Residual Optically Stimulated Luminescent (OSL) Signals for Al₂O₃:C and a Readout System with Reproducible Partial Signal Clearance

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Abstract
Optically stimulated luminescent dosimeters (OSLDs) are devices that, when stimulated with light, emit light in proportion to the integrated ionizing radiation dose. The stimulation of OSL material results in the loss of a small fraction of signal stored within the dosimetric traps. Previous studies have investigated the signal loss due to readout stimulation, and the optical annealing of OSLs. This study builds on former research by examining the behavior of OSL signal after annealing, exploring the functionality of a previously developed signal loss model, and comparing uncertainties for dosimeters reused with or without annealing. For a completely annealed dosimeter, the minimum signal level was 56 ± 8 counts, and readings followed a Gaussian distribution. For dosimeters above this signal level, the fractional signal loss due to the reading process has a linear relationship with the calculated signal. At low signal levels (below 20,000 counts) in this OSL system, calculated signal percent errors increase significantly but otherwise are on average 0.72 ± 0.27%, 0.40 ± 0.19%, 0.33±0.12%, and 0.24±0.07% for 30, 75, 150, and 300 readings. Theoretical calculations of uncertainties showed that annealing before reusing dosimeters allows for dose errors below 1% with as few as 30 readings. Reusing dosimeters without annealing leads to extremely large errors for only 30 or 150 readouts, thus theoretically 300 readings would be necessary to achieve errors below 1%.

Conclusions
OSLDs are radiation detection devices that lose a small amount of signal with each readout stimulation. Once an OSL is annealed, it no longer exhibits this signal loss with readout, and multiple readings follow a Gaussian distribution. For a completely annealed commercially available Al₂O₃:C dosimeter, the minimum signal level detected by a commercial reader was 56.24 ± 8.24 counts. Note that the effects of dosimeter history or accumulated dose on the minimum signal level was not evaluated in this work. Minimum signal levels may vary for OSL readers due to differences in background noise levels and stimulation methods. The fractional signal loss due to the reading process with this reader has a linear relationship with the calculated signal for dosimeters that have not been completely annealed. When readout 300 times, the fractional loss parameter corresponds to the equation \( f = (1.20 \times 10^{-3}) + 0.000497 \) with a R-squared value of 0.98. Above noisy low signal levels, the calculated signal percent errors are on average 0.72 ± 0.27%, 0.40 ± 0.19%, 0.33±0.12%, and 0.24±0.07% for 30, 75, 150, and 300 readings with the OSL system tested here. Simulations following error propagation rules showed that annealing before reusing dosimeters theoretically permits dose errors below 1% with as few as 30 readings. Reusing dosimeters without annealing leads to extremely large errors for only 30 or 150 readouts, thus theoretically around 300 readings would be necessary to achieve errors below 1%.

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References