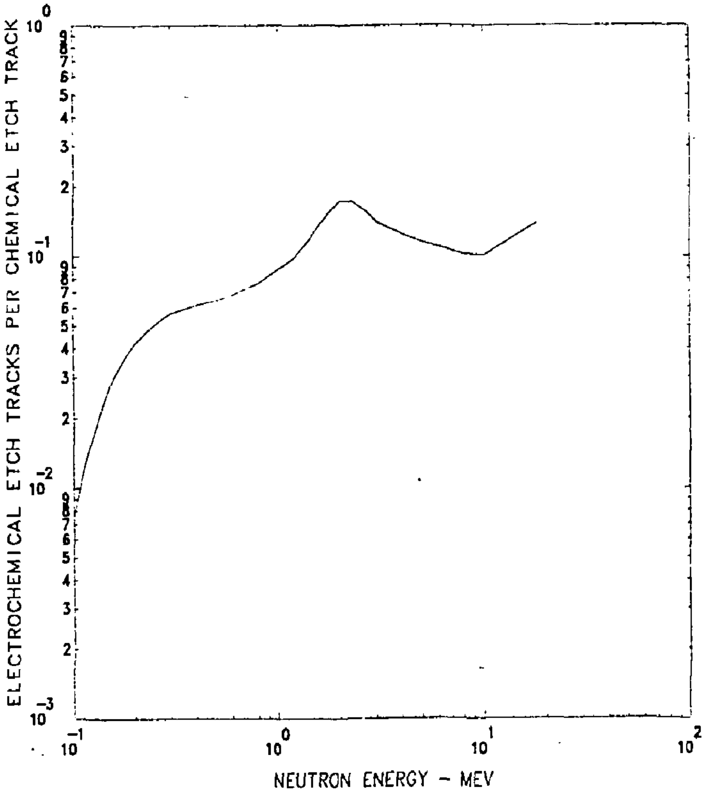

FIGURE 2. Energy Dependent Ratio of Electrochemical to Chemical Etch Tracks in CR-39 after Five Hours Pre-Etching (60 C, 6N KOH).

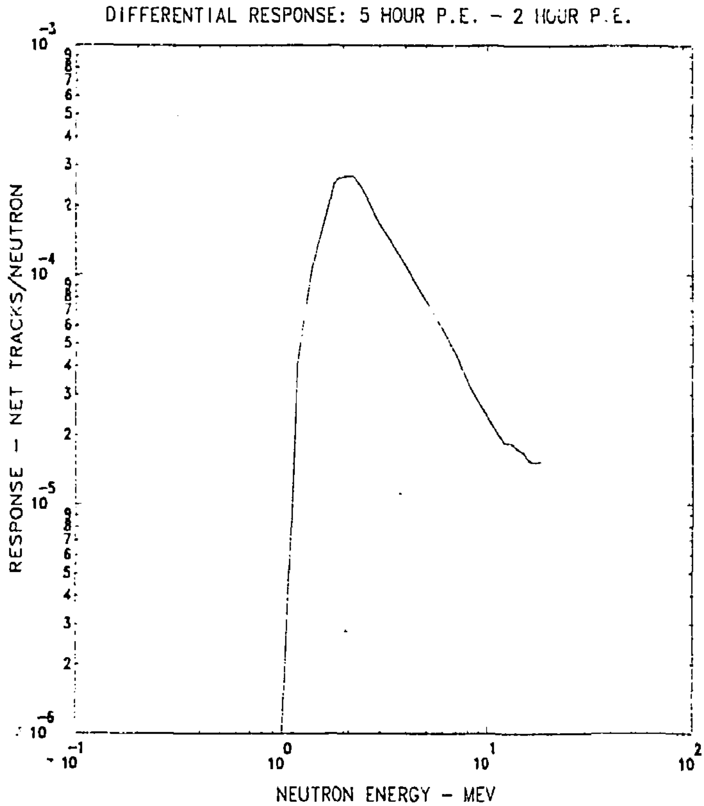

FIGURE 3. Energy Dependent Differences in Response Between CR-39 Samples with Two Hours and Five Hours Pre-Etching.

