Dosimetria e
Instrumentação
DEN - UFPE

SOLID STATE DOSIMETRY: State of Art

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Dosimetria e
Instrumentação

17th International Conference on Solid State Dosimetry

MarHotel - Boa Viagem – Recife - Brazil

Rua Barão de Souza Leão, n° 451

Participant Login | Abstract Book

September 22 -27, 2013

- SCOPE
- COMMITTEES
- DEADLINES NEW
- SCIENTIFIC PROGRAM
- ONLINE REGISTRATION
- 5TH SCHOOL NEW
- ORAL AND POSTER PRESENTATIONS
- VENUE
- CONFERENCE ACCOMMODATION
- SSD-18 NEW
- SSD17 TRAVEL INFORMATION
- CONFERENCE PROCEEDINGS NEW
- CONFERENCE TOUR
- POST CONFERENCE TOUR OPTIONS

It is my great pleasure to invite you to the 17th Solid State Dosimetry Conference, which will be held in Recife, an important, large and modern city, capital of the Pernambuco State, located in the Northeast Region of Brazil.

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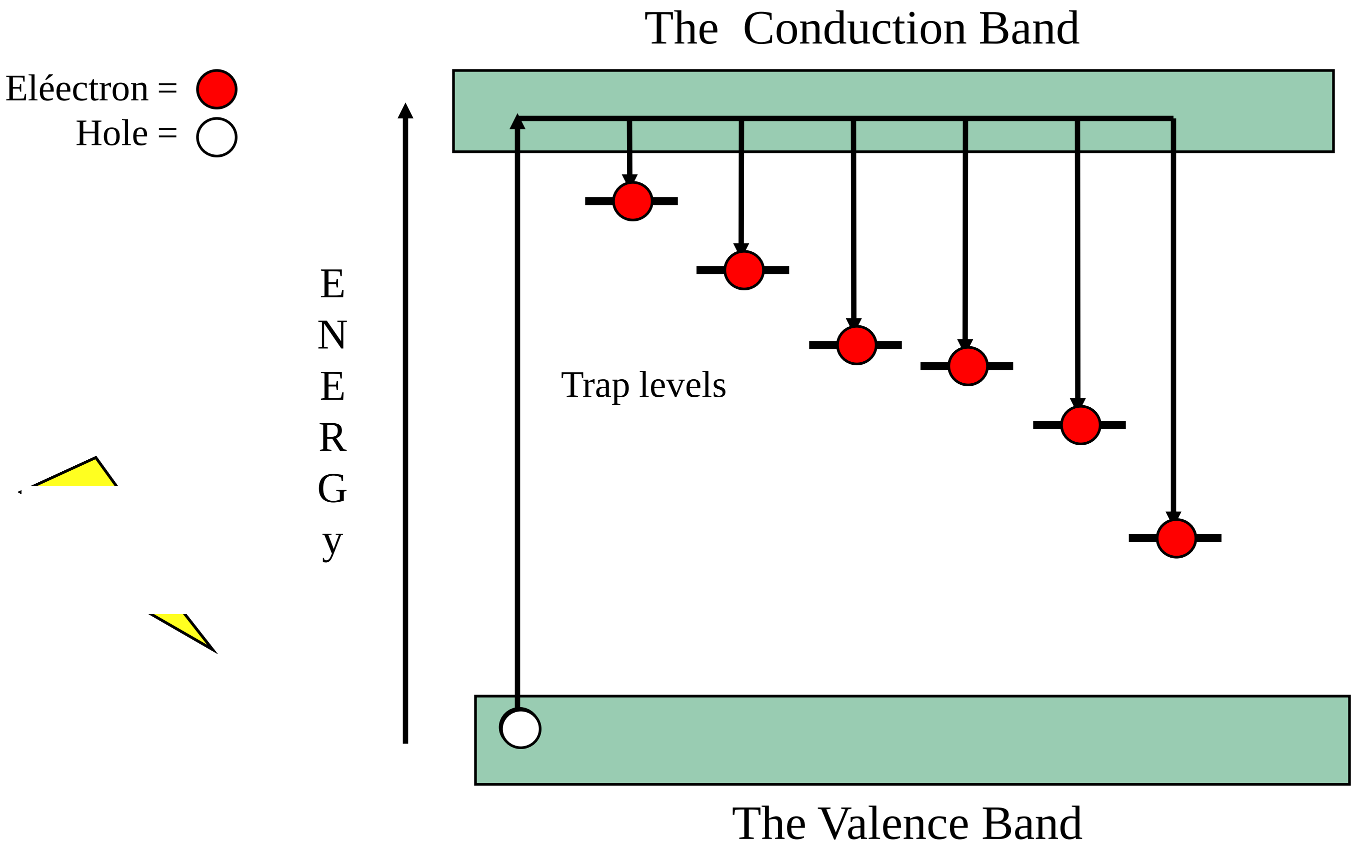
SOLID STATE DOSIMETRY

- Luminescent detectors (TLD, OSL, RPL)
- Semiconductor detectors
- EPR detectors
- Track detectors
- Gel dosimetry
- Superheated emulsions
- Radiochromic dyes

Thermoluminescent Dosimetry



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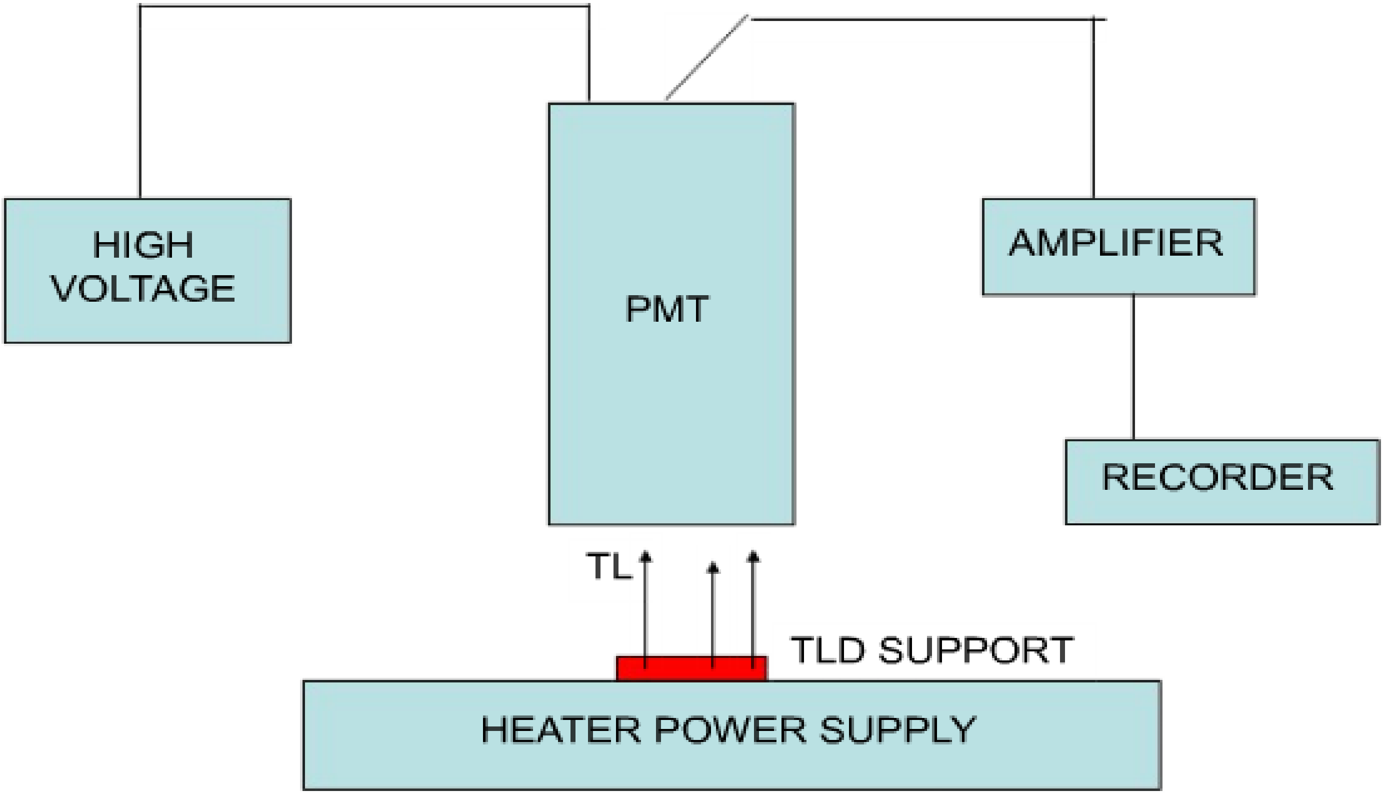

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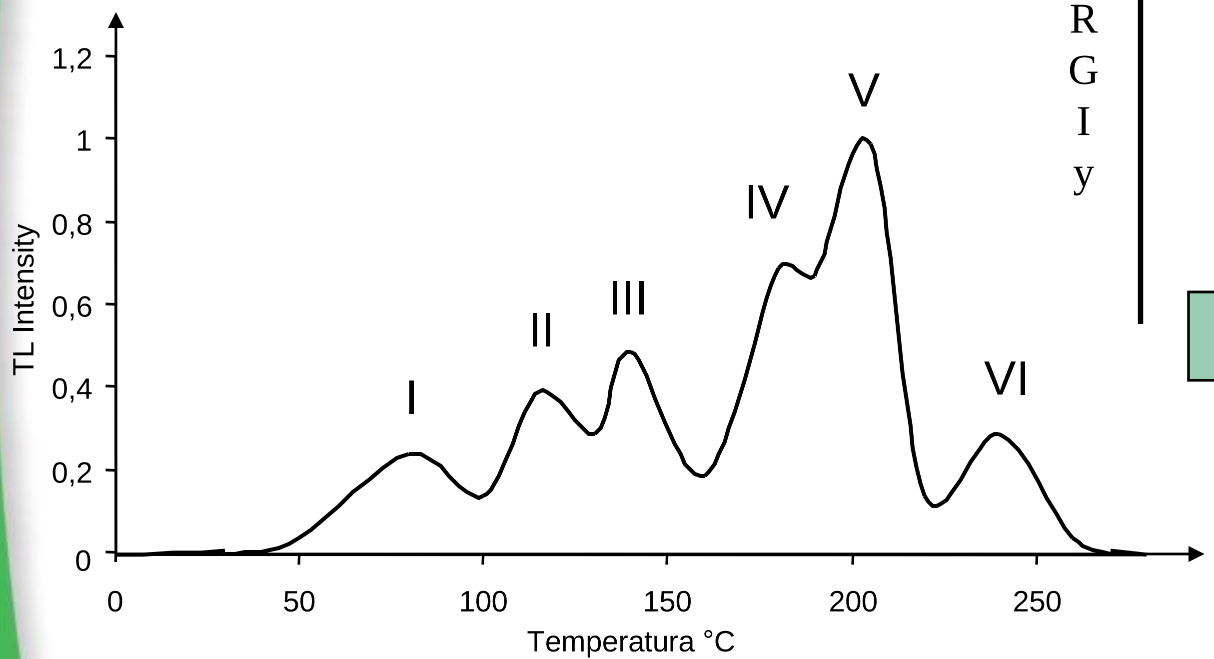
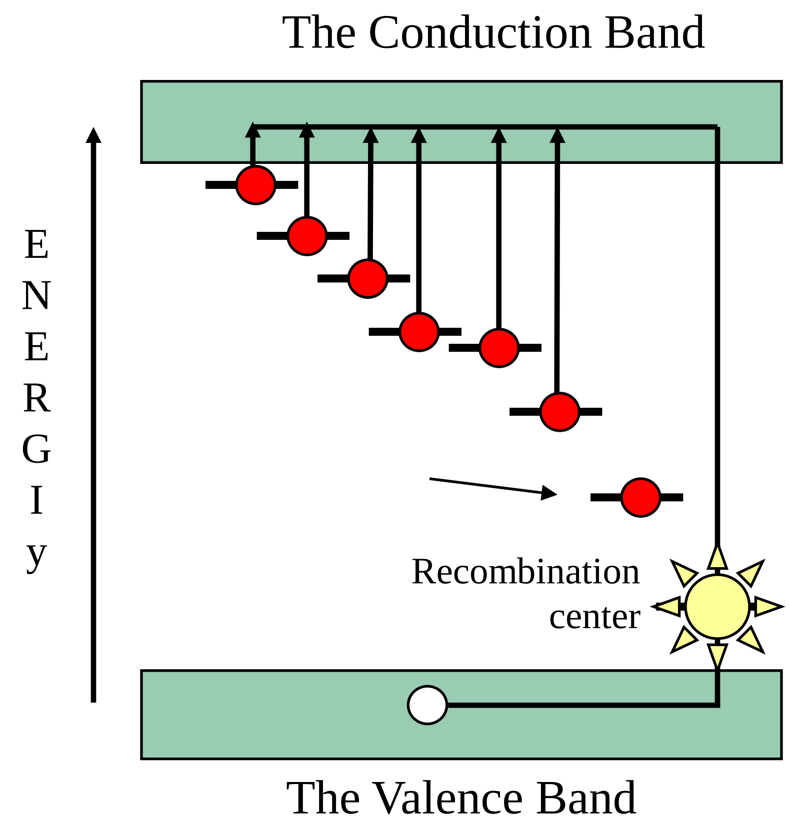
Termoluminescence (TL)

Glow Curve:





THERMOLUMINESCENT DOSIMETRY

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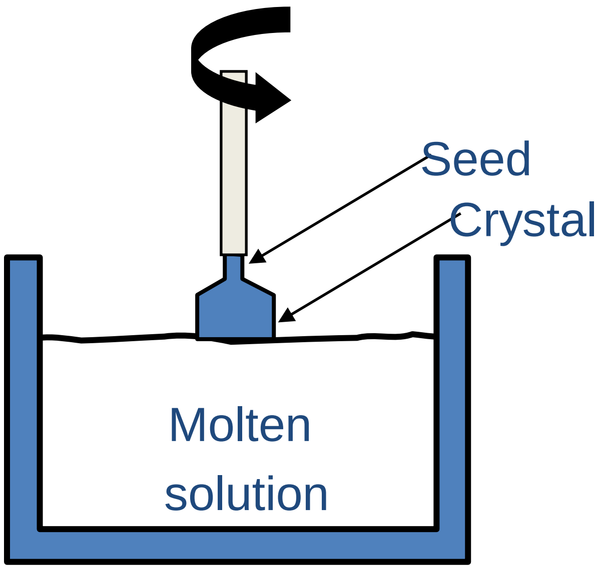
- LiF:Mg,Ti (TLD-100)
- LiF:Mg, Cu, P (GR-200)
- CaF_2
- $CaSO_4$:Dy
- $CaSO_4$:Tm
- $Li_2B_4O_7$
- MgB_4O_7:Dy
- MgB_4O_7:Tm
- Al_2O_3 ~1950
- α-Al_2O_3:C *Urals Politec. Inst. (Russia)*, 1990

CONVENTIONAL CRYSTAL GROWING TECHNIQUES

- Czochralski or Vernuil



Czochralski

Al_2O_3 F.P.= 2050ºC

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Combustion Synthesis

- Synthesis is based on the heat released from the redox chemical reaction (1500-6500K), instead of using high-temperature muffle furnaces.

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COMBUSTION SYNTHESIS

- 1 - The samples were prepared by mixing:
  - Aluminium nitrate ($Al(NO_3)_3.9H_2O$),
  - Urea ($CO(NH_2)_2$) as fuel
  - Dopants:
    - Europium nitrate ($Eu(NO_3)_3$)
    - Terbium nitrate ($Tb(NO_3)_3$)
    - TEOS ($C_8H_{20}O_4Si$)

- 2 - Evaporation of the excess water

- 3 – Sample was transferred to a pre-heated muffle furnace

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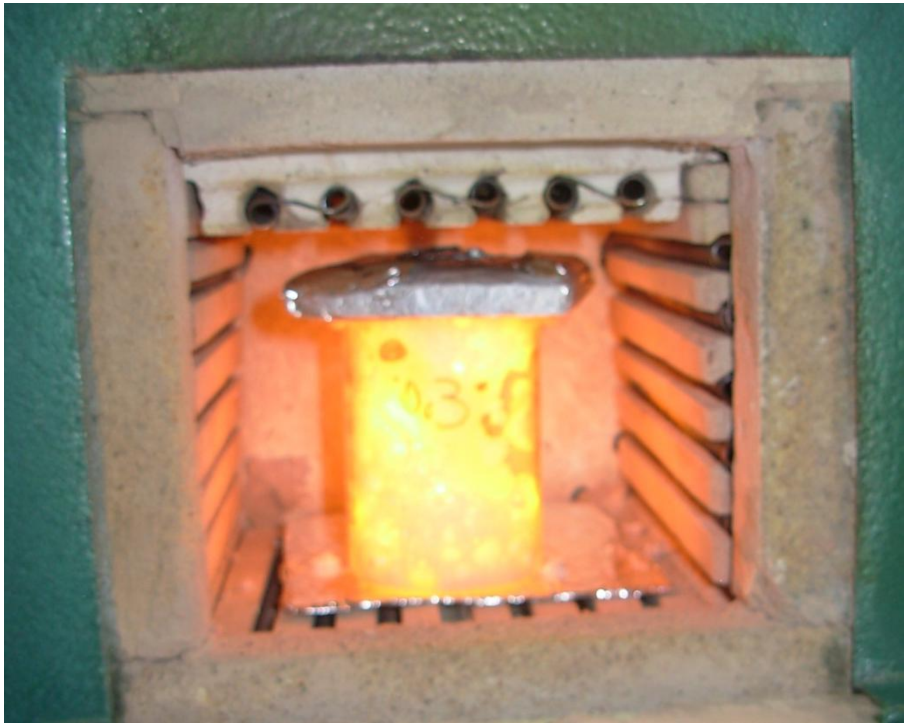
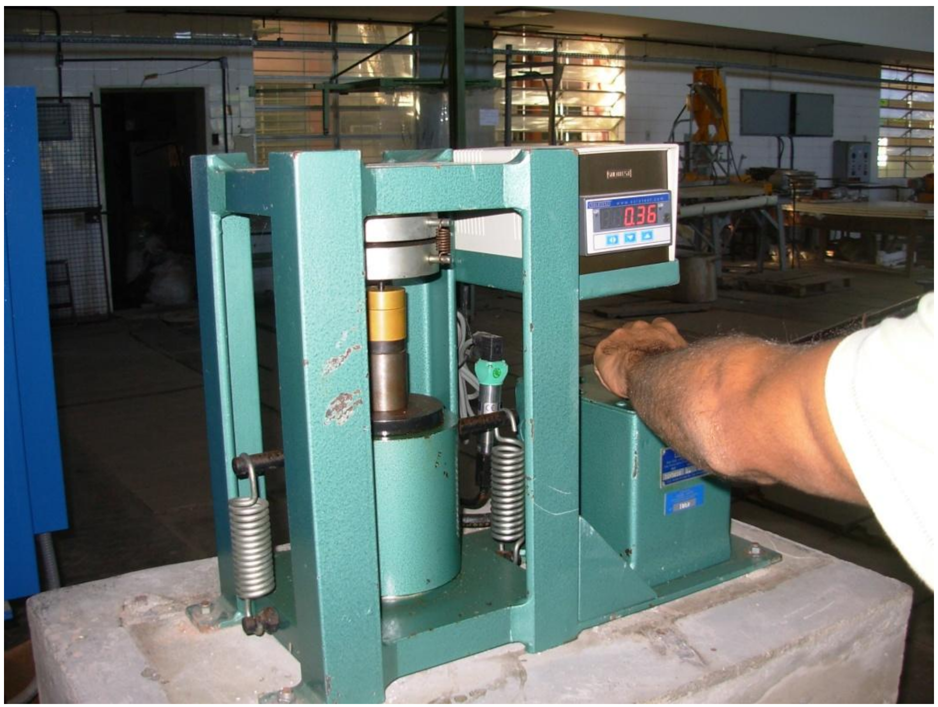
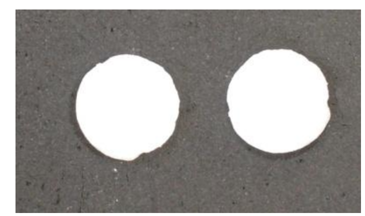
- 4 - Combustion after a few minutes



