An Experimental Study on the Neutron and Gamma Flux Measurements Using Thin Aluminum Nitride Pieces

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Extended Abstract

The results of experiments performed for testing the aluminum nitride pieces to see if they can be used as flux detectors in nuclear power plants are described. During the period of Sept. 2001 through April 2004, we have fabricated dozens of aluminum nitride based flux sensors (see fig.1) in ORNL with two different sizes of $3\times3\times0.635\,mm^3$ and $3\times3\times0.381\,mm^3$. They have been packaged in KAERI with MgO powers as insulators and long signal cables attached as shown fig.2.

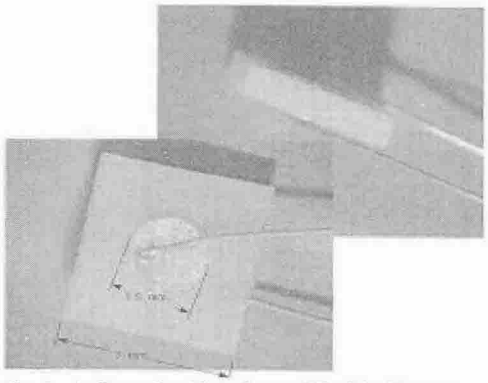

fig.1. A Sample Aluminum Nitride Sensor

This work has been carried out under the nuclear research and development program supported by the Ministry of Science and Technology of Korea.

The first part of the experiments was to determine the insulation resistance and the optimum operating voltage of the sensors with the long cables attached to them as seen in fig.2. The insulation resistance after the packaging turned out to be as high as $10^{13}\,\Omega$ and an optimum operating voltage is 3,000V for the 0.381mm thick sensors.

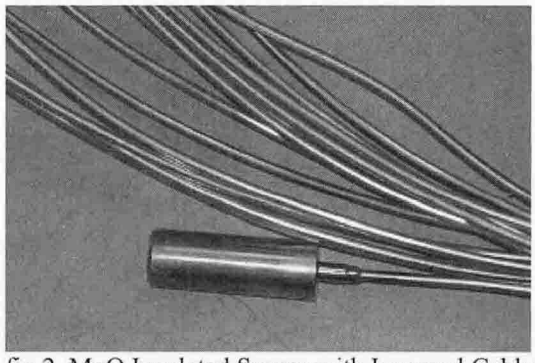

fig.2. MgO Insulated Sensor with Inconnel Cable

The second part of the experiments was to measure the high flux gammas from the 187Ci Co^{60}, 77,000 Ci Co^{60}, and from the 200,000Ci Co^{60} at the high level irradiation facility of KAERI at various distances. The measured values were compared with the EGS4 and MCNP4B based calculation results to find that they are in the same order of magnitude.

The third part of the experiments was to measure the low neutron flux at the 65MeV Pohang accelerator, where the gamma flux is less than about 1% of the neutron flux in some angles. The results of measurements at various distances from the target are shown in fig.3. Note that the lowest electric current measured is around a few pA. The neutron flux at that position is estimated to be about 10^9 / cm^2·sec.

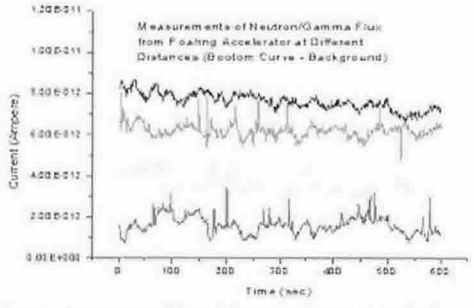

fig.3. Neutron Flux Measurements at Pohang (65MeV)

As the last part of the experiments, we measured the high-level neutron flux of 5×10^{13}/sec.cm^2 (mostly thermal) in the cold neutron source hole of the Hanaro research reactor using a 381micron thick detector. The flux was measured while the reactor power is being increased from 1MW to 8MW, hold steady at 8MW for an hour, increased from 8MW to 13MW, and finally the reactor is tripped. Our aim was to check the linearity of the generated current and to see how it responses to the power changes or the flux changes. The red curve in fig.4 shows the measured current by the aluminum nitride sensor with the scale on the vertical axis. The darker curve in fig.4 shows the changes of the reactor power during the experiment, which was linearly scaled so that the minimum and the maximum match with those of the measured current.
From fig.4, we conclude that the current generated by our aluminum nitride based detector increases as the reactor power varies from 0% to 43%. We also conclude that the generated current will continue to increase as the reactor power goes up to 100%. We observe that the response time of our detector is very good, i.e. the time lag is negligible. In the linearity, however, we do have a problem. The poor linearity is due to the low voltage of 1,000V applied to the sensor. The maximum voltage we can apply to the inconnel cable was only 1,000V and recall that the optimum voltage we determined was 3,000V.

Finally for the future works, one must develop a good method to compensate the decrease of the electric current due to the dielectric loss while the flux is maintained at a constant level. Another part of the work left is to handle how to discriminate the gamma flux from the neutron flux.

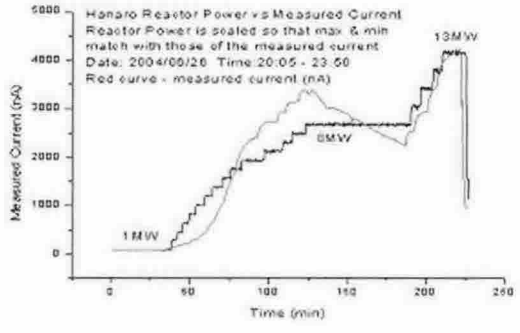

fig.4. Neutron Flux Measurements at HANARO(CNS hole)