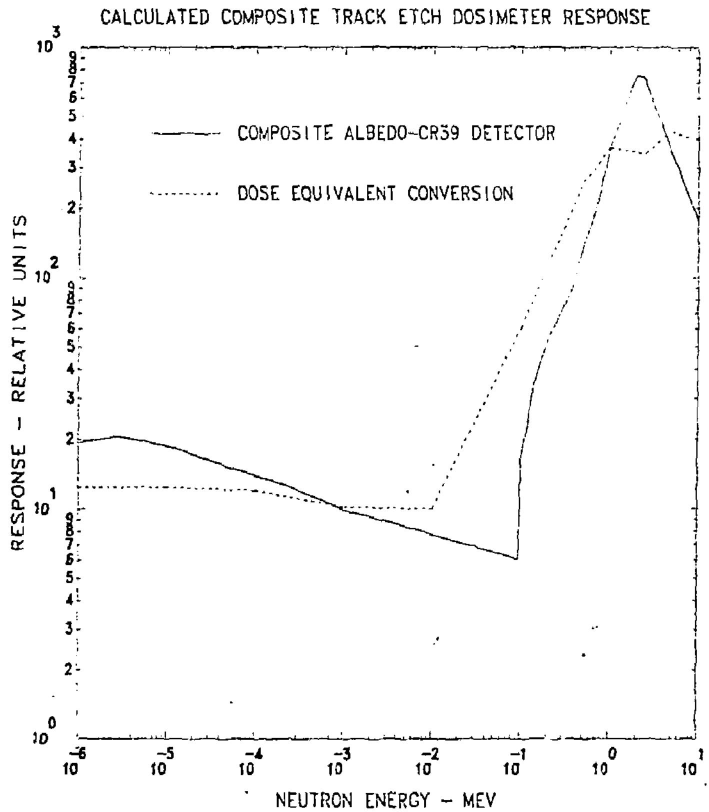

FIGURE 4. Calculated Response of DOSPEC II Using an Albedo Track Radiator (^{6}Li or ^{10}B) on fast Neutron Detection in the same Sample.

We are presently studying the processing parameters of the DOSPEC I and DOSPEC II components prior to developing a finished design and interpretation protocol. We have experienced some problems with track etch materials background level and variations, as well as occasional, apparent non-statistical variations in detector sensitivity. To that end, future sources of high quality, dosimetry grade CR-39 and polycarbonate will be very valuable.

Thin Film MOS Detectors

In concept, the thin film (100 - 1000 Å) detector is maintained at potential just below spontaneous breakdown. When a charged particle penetrates the film, a breakdown occurs, producing a single, easily detectable pulse that could be processed and registered by relatively unsophisticated pocket-size solid state circuitry.

A key to all this is a source of charged particles that relates to neutron dose. We are currently using thin fission fragment radiators - ^{235}U and ^{237}Np that are placed close to the MOS detector. The neutron dosimetric value of these materials, particularly ^{237}Np, is well-known and has been used for years.

We have tested small area detectors (3 - 5 mm^2), and are presently preparing a 10 cm^2 detector array for use with a large area ^{237}Np radiator obtained from Oak Ridge. There are some concerns about handling the ^{237}Np assembly for personnel use, but dosimetrists in England and Canada have used this material for some time. The cost of vapor plated neptunium sources ($\sim$ \$1000 - \$2000) is also a barrier to widespread use of these. However, that tissue can be addressed following successful demonstration of the technique.

Our efforts to detect lighter charged particles (alphas, recoil protons, etc.) has not been successful, but improved MOS technology may eventually improve that situation. More detailed information on our thin film work is available.[3]

REFERENCES

1. Griffith R., Fisher J., Tommasino L., and Zapparoli G., (1980), "Development of a Personnel Neutron Dosimeter/Spectrometer," 5th Congress, IRPA, Vol. II, 169-172.

2. Griffith R., Thorngate J., Davison K., Fisher J., Tommasino L., and Zapparoli G., (1981), "Monoenergetic Neutron Response of Selected Etch Plastics for Personnel Neutron Dosimetry," Rad. Prot. Dos. Vol, 1, p. 61-71.

3. Miller D., Griffith R., and Vindelov K., (1981). "Neutron Detection with Real-Time Response by Compact Thin-Film M-O-S Arrays," Lawrence Livermore National Laboratory Rept. UCRL-86035.