- Resulting material

- Samples are pelleted





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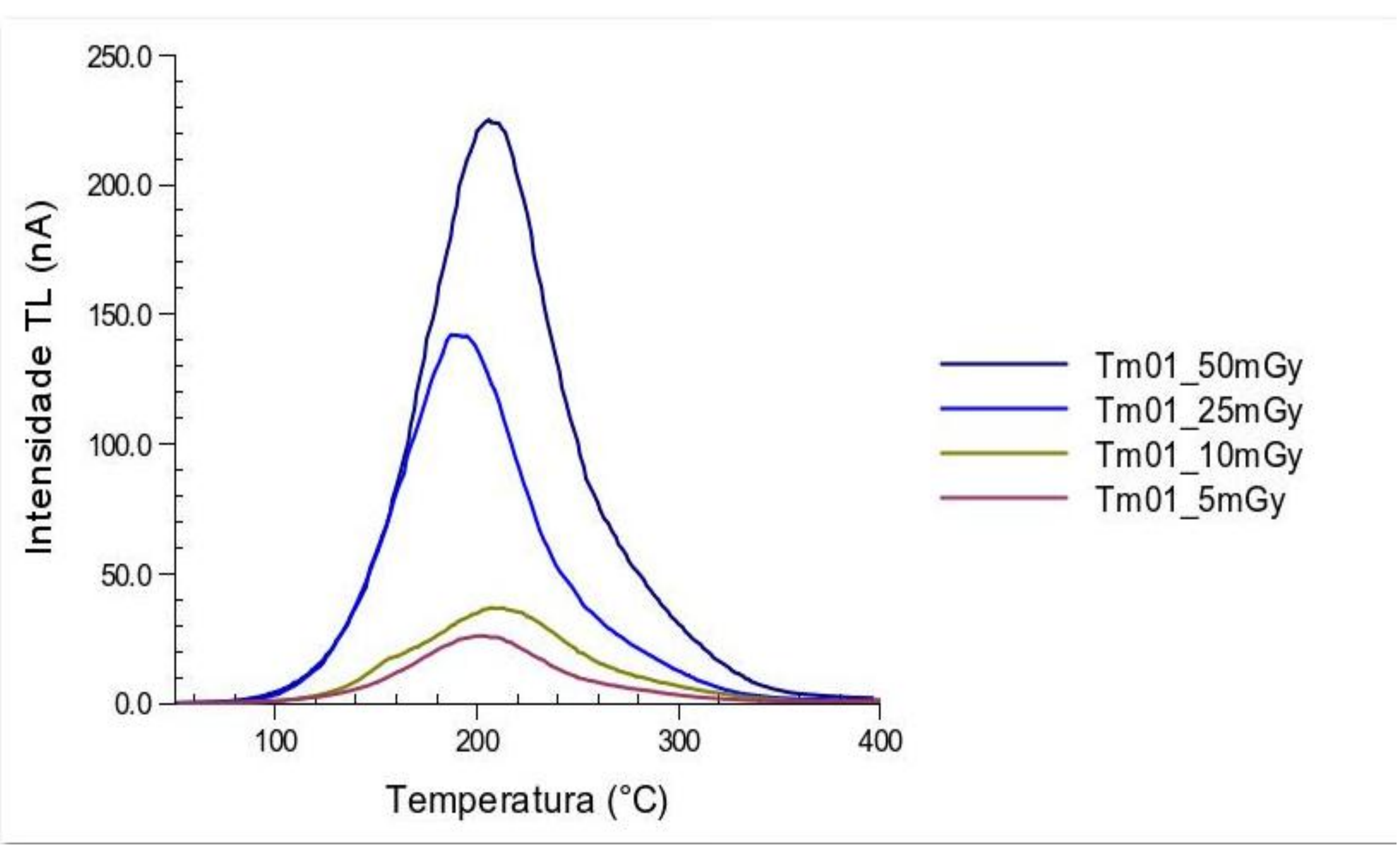
RESULTS



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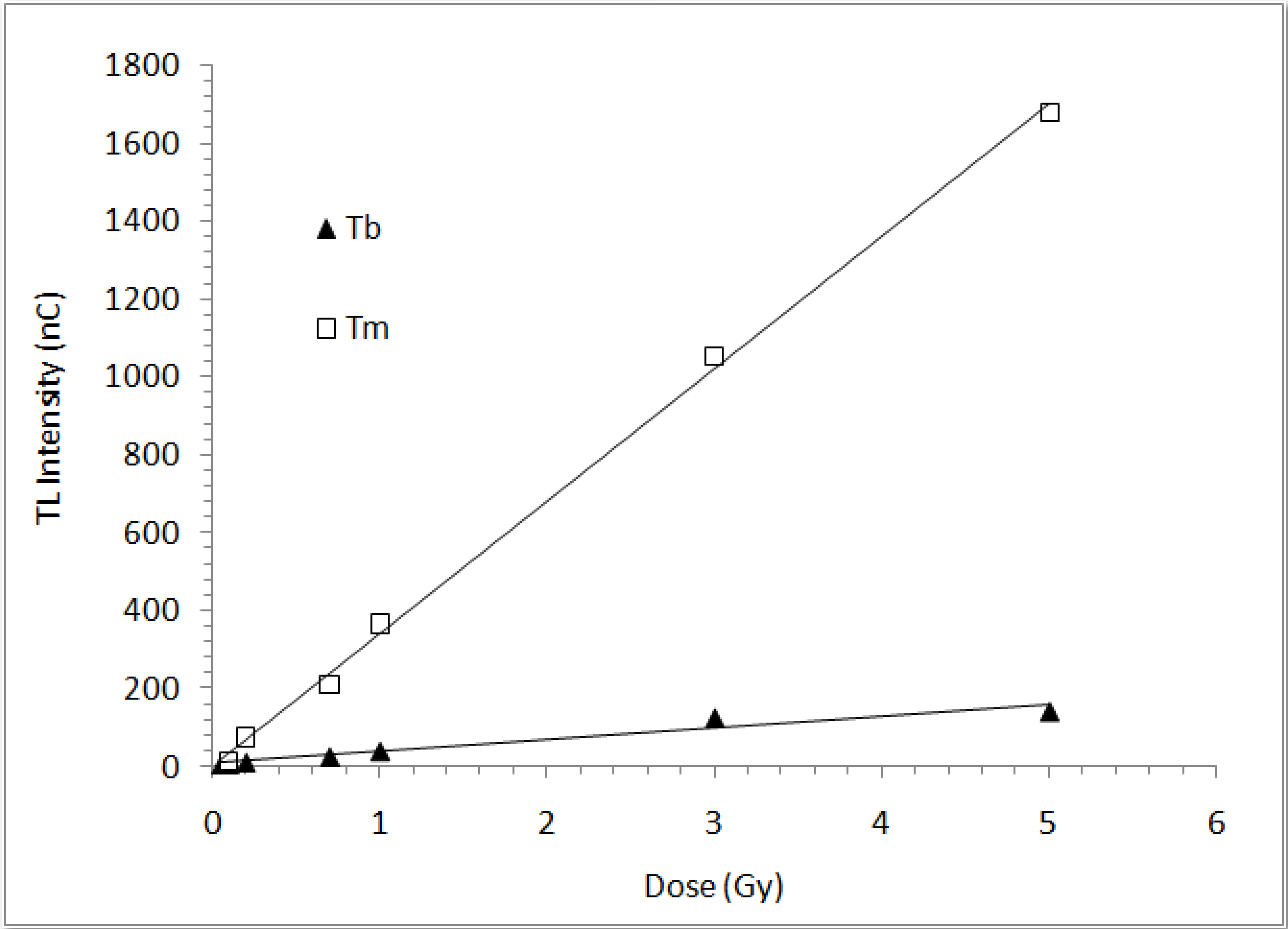
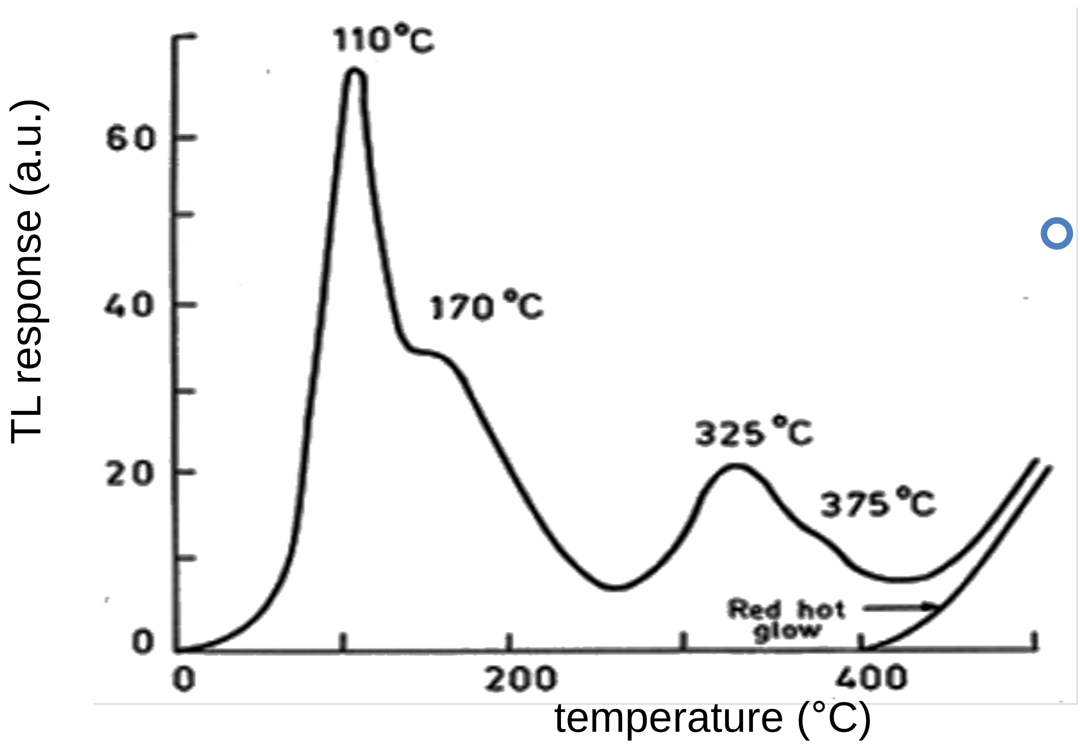


QUARTZ



- High temperature peak used for dating

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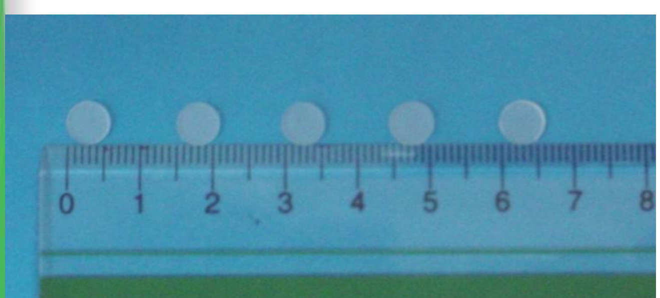
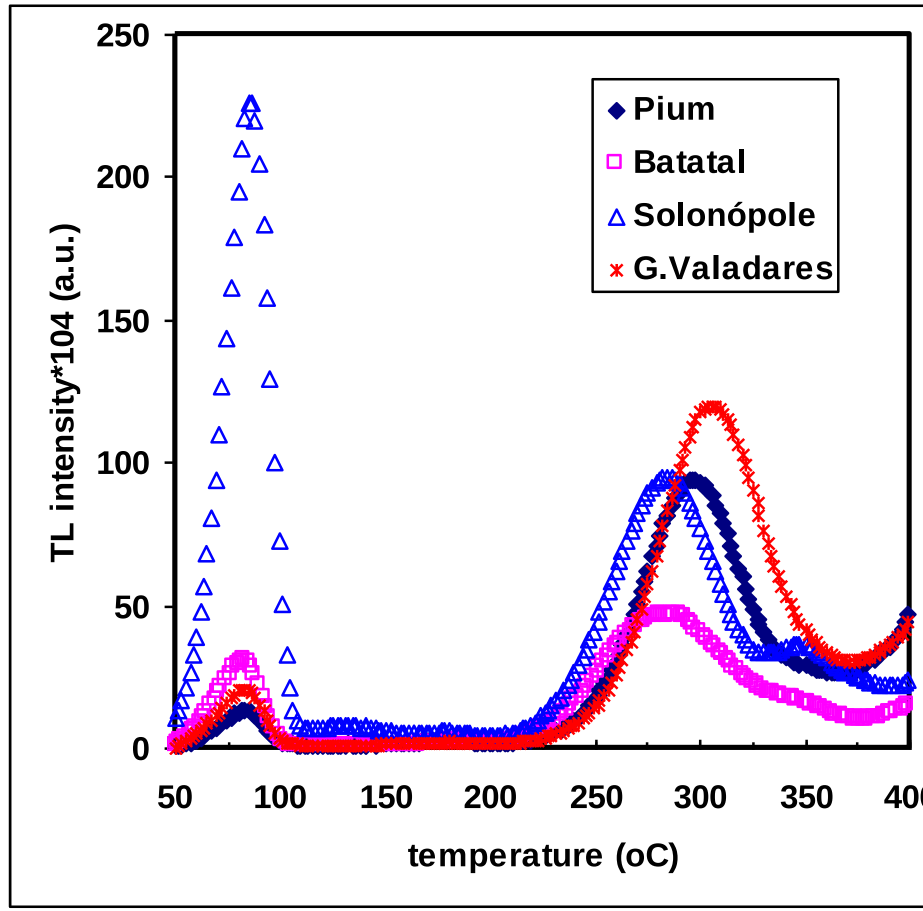
RECENT RESEARCHS

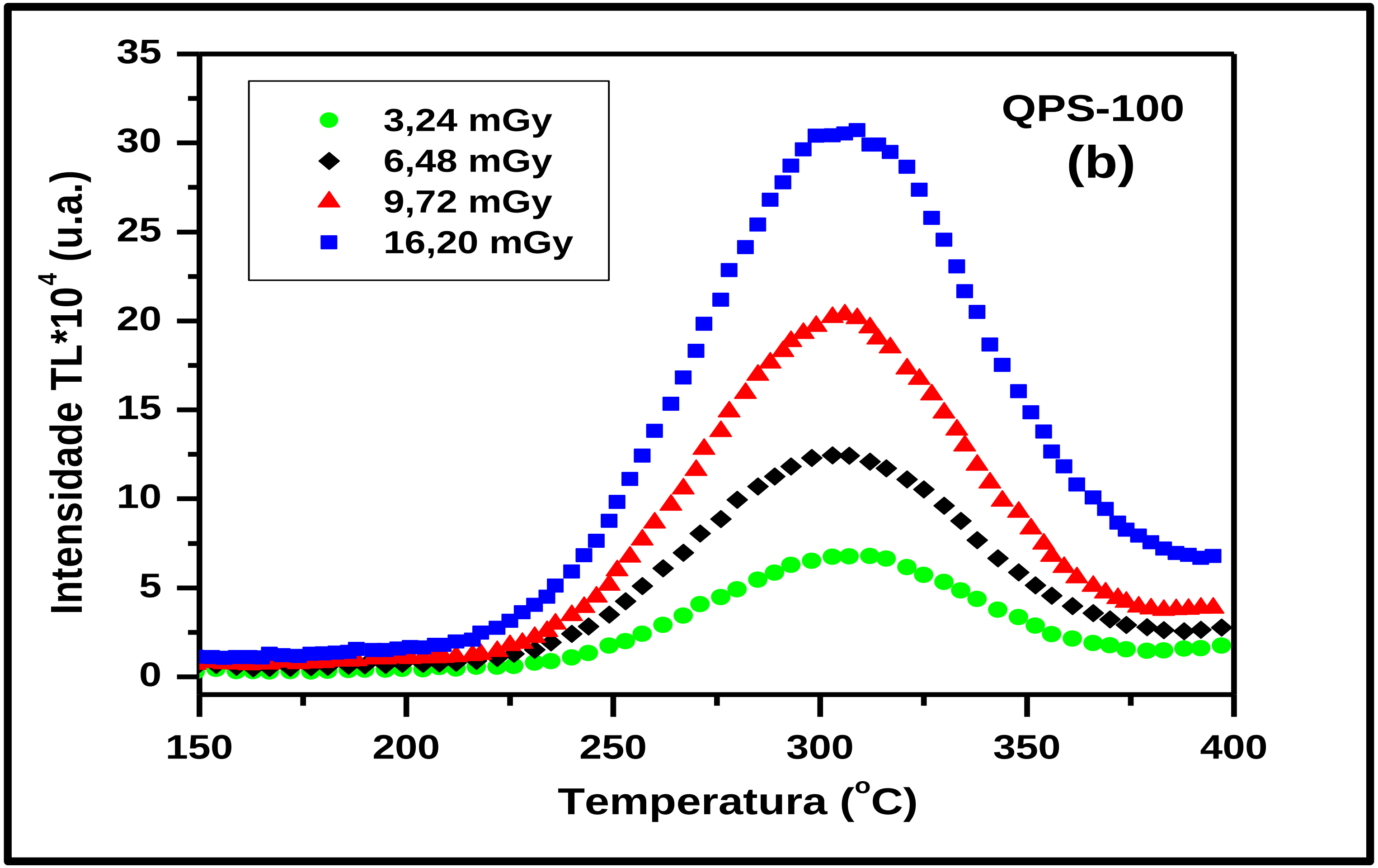
Natural quartz sensitized
by heat and gamma radiation





