ABSTRACT

THERMOCURRENT DOSIMETRY

WITH HIGH PURITY ALUMINUM OXIDE

by

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The application of thermocurrent (TC) to ionizing radiation dosimetry was studied. It was shown that TC in alumina (Al_2O_3) has properties that are suited to personnel dosimetry and environmental monitoring.

TC dosimeters were made from thin disks of alumina. Aluminum electrodes were evaporated on each side: on one face a high voltage electrode and on the opposite face a measuring electrode encircled by a guard ring. Exposure to ionizing radiation resulted in stored electrons and holes in metastable trapping sites. The signal was read-out by heating the dosimeter with a voltage source and picoammeter connected in series between the opposite electrodes. The thermally remobilized charge caused a transient TC. The thermogram, TC versus time or temperature, is similar to a TL glow curve. Either the peak current or the integrated current is a measure of absorbed dose.

Six grades of alumina were studied from a total of four commercial suppliers. All six materials displayed radiation induced TC signals. Sapphire of uv-grade quality from the Adolf Meller Co. (AM) had the

best dosimetry properties of those investigated.

The AM sapphire dosimeter has a useful range from hundreds of microrads to greater than 100 rads (^{60}Co). On a single dosimeter a measurement precision of $\pm$ 2% (1 st. dev.) was observed over all but the extremes of the dose range. The TC thermogram consists of two dosimetry peaks, the most sensitive at 260° C and the other near 320° C. The response of both peaks was linear with dose and the range of the most sensitive peak extended to 10 rads. The signal faded less than 5% in six weeks. The TC response was exposure rate independent from at least 10^{-4} to 1 R/sec. The dosimeter was immediately re-useable without additional treatment following readout for exposures below 1000 R. The TC response to low energy X rays was proportional to absorbed dose. As the effective atomic number of Al_2O_3 is 11.0 versus 7.64 for air the over-response of this material never exceeds a factor of 4.0. By using other alumina materials the linear range of response can be moved to a higher dose range, e.g. 0.1 to greater than 10^4 rads for AM standard-grade sapphire. Useable TC dosimetry signals were also observed in high purity ceramics.

Sources of interference were studied. Thermal fading, residual signal and radiation damage do not limit TC dosimetry. Ultraviolet light can induce a TC response but it is readily excluded with uv-opaque cladding. Improper surface preparation prior to electrode evaporation was shown to cause interference. A spurious TC signal resulted from polarization of surface contaminants. Spurious TC was reduced by improved cleaning prior to electrode application. Polished surfaces resulted in blocking electrodes and caused a sensitivity shift due to radiation induced thermally activated polarization. This was not observed with rough cut surfaces.

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