Contribution ID: **122** Type: **Verbal**

NGD Cold Neutron Prompt Gamma-ray Activation Analysis Spectrometer at NIST

Wednesday, 14 May 2014 11:00 (15 minutes)

An instrument for cold neutron prompt gamma-ray activation analysis (PGAA) has been operational on neutron guide NG7 at the NIST Center for Neutron Research (NCNR) since December 1990. The applicability of this instrument suffers from the presence of the adjacent upper half of the NG7 guide, just 3 cm above the sample position, limiting both sample size and available space for setting up experiments. The scattered neutrons from the upper guide create a gamma-ray background when absorbed by surrounding material, specifically air. The upper beam guide has been painted with lithiated paint on the outer surface to reduce scattered neutrons.

In conjunction with the expansion of the NCNR, a new PGAA instrument has been built on the guide NGD. A 2 cm x 2.7 cm beam of cold neutrons is extracted from the guide into air through a magnesium alloy window upon opening a lead-lined 6Li glass shutter, and is collimated by a 6Li glass aperture mounted just before the sample box. Samples are irradiated in an evacuable aluminum box (273 cm (h) x 171 cm (w) x 247 cm (l))) with removable magnesium alloy windows. A piece of enriched 6LiF mounted downstream serves as a beamstop. Prompt gamma rays emitted by the sample pass through an adjustable collimating lead aperture and are measured by a high resolution germanium detector with a bismuth germanate Compton shield. The sample cave is shielded by lead and covered with cadmium except in front of the aperture, which is shielded by a piece of lithoflex. The detector cave rests on a moving plate, mounted on precision rails, with an adjustable detector-to-sample distance. Detector signals are processed using a digital signal analyzer.

A gold foil irradiation measured a thermal equivalent neutron flux of 6.8E9 cm-2s-1 at the sample position, nearly a factor of 8 higher than the flux for the NG7 instrument. With the detector positioned 70 cm from the sample (twice the sample-to-detector distance at NG7), measurement of prompt gamma-rays from Ti, Fe, Al, Cu, and urea indicated element sensitivities (cps/mg) nearly twice that measured at NG7.

The initial gamma-ray background was high primarily due to scattering of neutrons by air and the sample box windows. Significant reduction in gamma-ray and neutron background was accomplished by installing temporary lithoflex-lined aluminum neutron flight tubes, additional lithoflex shielding inside the sample box and around the detector, boroflex around detector Dewar, and lead shielding between the flight tubes and the detector. The improvements yielded background count rates for H, Al, Cu, Si, and Ge lower than measured at NG7. The H background equivalent to 3.2 μg of H is half that measured at NG7.

The new instrument yields greater applicability, higher neutron flux, and better signal-to-noise ratio than the NG7 instrument. Future improvements will include optimization of neutron and gamma-ray shielding and installation of permanent evacuable neutron flight tubes. The improvement in sample space will allow the mounting of larger samples, addition of automated scanning stages for compositional mapping, automatic sample changer, atmosphere/temperature controlled sample chambers for studying in situ reactions, and additional detectors for performing coincidence measurements.

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Session Classification: Nuclear Analytical Methods 3

Track Classification: Nuclear Analytical Methods