(KHOURY et al., *Radiation Effects and Defects in Solids*, v. 162, pp. 101-107, 2007

TL GLOW CURVE OF QPS-100 DOSIMETER IRRADIATED WITH X-RAY - MAMMOGRAPHY



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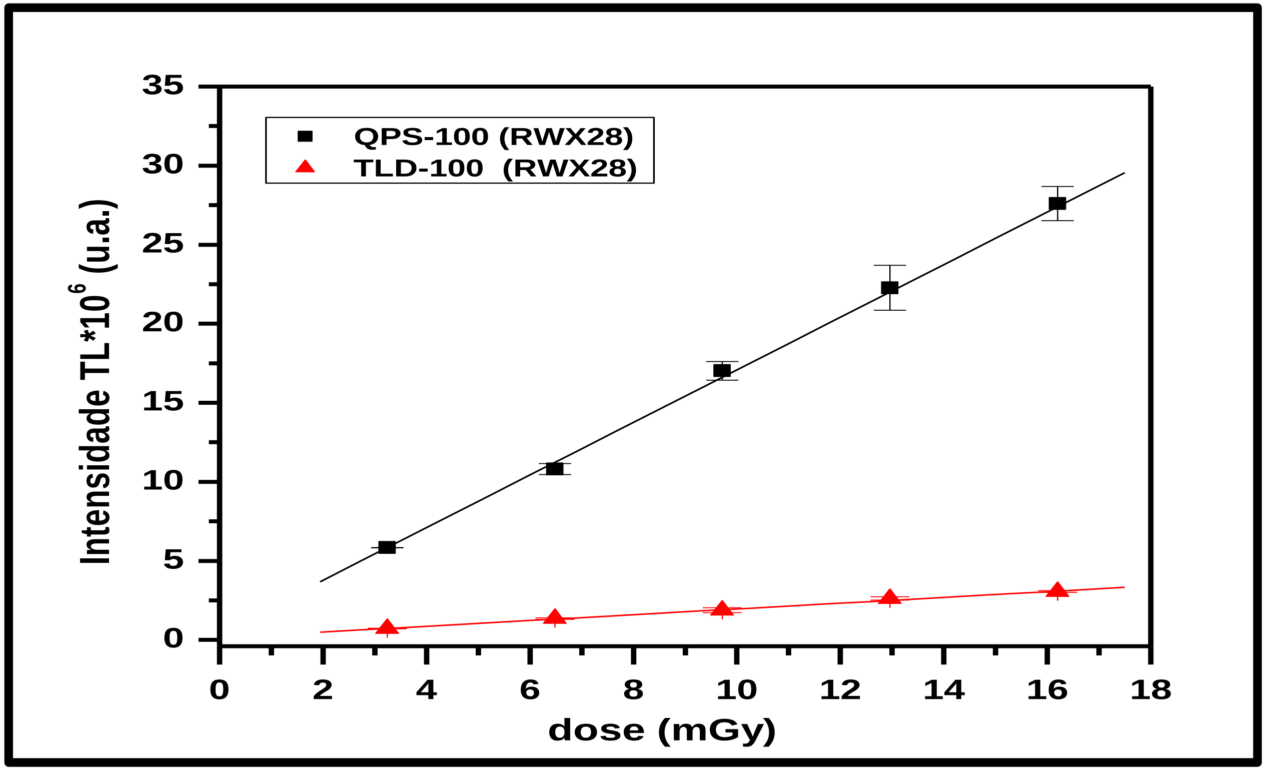
y = ax + b	QPS-100			TLD-100		
Beam	a	b	R^2	a	b	R^2
RXW28	1,663	0,448	0,997	0,182	0,135	0,999
RXW35	1,797	0,461	0,997	0,197	0,147	0,999



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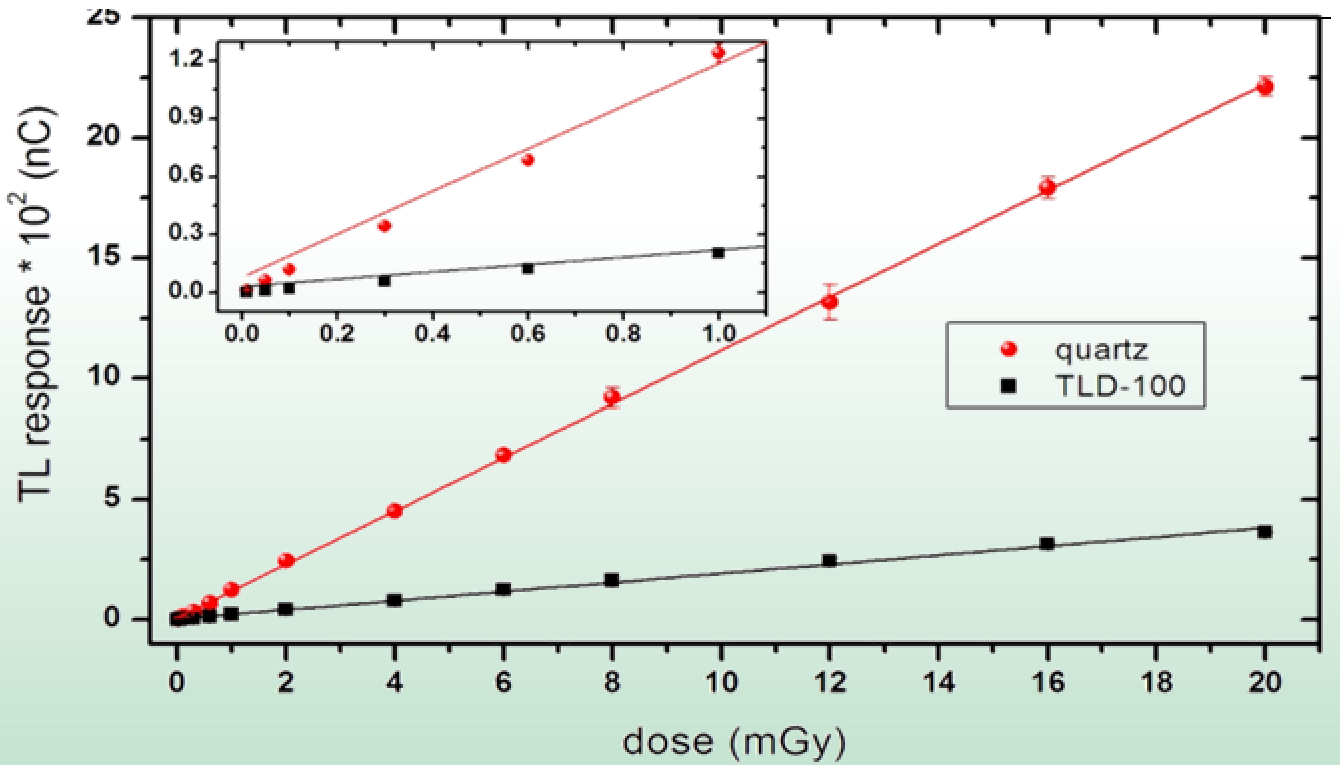
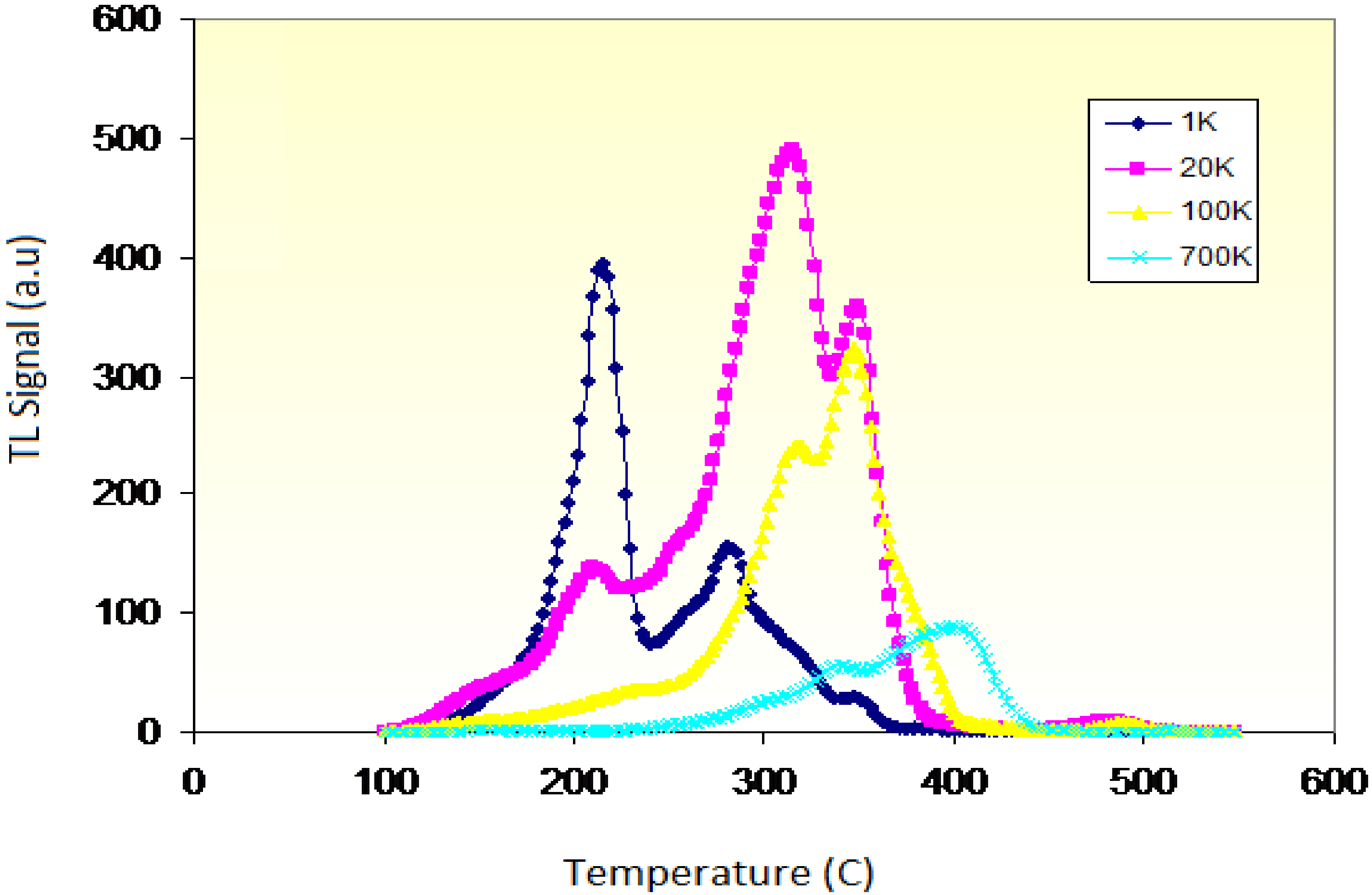


Dose response curve of Solonópole quartz to γ rays of ^{137}Cs.

HIGH DOSES DOSIMETRY



TL Response of the dosimeter MTS irradiated with gamma radiation of Co-60

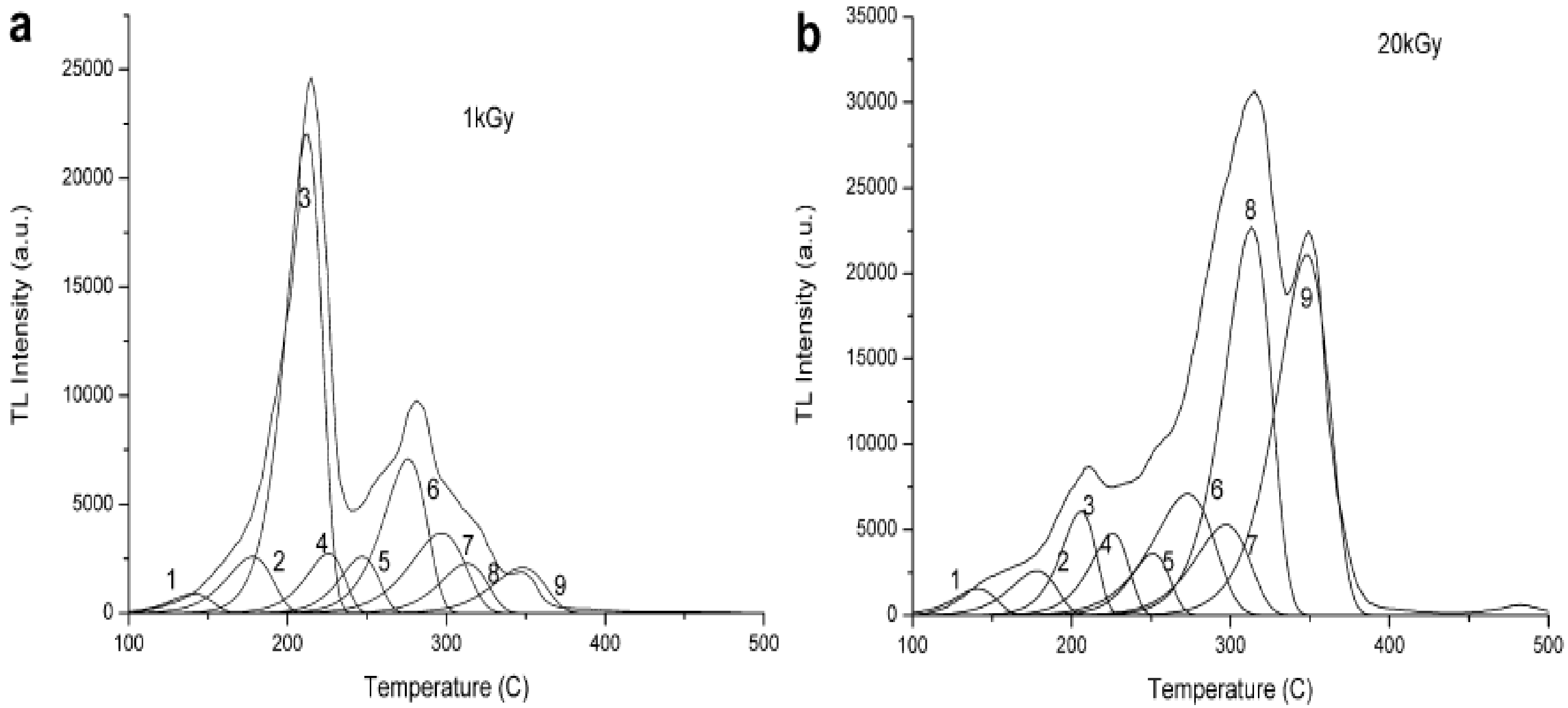
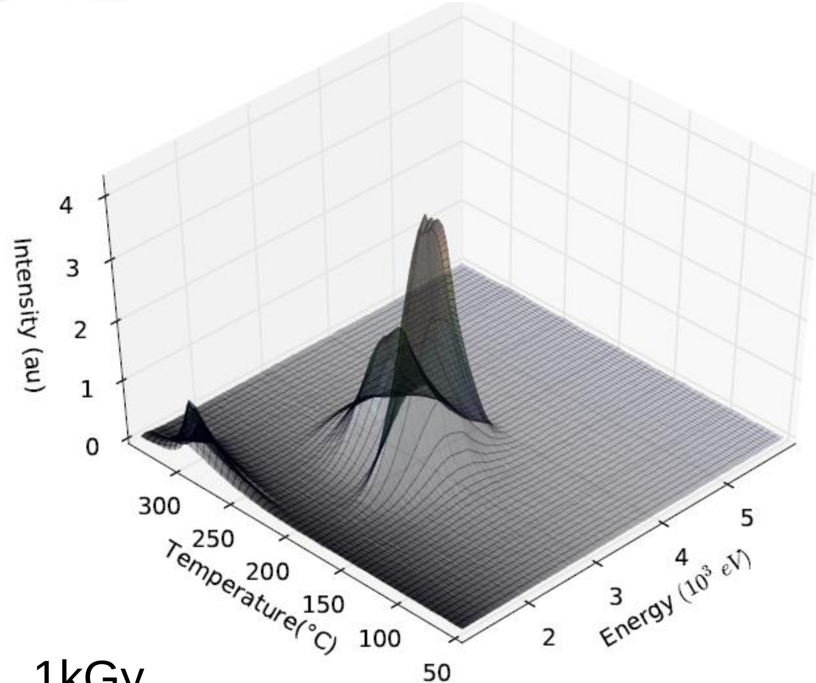


Fig. 3. Fully deconvoluted glow curves of MTS dosimeters at gamma doses of (a) 1 kGy and (b) 20 kGy.

