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U and Pu Gamma-Ray Measurements of Spent Fuel Using a Gamma-Ray Mirror Band-Pass Filter

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We report the use of grazing incidence gamma-ray mirrors as narrow band-pass filters for advanced non-destructive analysis of spent nuclear fuel. The mirrors limit radiation reaching an HPGe detector to narrow spectral bands around characteristic emission lines from fissile isotopes in the fuel. Ideally, these emissions could be used to determine the fuel's fissile content, but they are normally masked by the overwhelming radiation emitted by short-lived fission by-products. These latter emissions raise the overall background, making direct observation of the fuel with HPGe detectors virtually impossible. Such observations can only be performed using precise collimators that restrict the detector's field of view to very small solid angles. This results in impracticably long dwell times for safeguards measurements targeting the weak isotopic lines of interest. In a proof-of-concept experiment, a set of simple flat gamma-ray mirrors was used to observe the atomic florescence lines from U and Pu from a spent nuclear fuel pin. For the measurements, the mirrors were placed at the egress of an access port in a hot cell wall. A coarse collimator in the port restricted radiation from a fuel pin placed in front of the port to fully illuminate the front surface of the mirror assembly (0.5 x 3.8 cm2). The mirrors, consisting of highly polished silicon substrates deposited with WC/SiC multilayer coatings, were successfully used to deflect the lines of interest onto an HPGe detector while the intense primary radiation from the spent fuel was blocked by a lead beam stop. The gamma-ray mirror multilayer coatings used here at ˜ 100 keV, have been experimentally tested at energies as high as 645 keV, indicating that direct observation of nuclear emission lines from 239Pu should be possible with an appropriately designed optic.

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