Optically Stimulated Luminescence Dosimeters (OSLDs) & Thermoluminescence Dosimeters (TLDs)

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Thermoluminescence (TL)
- the process of stimulating, using thermal energy, the emission of luminescence from a substance following the absorption of energy from an external source by that substance.

Optically Stimulated Luminescence (OSL)
- the process of stimulating, using optical energy, the emission of luminescence from a substance following the absorption of energy from an external source by that substance.

Picture taken by Larry A. DeWerd
Courtesy of Prof. DeWerd, UW-Madison
Luminescent Material (Insulator)

1st Stage Involved in the Luminescence Process
Excitation by ionizing radiation

2nd Stage Involved in the Luminescence Process
Latent Period

3rd Stage Involved in the Luminescence Process
Readout: heating for TLD
Background

- Both thermoluminescence and optically stimulated luminescence have been known for many years.
- TLD has a long track record as a successful method for radiation dosimetry, from LiF: Mg, Ti emerged in 50s to the recent LiF:Mg, Cu, P as a new TL material.
- OSLD for radiation dosimetry was more recent. Al₂O₃:C was developed in 90s. The future of OSLD is bright.

Comparison of TLD & OSLD

- Dose linearity
- Energy response
- Angle dependence
- Temperature dependence
- Transient signal and fading
TLD Dose Linearity

(TG. Stoebbe and LA DeWerd, J Appl Phys 57:2217-2220, 1985)

OSLD Dose Linearity

Jursinic PA, Med. Phys. 37(1), 132-140, 2010


TLD Dose Linearity: TLD & OSLD

- TLD (LiF:Mg,Ti)
  - Supralinear at high accumulated doses (>10 Gy)
  - The characteristics needs to be considered and controlled in order to make precise measurements in single-use protocol or multiple-use protocol.

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Energy Response: OSLD

\[ Z_{\text{water}} = 7.4; \ Z_{\text{Al}_2\text{O}_3} \approx 11.28 \]


Energy Response in Radiation Therapy: OSLD

No significant variation for OSLD in therapy energy range:

3.7% difference in OSL response between the photon beam and electron beam responses:

OSLD Energy Correction Factors in Diagnostic Energy Range


It is important to determine the beam energy and to use the correction factor for dose estimation.
Energy Response: TLD & OSLD

Both TLD and OSLD have energy response.
Correction factors are needed.
Particularly for OSLD applied in diagnostic energy range, beam quality needs to be carefully defined in order to reduce errors.

Z_{water} = 7.4; Z_{Al_2O_3} = 11.28

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Angle Dependence: TLD & OSLD

(Jursinic, Med. Phys. 34(12), 4594-4604, 2007)

- TLD and OSLD: no angle dependence.
- Diode (MOSFET): ~ 20% variation.

Angle Dependence: OSLD


- OSL: a nontrivial angular response of 3-4% was observed at 90°.
- TLD: encapsulated in cylindrical shape, shows no angular dependence.
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Temperature Dependence at Time of Irradiation: OSLD

(OSLD: no temperature effect at time of irradiation; thus good for in vivo dosimetry.)
Fading and Transient Signal: OSLD
(Jursinic, Med. Phys. 34(12), 4594-4604, 2007)

- OSLD: A wait time in the dark of 8 min after irradiation is adequate to avoid the transient signal.

Fading and Transient Signal: OSLD
(Schembri et al, Med. Phys. 34, 2113-8, 2007)

- Slow fading in a 3-wk period from Day 17 to Day 38.

Summary

- Both TLD and OSLD are strong and popular tools for radiation dosimetry.
- OSLD adds the versatility.
- Both TLD and OSLD methods have multiple materials that provide various properties. When we consider pros and cons of the two, we should not only look at LiF and Al₂O₃.
- More clinical applications are being developed, e.g., remote fiber optic dosimetry using OSLD.

References

- L. A. DeWerd et al: TLD
- J. E. Cygler et al: OSLD

Available on AAPM Virtual Library

ANY QUESTIONS?