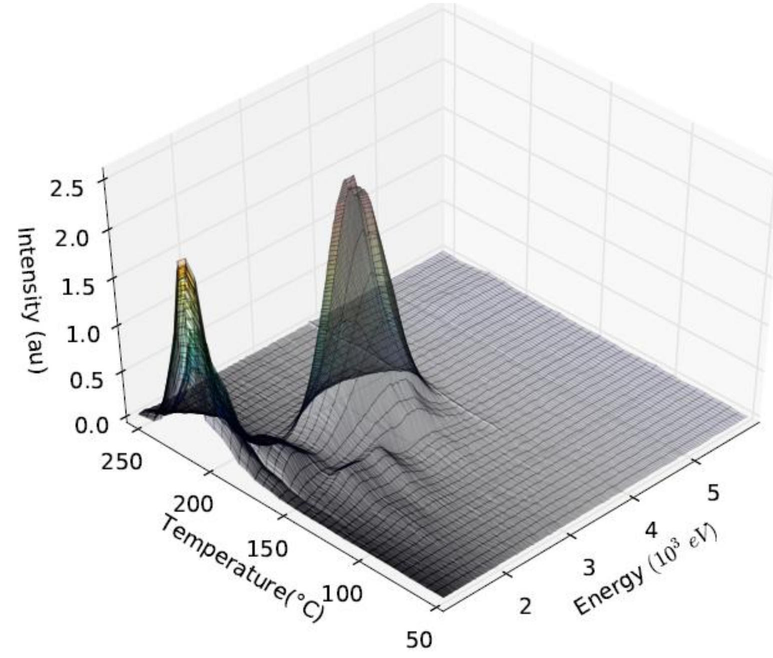
H.J. Khoury a,*, B. Obryk b, V.S. Barros a, P.L. Guzzo c, C.G. Ferreira a, P. Bilski b, P. Olko - Radiation Measurements 46 (2011) 1878e1881

EMISSION SPECTRA MTS



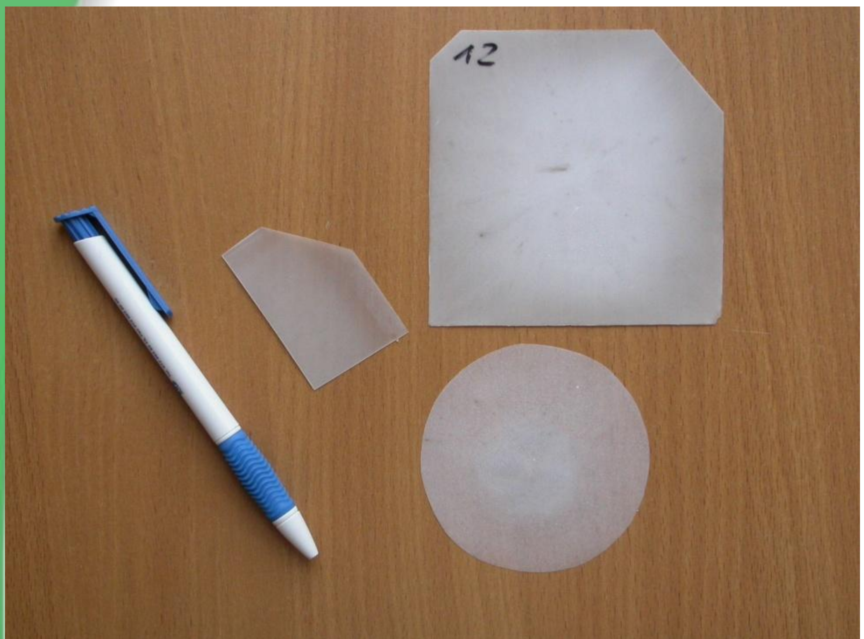
1kGy

80 kGy

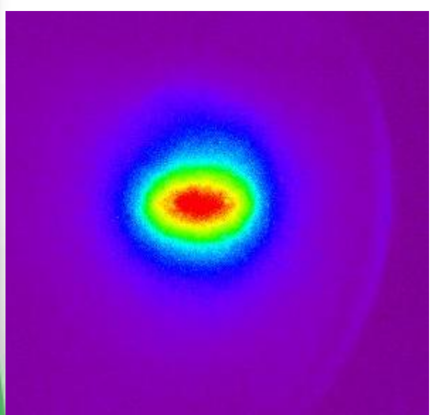


TL system for 2-D dosimetry for radiotherapy

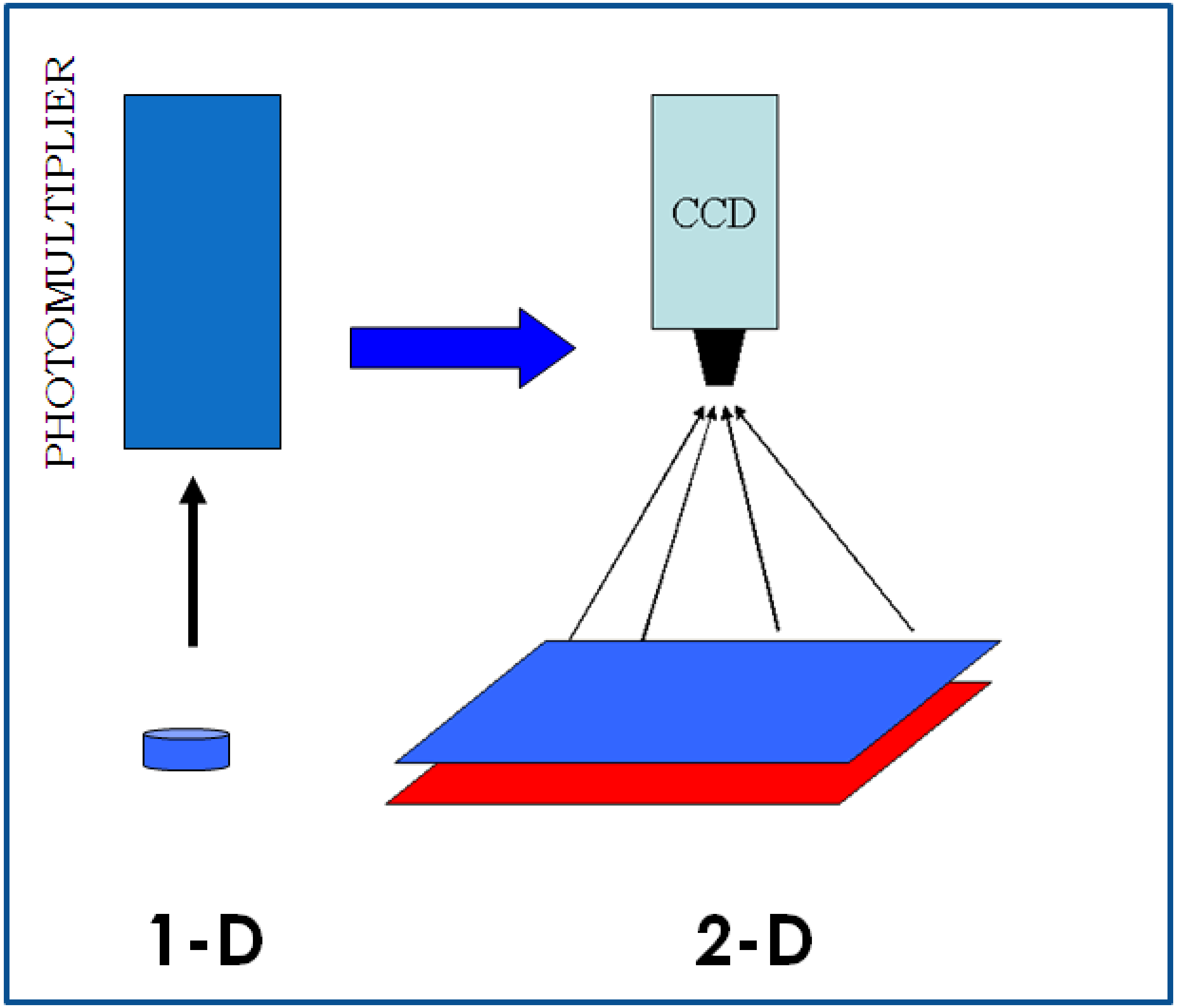
TLD foils



TLD reader with CCD camera



Measured 2-D dose distribution



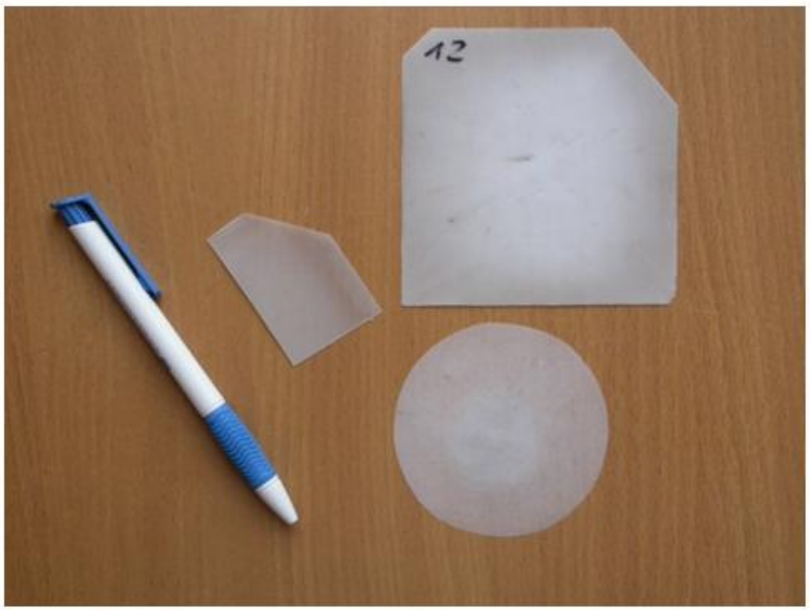
Thermoluminescent TL reader with CCD camera developed at IFJ

R. Kopec-SSD-17

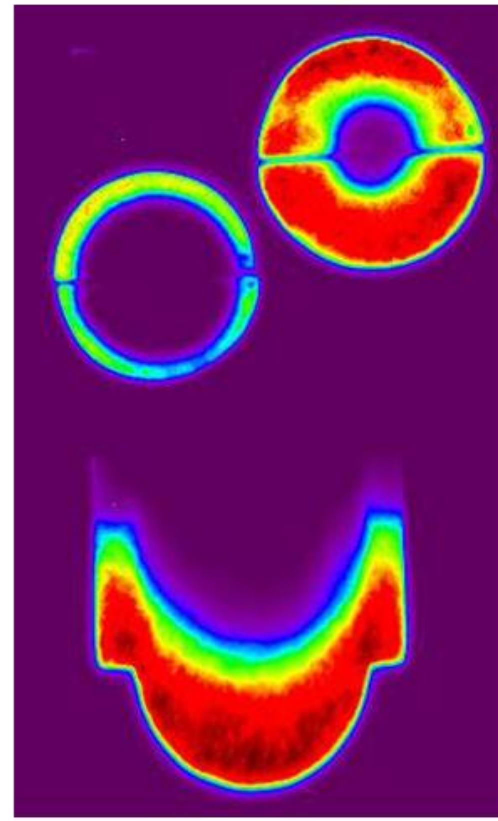
-Type : MCP-N (LiF:Mg,Cu,P) powder with ETFE

-Shape: square 30 mm x30 mm and thickness 0.3 mm

-Spatial resolution: 0.1 mm



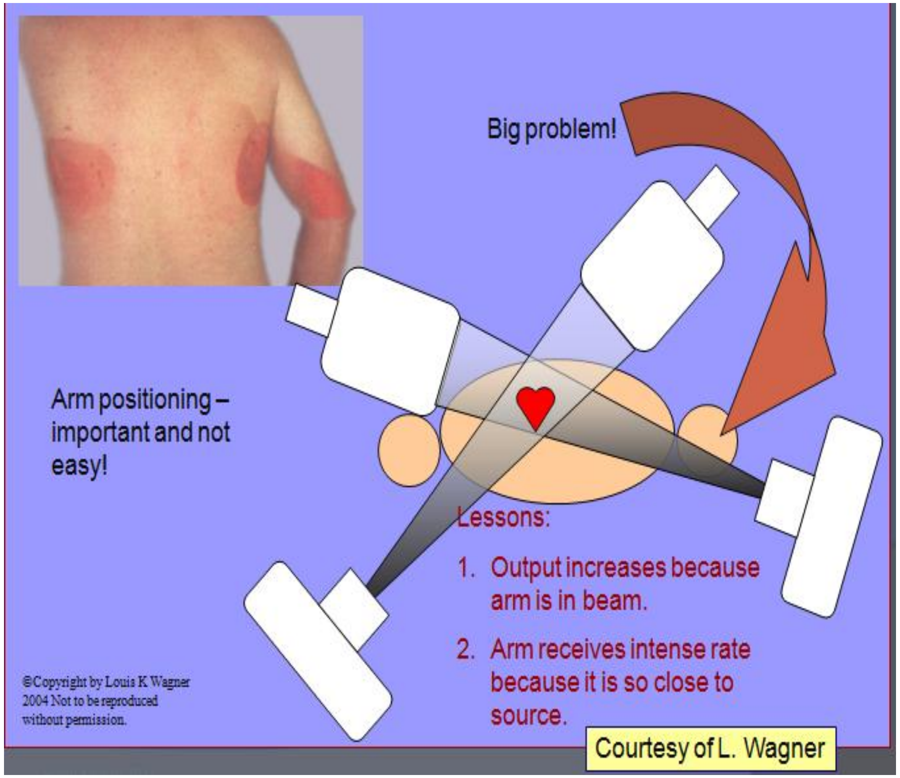
Thermoluminescence foils



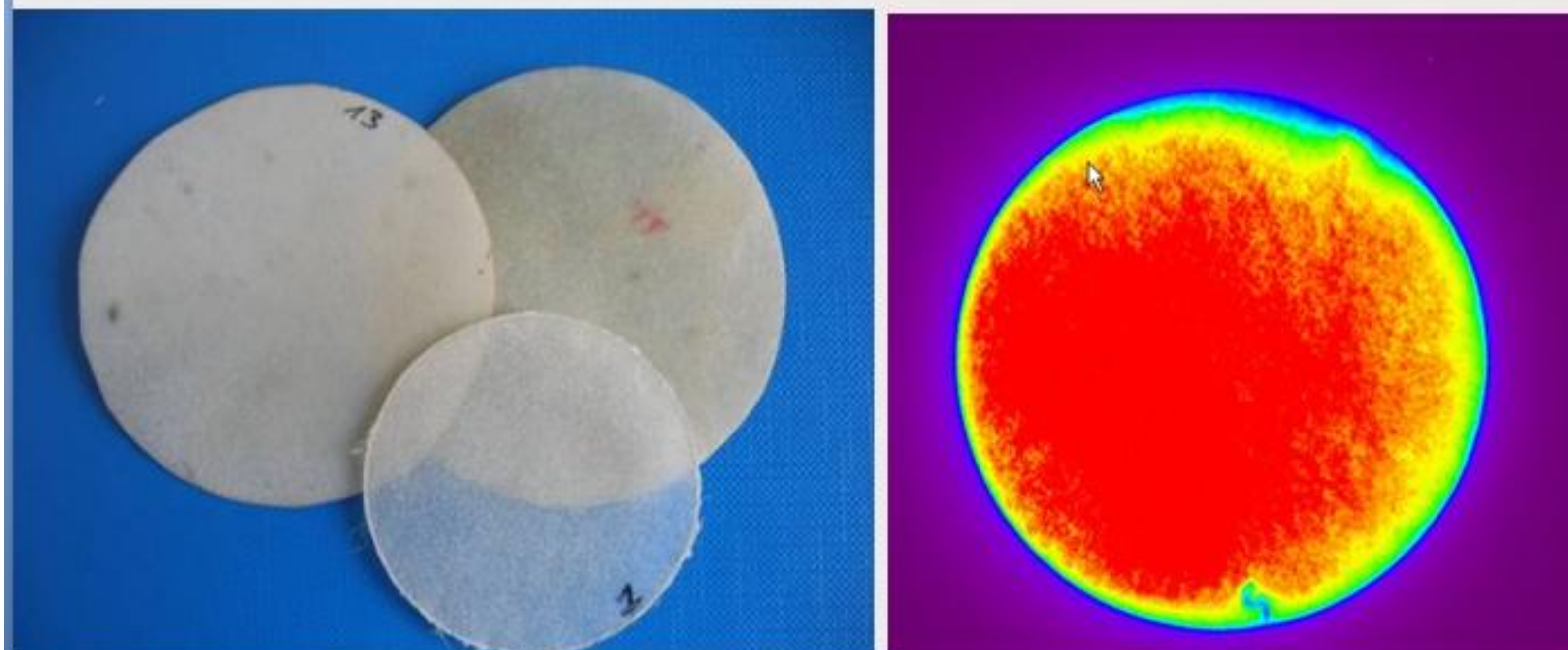
Examples of 2D images - dose distribution.

Mariusz Klosowski, IFJ PAN


Superior Direito
Superior Esquerdo
2 Gy
4 Gy
< 0,5 Gy
0,5 Gy
0,5 Gy
1 Gy
4 Gy
1 Gy
2 Gy
1 Gy
0,5 Gy
0,5 Gy


Big problem!
Arm positioning – important and not easy!
Lessons:
1. Output increases because arm is in beam.
2. Arm receives intense rate because it is so close to source.
©Copyright by Louis K Wagner 2004 Not to be reproduced without permission.
Courtesy of L. Wagner

2D TLD film
for characterization of clinical proton beams



Olko *et al*, 2004

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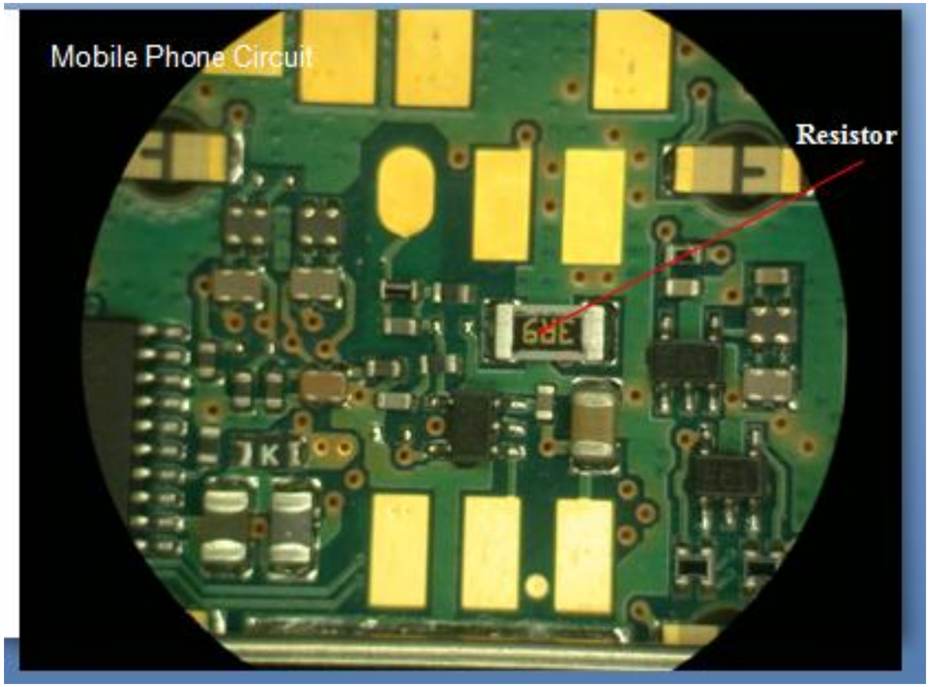
Retrospective Dosimetry



Ian Bailif-SSD-17-2013

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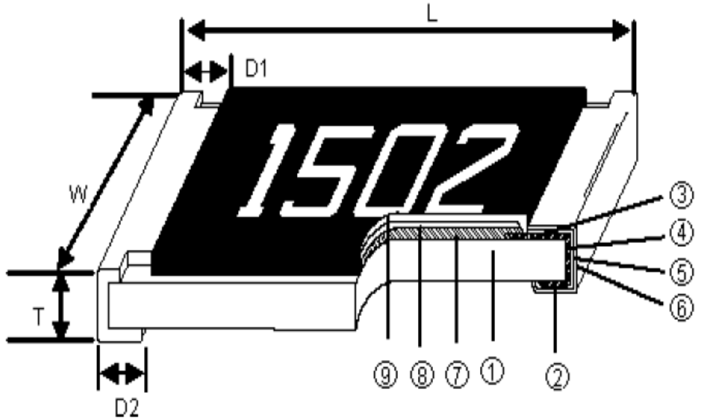
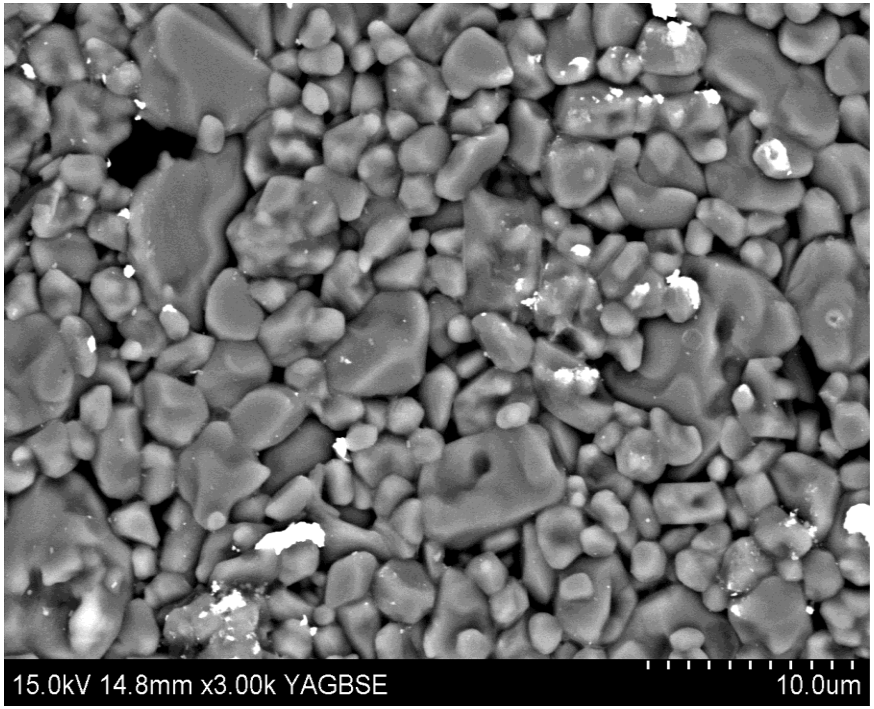
Construction of thick-film chip resistor

