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GAMMA-RAY SPECTROSCOPY OF IN-SITU SNM WITH THE M^{3}CA AND A NEW ROOM-TEMPERATURE DETECTOR

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Gamma-ray spectroscopy with real-time readout is applied in portable and fixed (continuous) quantitative assays of *in situ* special nuclear materials (SNM). Holdup, in-process inventory, stored inventory and dynamic (active process) materials, are several categories of SNM for which *in situ* measurements are required. The measured element and isotope quantities satisfy external orders and internal protocols for safety; control, accountability and verification of SNM; control of processes; and decontamination and decommissioning.

Conventional, room-temperature gamma-ray detectors serve in a limited range of these applications. Conventional detectors equipped with the required gamma-ray shielding and collimation are larger and heavier than the new complementary electronics: a self-contained, miniature gamma-ray spectroscopy unit.[1] The size and weight of the conventional detector restrict physical access and single-user activities. While efficient, reliable, and rugged to some extent, a conventional room-temperature detector also has a low gamma-ray energy resolution that limits discrimination capabilities and measurement sensitivities.

More compact, rugged, efficient, and reliable room-temperature gamma-ray detectors with better energy resolution are needed for *in situ* applications. These improved detectors are sought as alternatives to the compact NaI(T1) detectors[2] now available commercially. Better detectors are essential to extending the applications of gamma-ray spectroscopy for nondestructive assay (NDA) of SNM *in situ*. A greater variety of material types and measurement circumstances as well as increasing regulatory requirements and inspection needs could be accommodated.

The ability to grow large, solid-state crystals of sufficient purity for improved room-temperature gamma-ray spectroscopy has evolved slowly until recently.[3] Improvements in the

quality of gamma-ray spectra from room-temperature detectors have also been restricted by the intrinsic charge-carrier properties of room-temperature solid-state materials, constraining the useful thicknesses of crystals for gamma-ray spectroscopy. Proposed solutions to these intrinsic limitations include new analog-pulse-processing technologies to reject or compensate for defective analyzed pulse heights as well as assemblies of multiple small-crystal components to minimize the defects. The solutions themselves are sophisticated advances that require significant development and testing. A more promising approach is an elegant new detector design[4] that benefits fully from the recent advances in solid-state materials technology for production of large, good-quality crystals of CdZnTe for room-temperature gamma-ray spectroscopy.[3] The new detector, equipped with simple but innovative electrode technology to address the intrinsic charge-collection deficiencies, operates with the new self-contained portable gamma-ray spectroscopy system, the miniature modular multichannel analyzer (M^3CA), without added layers of electronic complexity for pulse processing. Initial testing of a prototype detector with a 1-cm-thick CdZnTe crystal demonstrates comparable intrinsic photoelectric efficiency, equivalently symmetric photoelectric peak shapes, and a factor-of-two improvement in energy resolution compared to the 1.2-cm-thick compact sodium iodide detector.

Applications of *in situ* NDA for portable determinations of fixed uranium and plutonium quantities and the continuous assay of dynamic quantities of these materials will provide the test criteria for evaluating the performance of such detectors operating with the M^3CA. Performance characteristics specific to these applications (such as sensitivity of quantitative assays of uranium and plutonium, ^{241}Am-Pu or ^{232}U-^{235}U discrimination, and accuracy of quantitative assays of uranium and plutonium isotopes in materials with varying isotopic distributions) will be evaluated in comparison to the performance of the compact sodium iodide detector. The size, ruggedness, and reliability of the room-temperature detectors will be compared to those of the conventional detectors. Finally, the performance of the new detector will be compared to that of a high-quality CdZnTe detector of equivalent size whose pulses are analyzed using state-of-the-art commercial analog-pulse-processing technologies to digitally compensate for defective analyzed pulse heights.

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