Ian Bailiff 2013



1	Alumina Substrate
2	Bottom Electrode (Ag-Pd)
3	Top Electrode (Ag)
4	Edge Electrode (NiCr)
5	Barrier Layer (Ni)
6	External Electrode (Sn)
7	Resistor Layer (RuO_2/Ag)
8	Primary Overcoat (Glass)
9	Secondary Overcoat (Epoxy)



SEM image: BSE

Table 1 | *Compilation of the main characteristics of all materials usable for retrospective and/or accident dosimetry, using luminescence techniques. The fading rates of capacitors and integrated circuits are reported here for measurements at room temperature without preheat. Tooth enamel and dental ceramics are not listed in this table, as only an (not yet existing)* in vivo *application would be useful for these materials*

Materials	Zero dose signal	Dose response	Fading	Minimum detectable dose (mGy)	Type of dose	Ubiquity	Processing time
Bricks, tiles, porcelain	No	Linear up to several Gy	No	25	local	high	Days to weeks
Cement, mortar	No	Linear up to several Gy	No	> 100	local	high	Days to weeks
Chemicals	< 10 mGy	region of linearity dependent on material	Negligible for most materials	1-20	local	moderate	< 1 h
chip cards with translucent encapsulation	Yes (TL) No (OSL)	Linear up to 7 Gy	70-80% in 10 days	3-20	individual	low	< 1 h
Alumina rich resistors	No	Linear up to 90 Gy	50% in 10 days	< 10	individual	high	< 1 h
Capacitors	No	Linear up to 160 Gy	50% after 10 h	< 700	individual	moderate	< 1 h
Integrated circuits	No	Linear up to 160 Gy	50% after 10 h	< 700	individual	high	< 1 h
Glass in monitor displays	Yes/No	Linear up to 200 Gy	40% in 1 day, slow decay after	< 1000	individual	high	< 1 h
Watch glasses	Yes/No	Linear up to 200 Gy	40% in 1 day, slow decay after	< 1000	individual	high	< 1 h

Ian Bailif-SSD-17-2013

FUTURE WORK

- ► Investigation of luminescence mechanisms
- ► Optimum procedure for determining absorbed dose
- ► Convert dose in chip to dose in air (computational modeling and phantom irradiation)
- ► Blind tests with irradiated phones in known gamma radiation field
- ► Interlaboratory comparisons (EURODOS group)

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Optically Stimulated Luminescence is a related phenomenon in which the luminescence is stimulated by the absorption of optical energy rather than thermal energy

OSL- Optically Stimulated Luminescence

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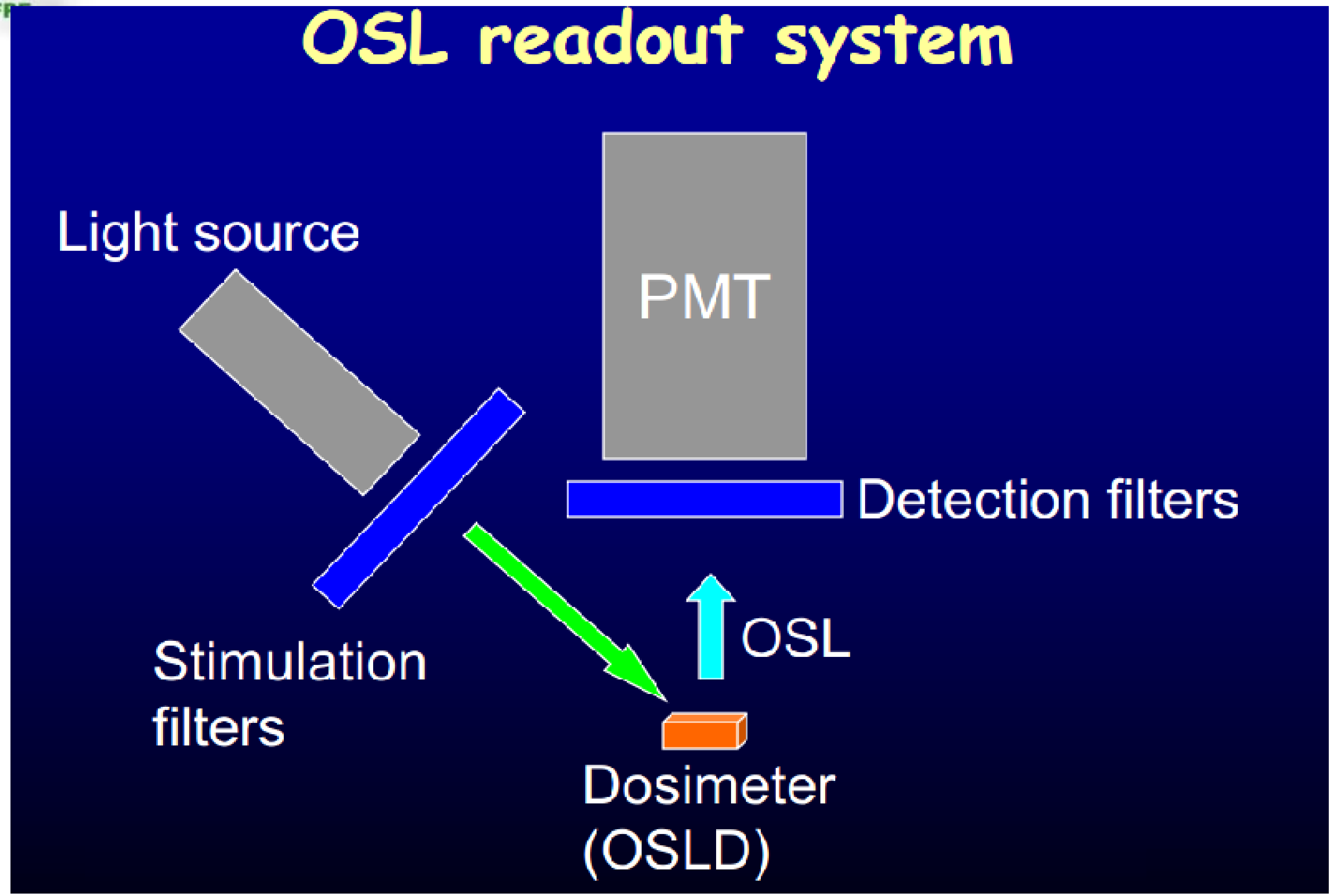
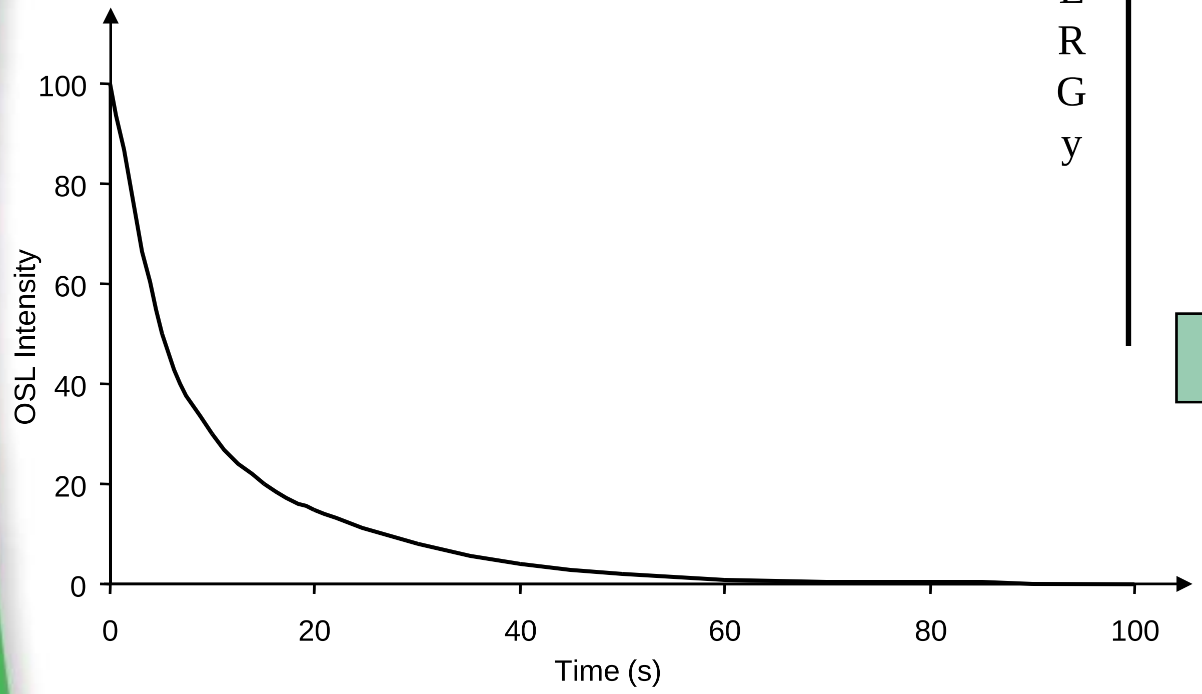
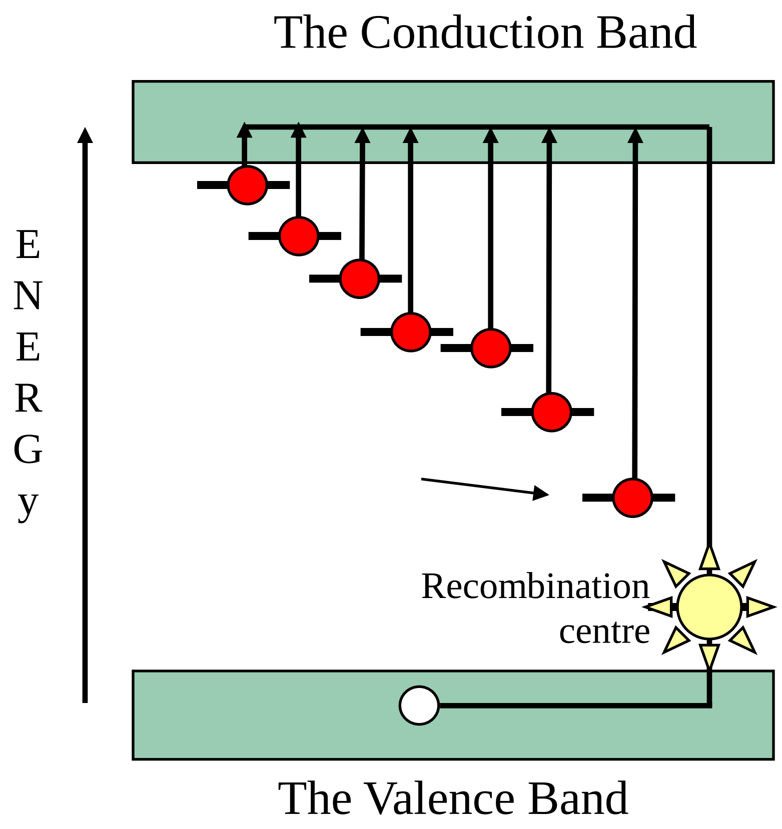


OPTICALLY STIMULATED LUMINESCENCE





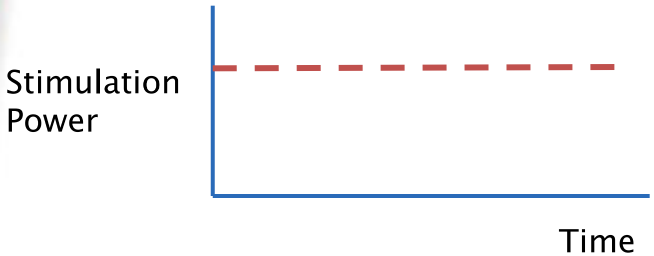
Methods of OSL stimulation

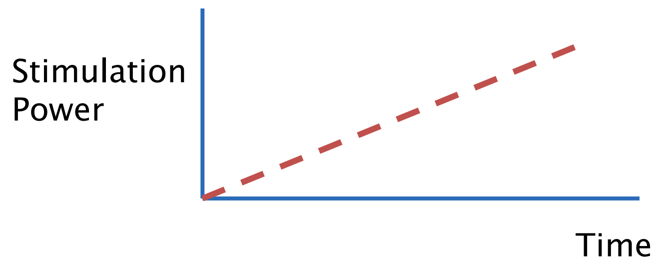
- CW-OSL (continuous wave OSL)
- POSL (pulsed OSL)
- LM-OSL (linearly modulated OSL)

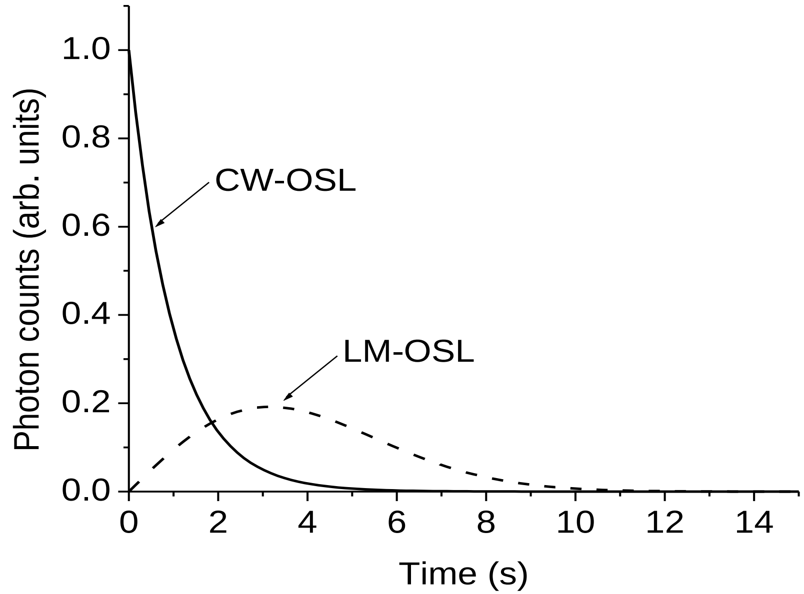
OPTICALLY STIMULATED LUMINESCENCE

Modulate the stimulation intensity. Either:

Constant – **CW–OSL** or Linear increase – **LM–OSL**







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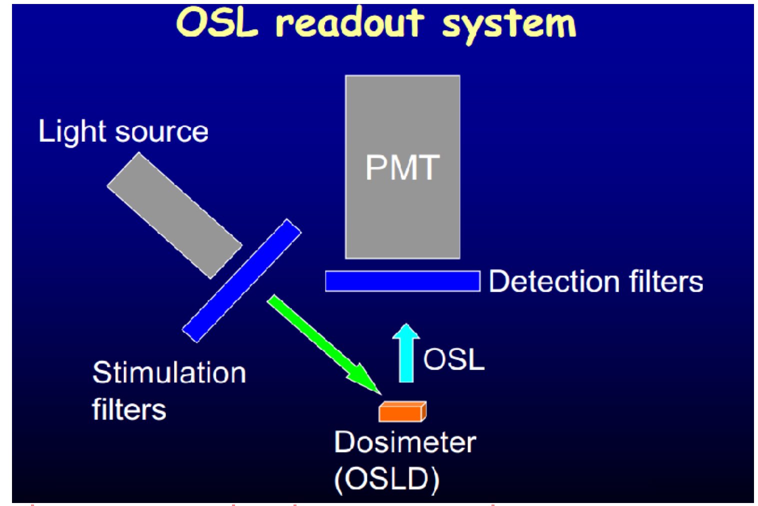
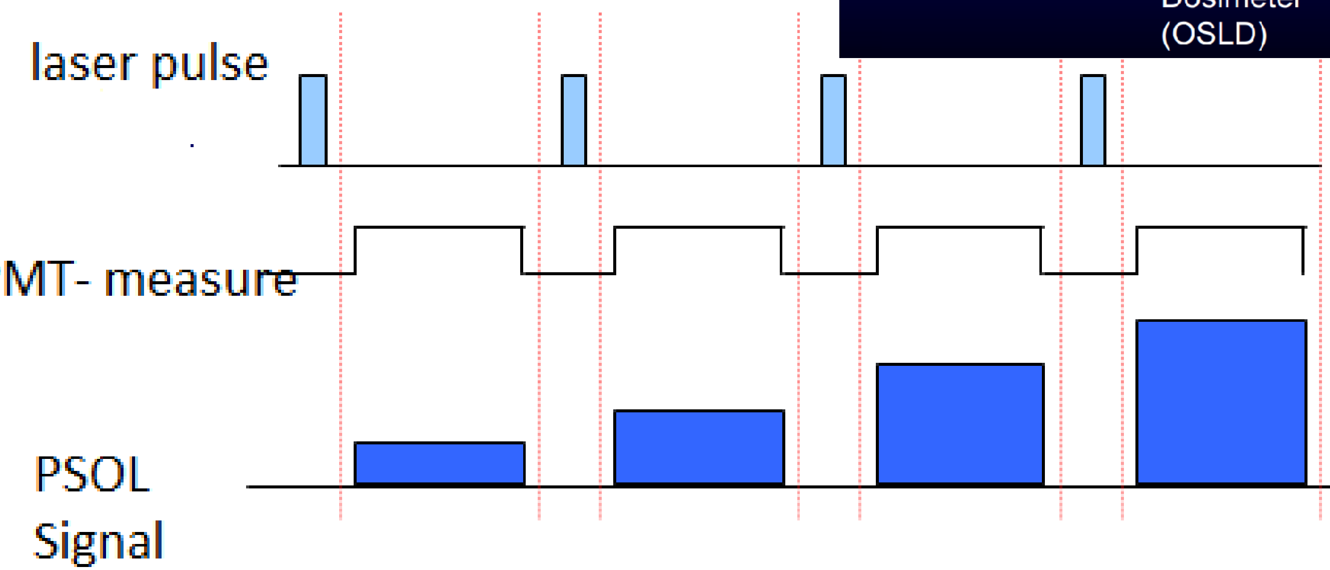
Optically Stimulated Luminescence

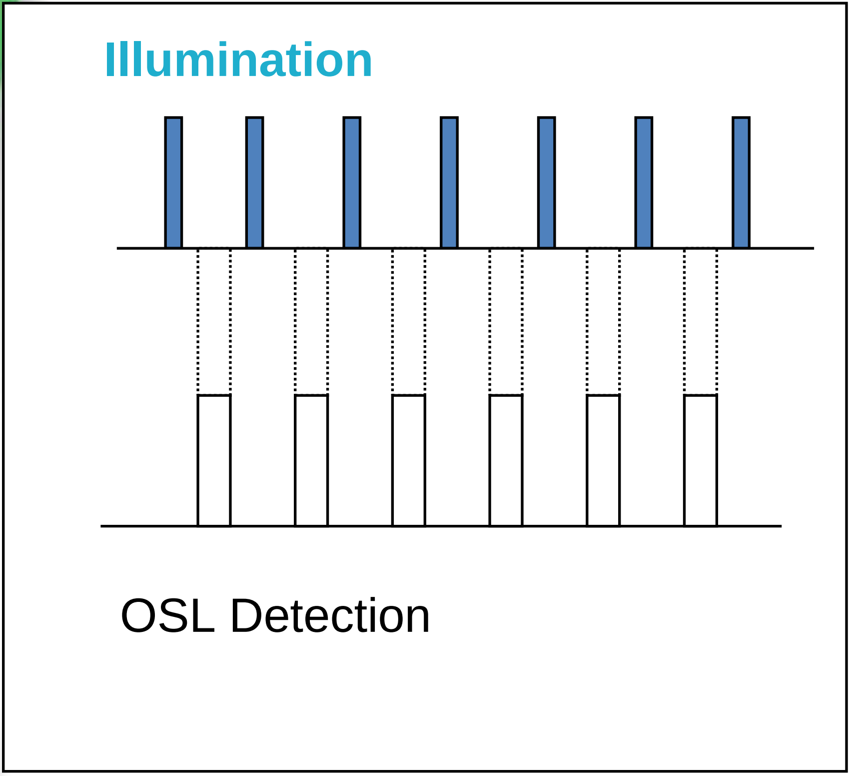


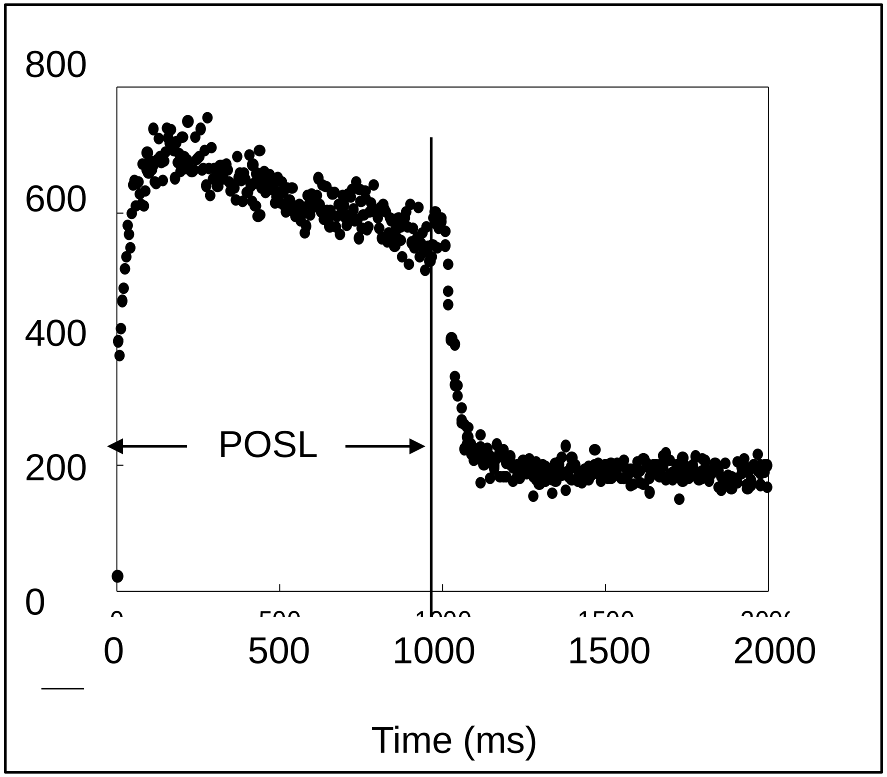
<u>Pulsed</u> – POSL



Optically Stimulated Luminescence

……or Pulsed – **POSL**





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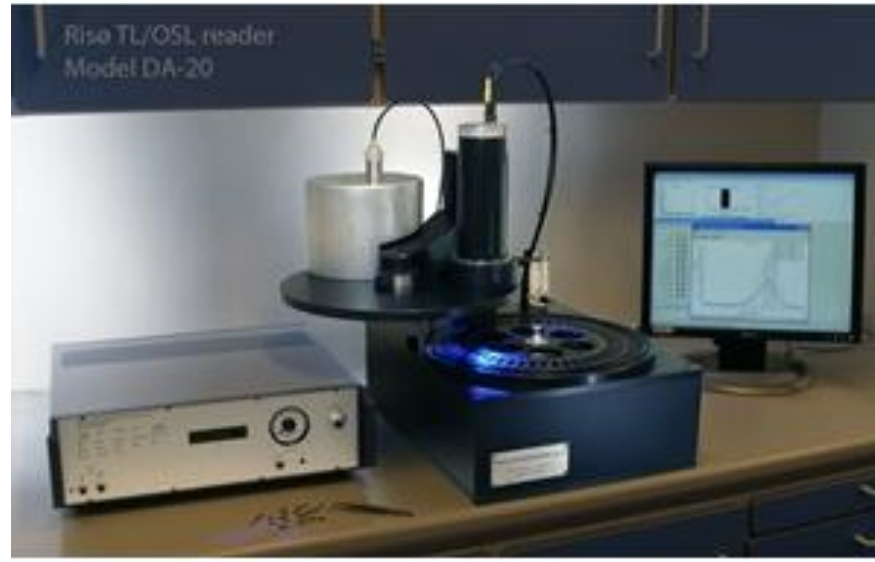
OSL EQUIPMENT

Risø DTU



Landauer

Lexsyg

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HOMEMADE READER

GDOIN-DEN-UFPE

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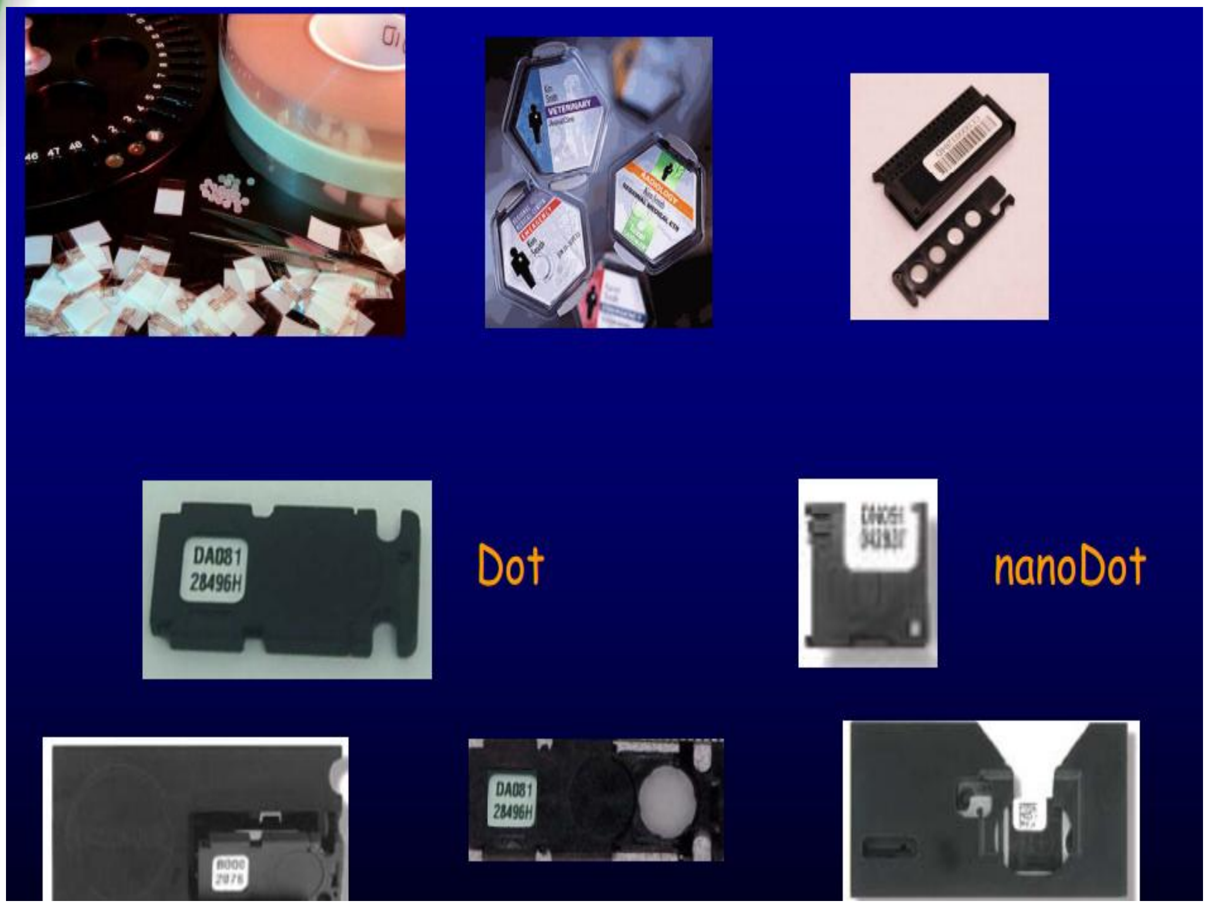
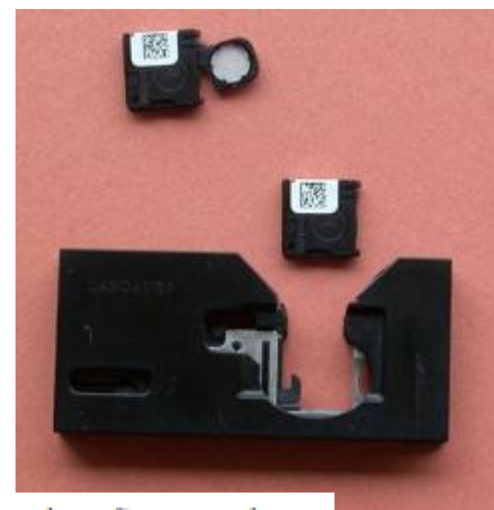
OSL DOSIMETERS

: OSL strip and dosemeters.





The new 'nanoDot' and adaptor for readout in the microStar reader.

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OSL DOSIMETRY

Advantages

- High sensitivity
- High precision
- Size
- Convenience
- Readout flexibility
- Fast, non-destructive readout
- Narrow stimulating beams may could allow dose mapping
- No significant fading - dose storage
- No need for annealing
- Although it can be bleached and re-used if needed*

Disadvantages

- Sensitivity to light
- Non-tissue equivalent – energy dependence
- Only 1 material currently available (only 1 provider)

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OSL APPLICATIONS

- SPACE
- MEDICAL
- PERSONAL DOSIMETRY
- DATING

Characteristics of Al_2O_3:C OSLDs for radiotherapy applications

Ideal detector

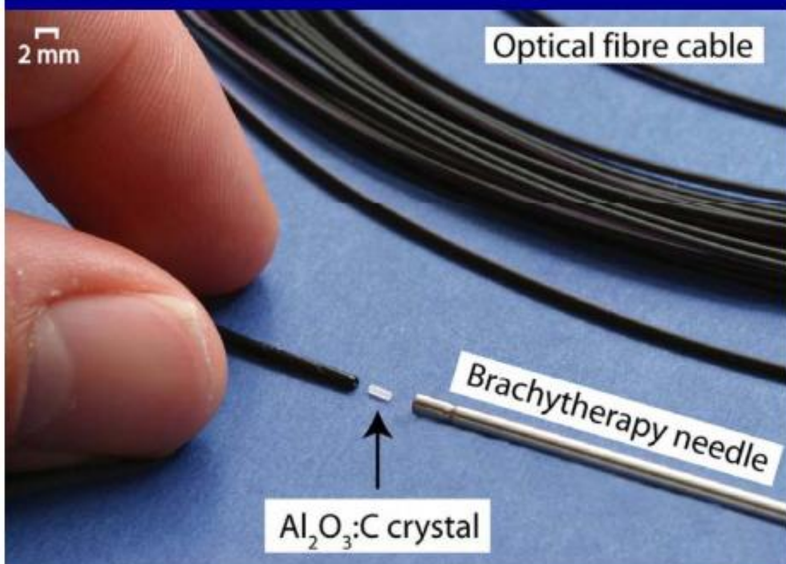
- Small size
- Good reproducibility
- None or well defined environmental corrections
- Dose linearity
- Dose rate independence
- Energy independence
- No directional dependence -isotropic response to radiation

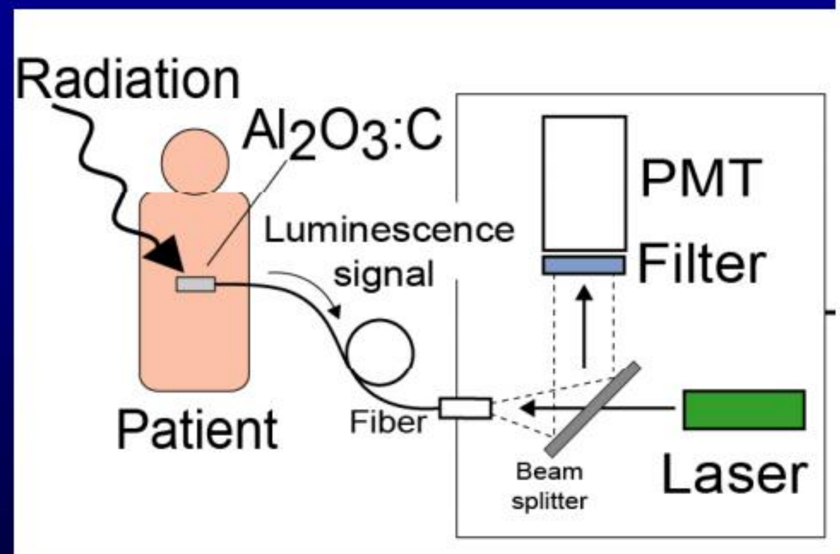
Clinical dosimetry applications

- In phantom
  - PDD
  - ROF
  - IMRT QA

- In vivo
  - external beam (entrance, exit dose)
  - brachytherapy

The small Al_2O_3:C crystals





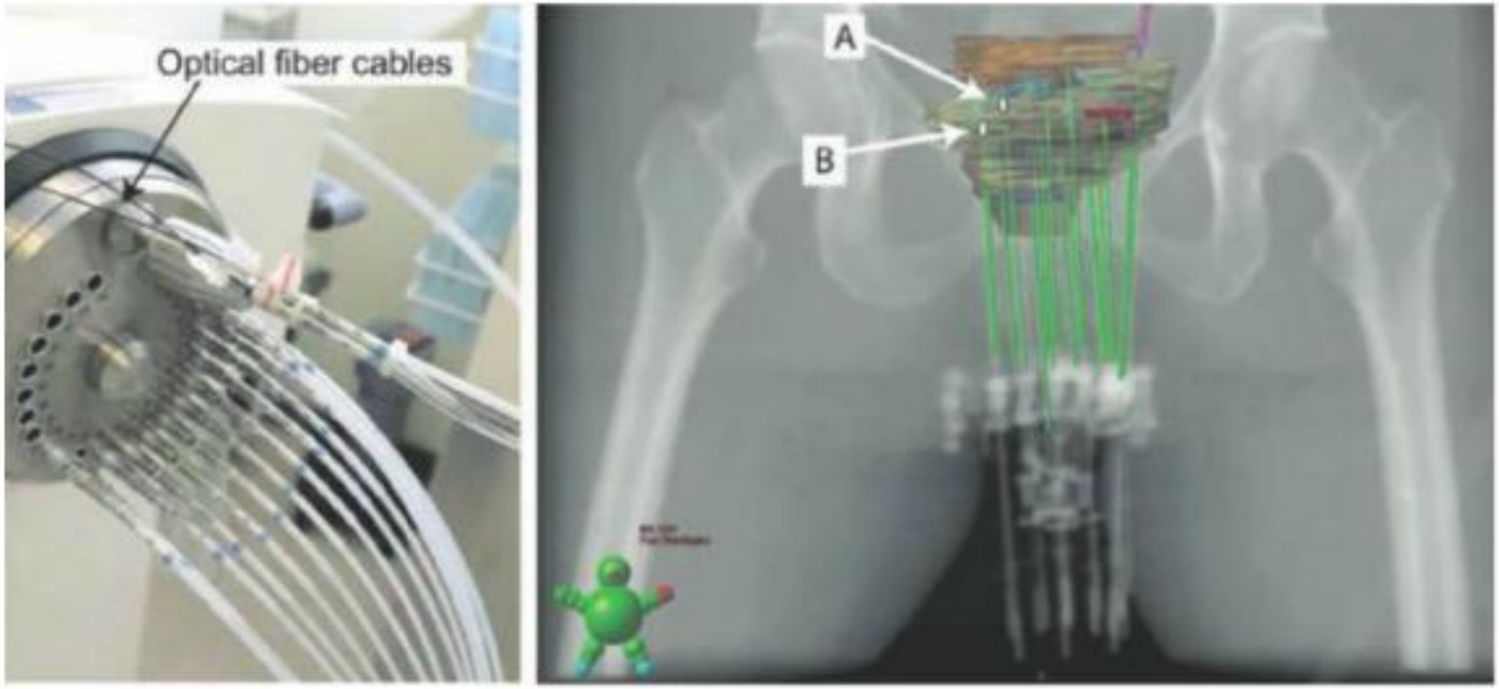
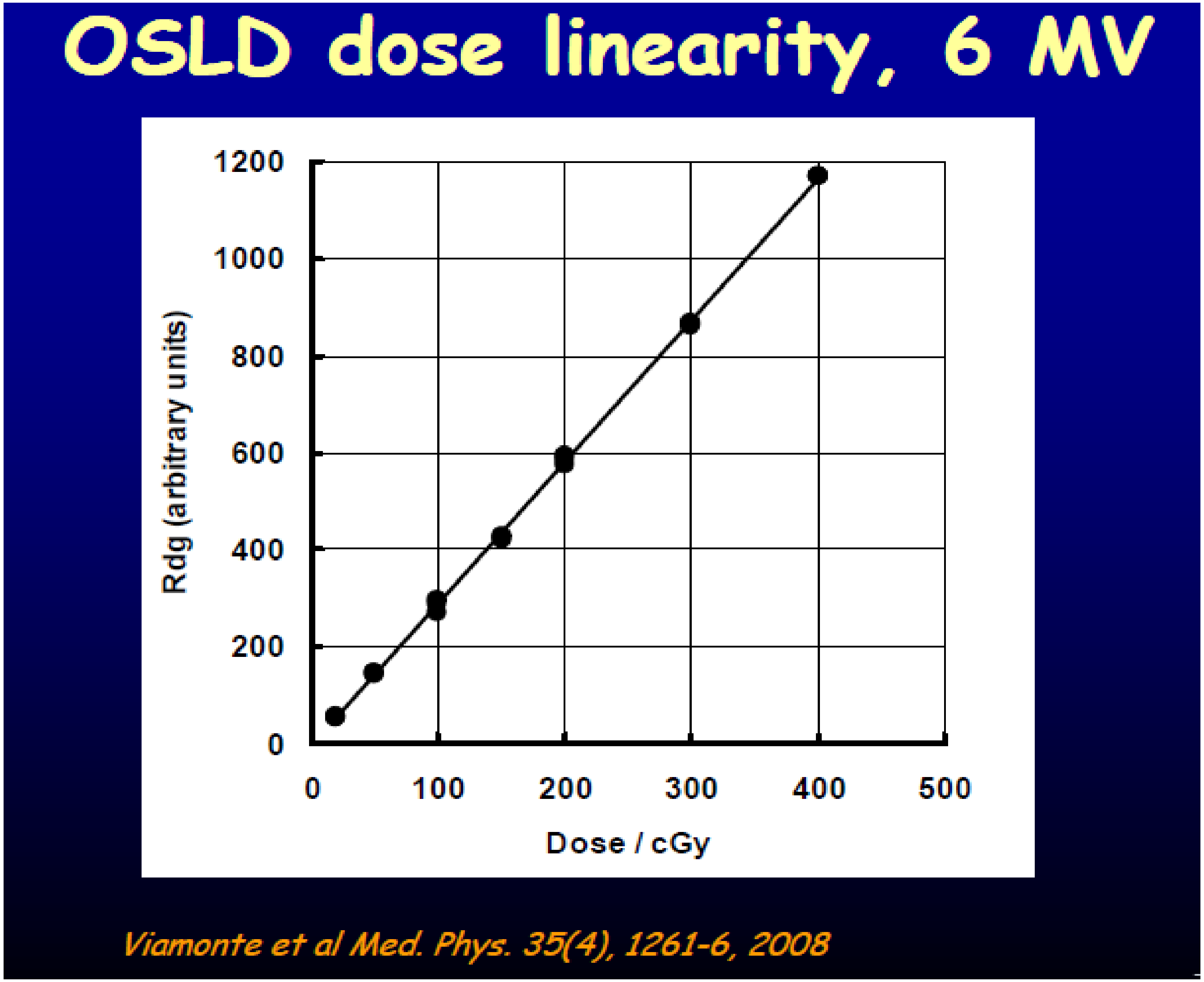
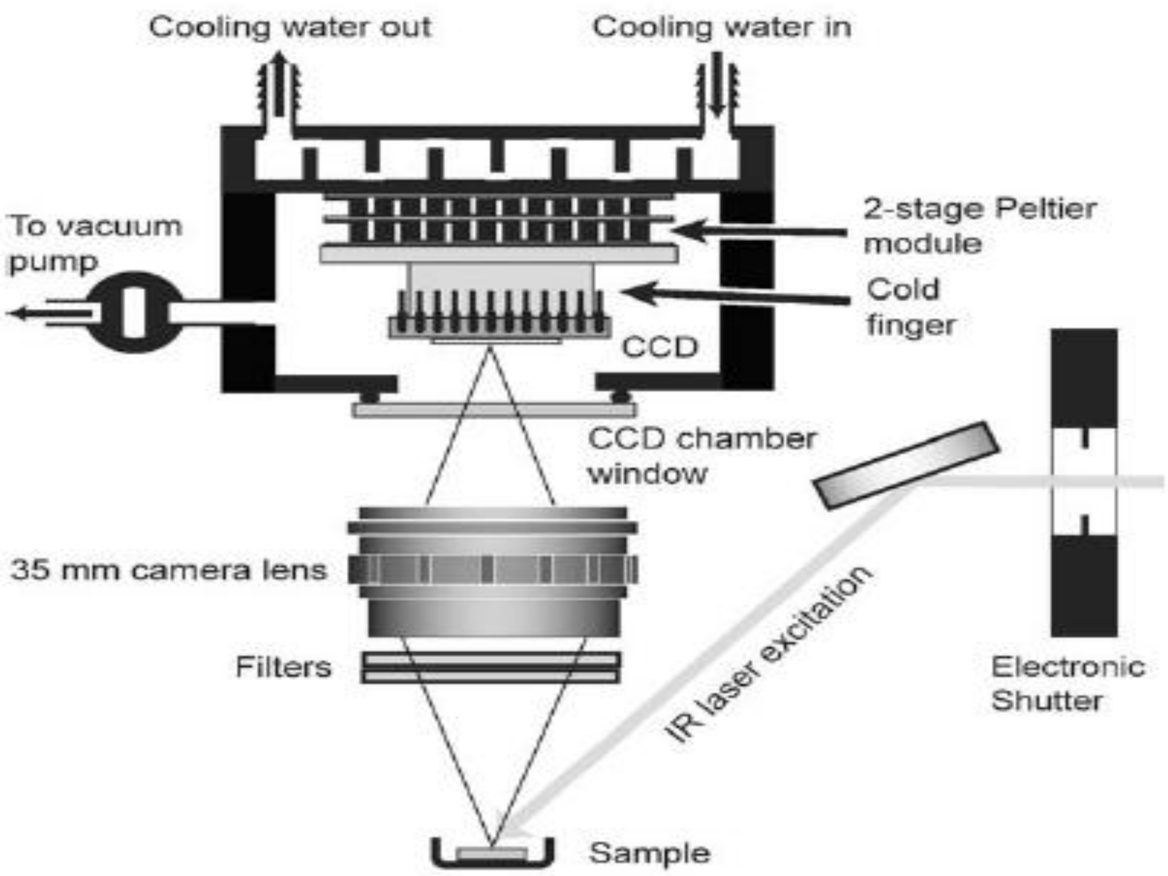


Figure 5.37 *Afterloader with* ^{192}Ir *source and guide tubes used in the brachytherapy treatment. The right-hand figure indicates the position of the OSL probes (A and B). Reprinted from* Andersen et al. *(2009b) with permission from Medical Physics Publishing.*

CHARACTERISTICS OF AL_2O_3:C OSL DOSIMETER



SCHEMATIC REPRESENTATION OF THE SETUP USED FOR IMAGING THE INFRA-RED STIMULATED LUMINESCENCE



M.R. Baril / Radiation Measurements 38 (2004) 81– 86

Dosimetria e Instrumentação DEN - UFPE

RPL- DOSIMETRY

- Some kinds of glasses irradiated with the ionizing radiation show emission of visible photons when excited by UV light. This phenomenon is usually called the radio-photoluminescence (RPL).

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Material: Silver activated metaphosphate glass

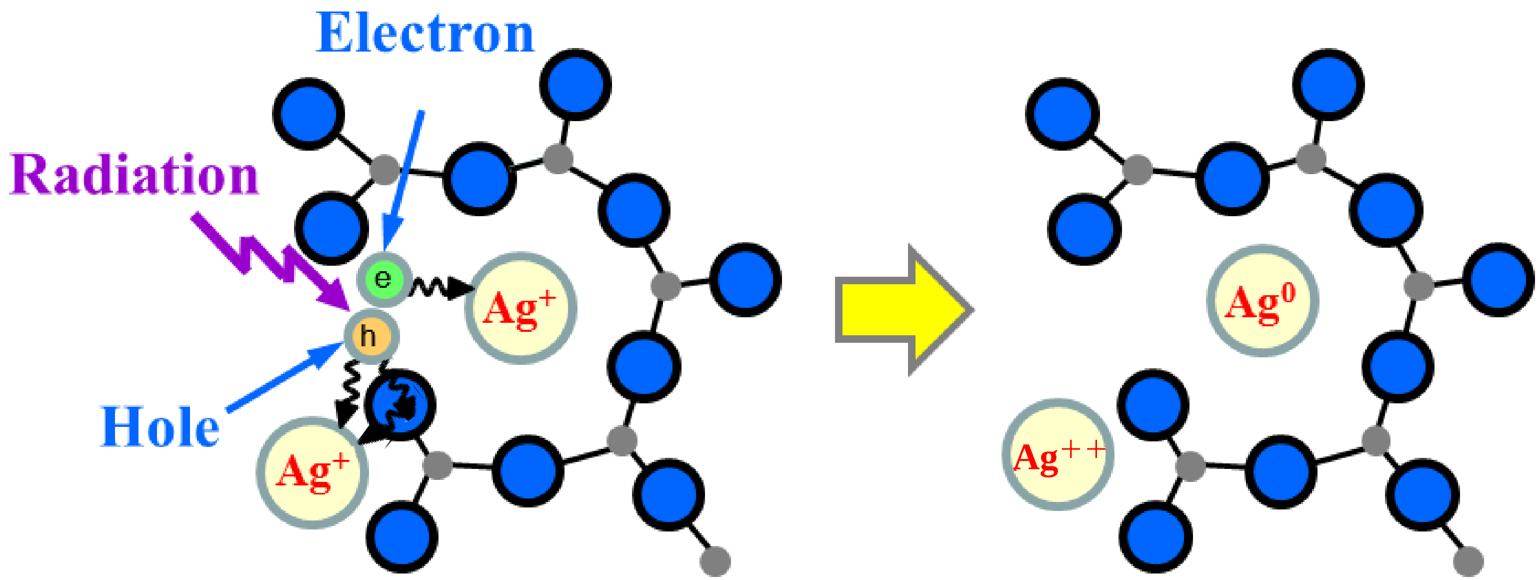
Effect:

- Ionizing radiation creates radio-photoluminescence centers
- Colorization

Analysis:

- Luminescence intensity after UV-light exposure
- Optical density

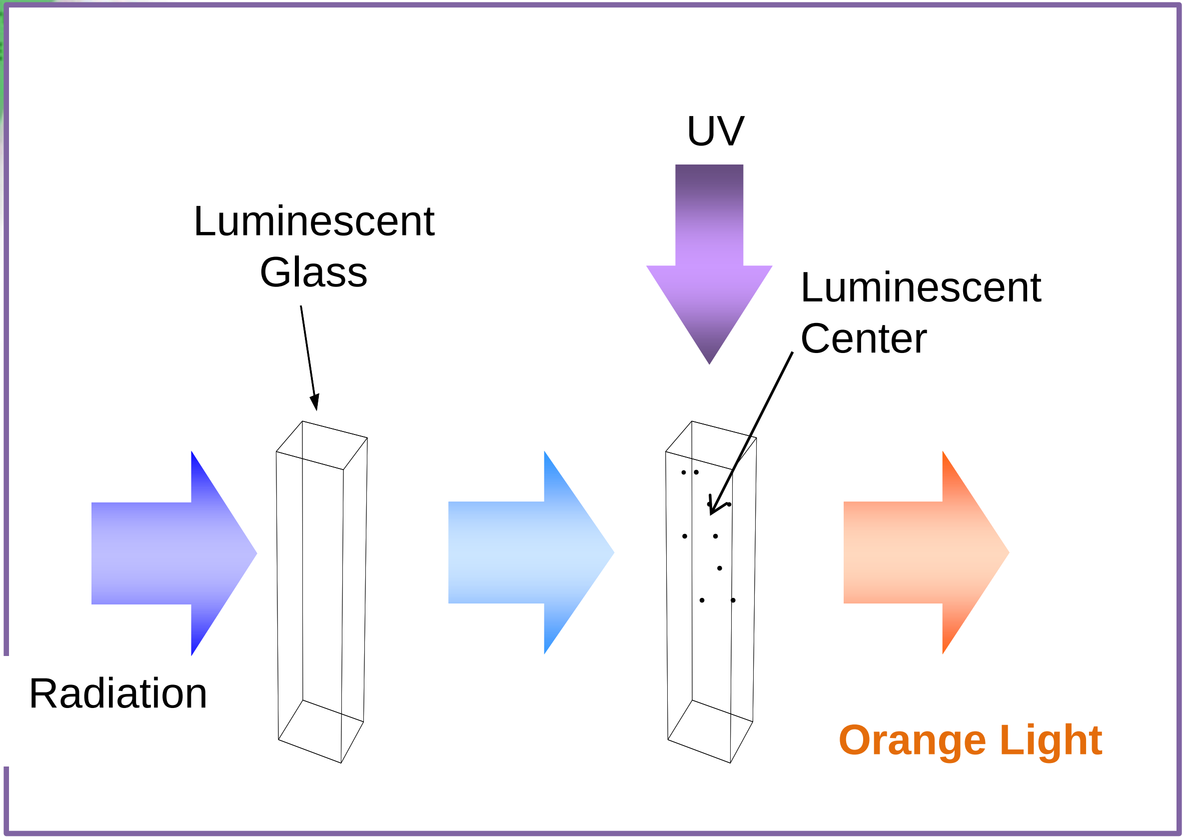
Formation of RPL Centers



$Ag^+ + e \rightarrow Ag^0$ (electron capture)

$Ag^+ + hPO_4 \rightarrow Ag^{++}$ (hole capture)

Radiophotoluminescence



Dosimetry with luminescent glass

The silver activated phosphate glass irradiated with ionizing radiations emits luminescence when exposed to UV light.

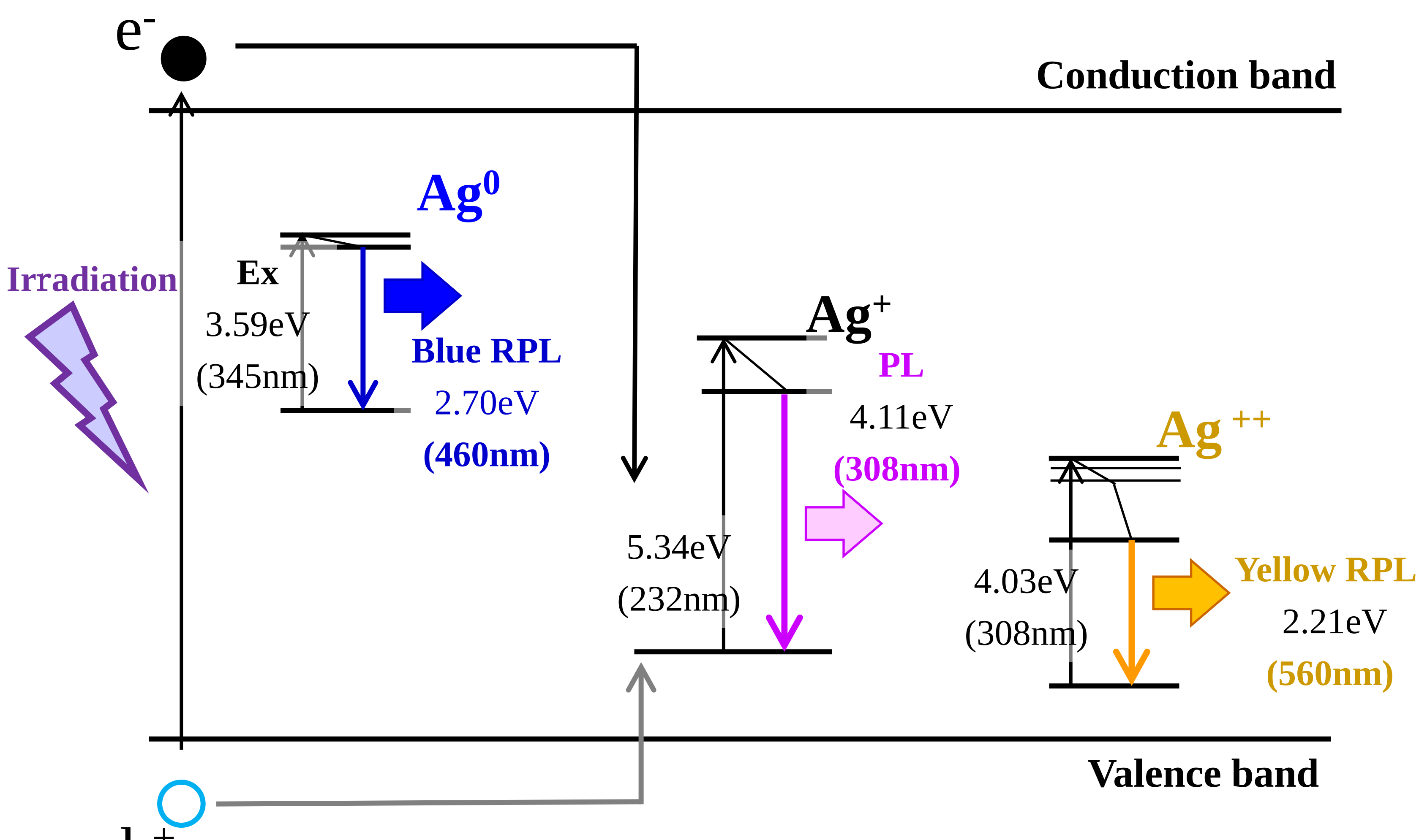
This phenomenon is called RPL.

At present, the most common type of glass in RPL Dosimetry is FD-7.

The AgPO4 in silver activated phosphate glass of FD-7 can be viewed as Ag+ and PO4

-

Energy Levels of RPL Centers



Energy gained by electrons from the pulse ultra-violet laser is not high enough to let electron escape from color centers. Therefore these electrons will not return to the valence band of the glass material directly.

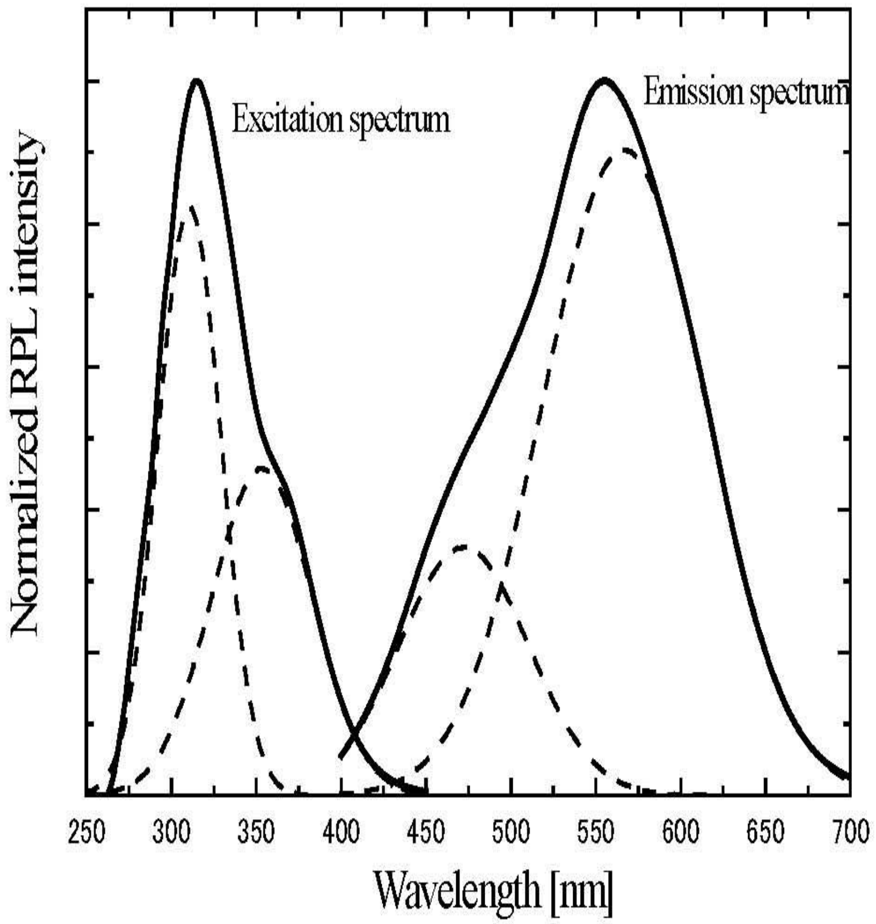


FIGURE 4. Typical RPL emission and excitation spectra of Ag+-doped phosphate glass after x-ray irradiation

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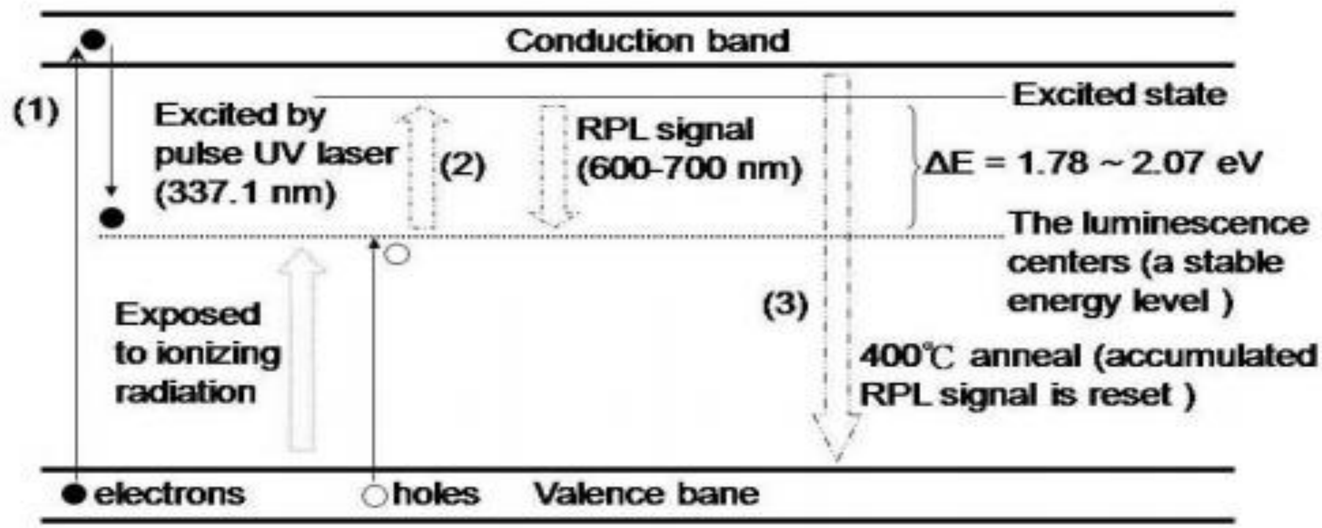
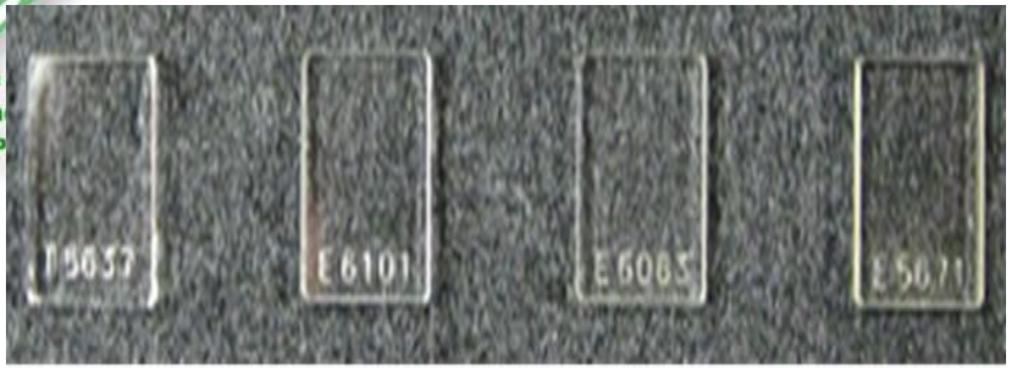
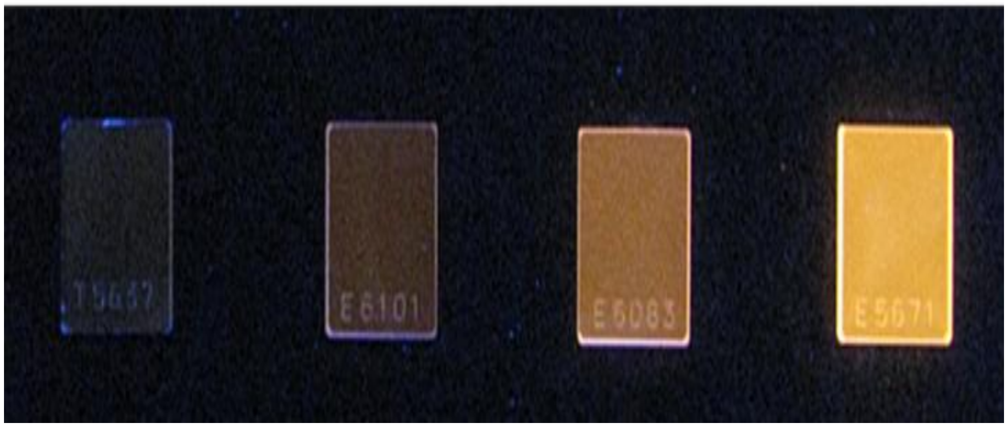
- The luminescence centers never disappear after reading out the accumulated data by UV light again and over again. This is the most different characteristic of the RPL from that of the thermally stimulated luminescence (TSL or TL) and the optically stimulated luminescence (OSL).





UV off

The most characteristic features of the glass dosimeters are data accumulation and no fading.

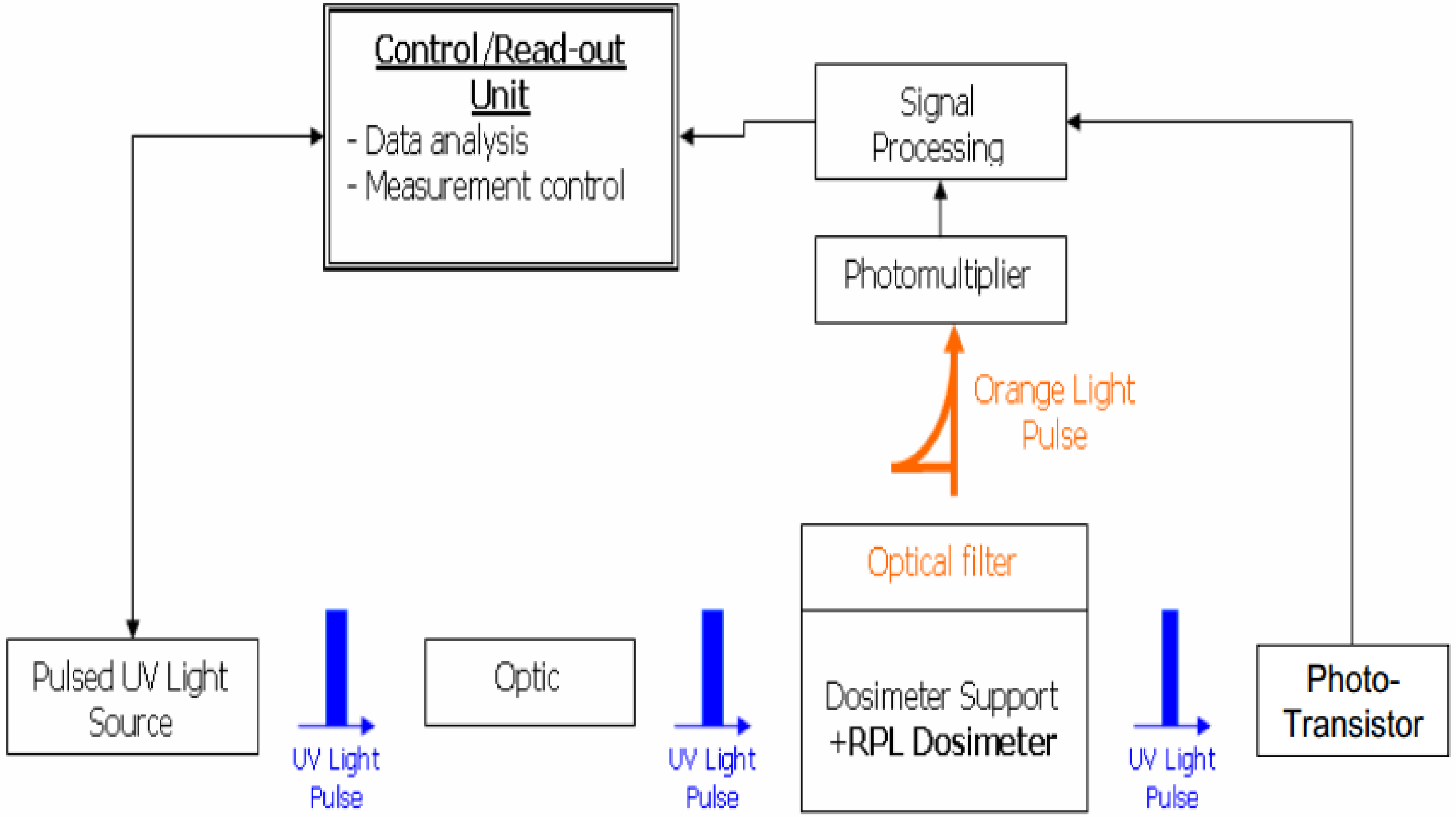


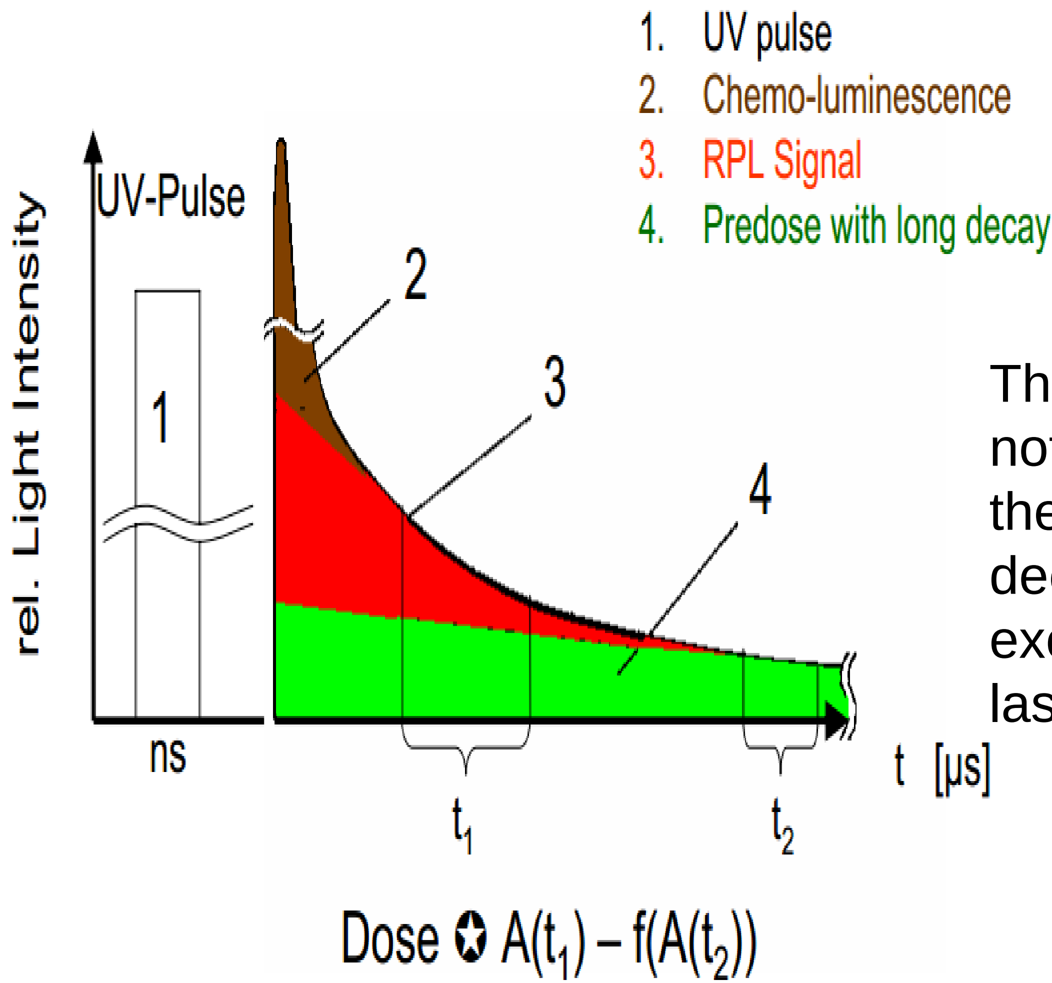
UV on

Low **Absorbed Dose** high

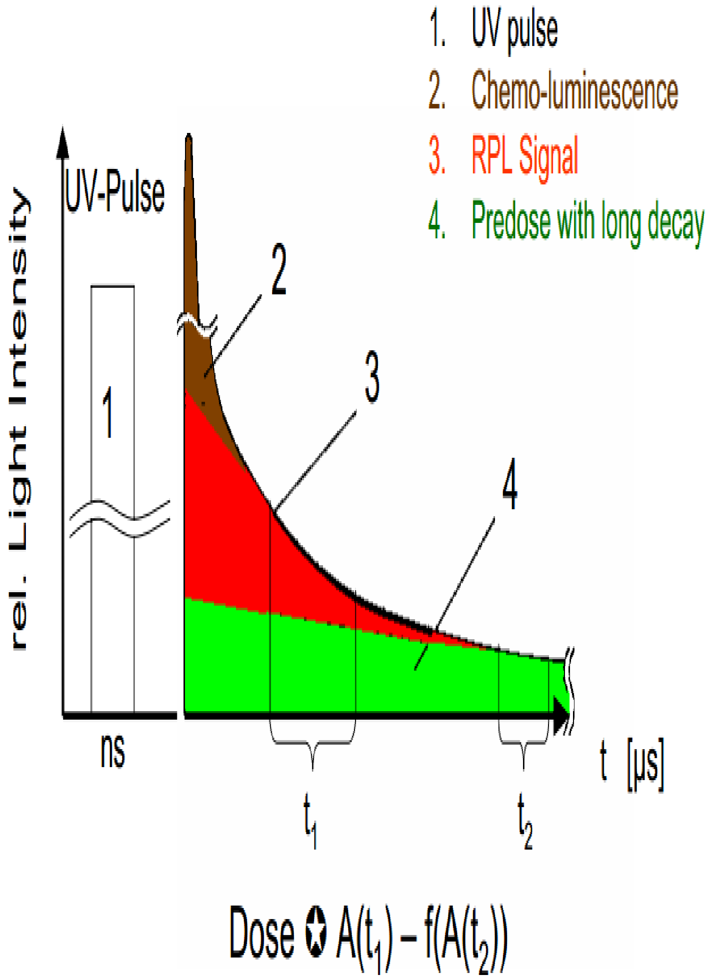
The glass dosimeter always measures the integrated dose, and so if one wants to know, for example, only today's exposure dose, one has to subtract the accumulated dose till yesterday from the total dose observed today. This is the remarkably different point from TLD and OSLD.

Dosimetria e Instrumentação





The glass dosimeter does not utilize the spectrum of the RPL but observe the decay curve of the RPL excited by a short-pulsed UV laser beam

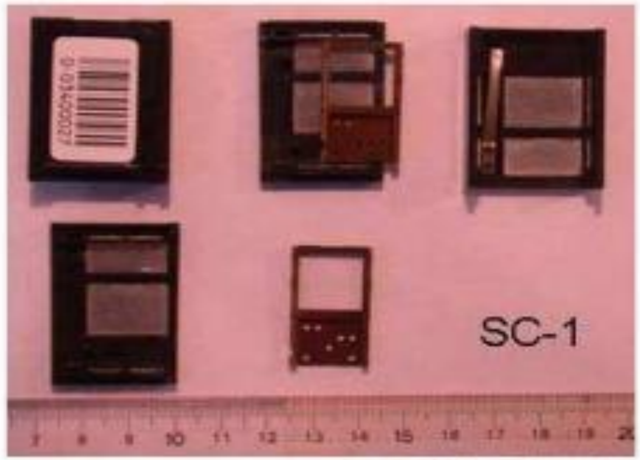


The decay curve could be divided into three parts.

The first intensive peak might be attributed to the PL inherent in the glass and would decay out within 1µs.

The true RPL signal would decay in 40µs and

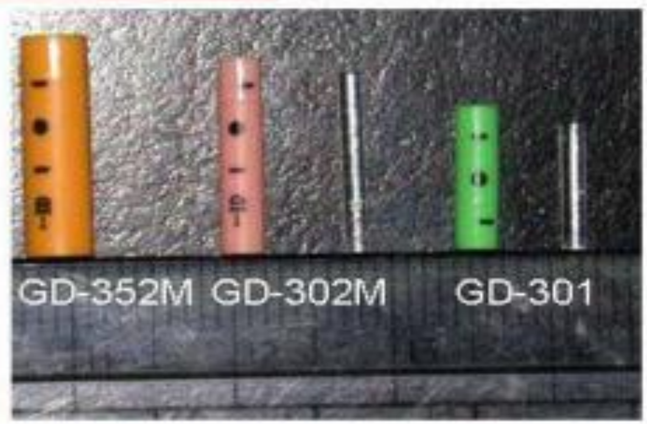
the long decay small signal of the order of 1 ms would correspond to the pre-dose due to the surface dirt of the glass.



environmental radiation monitor

personal dose monitor,

small volume Dose



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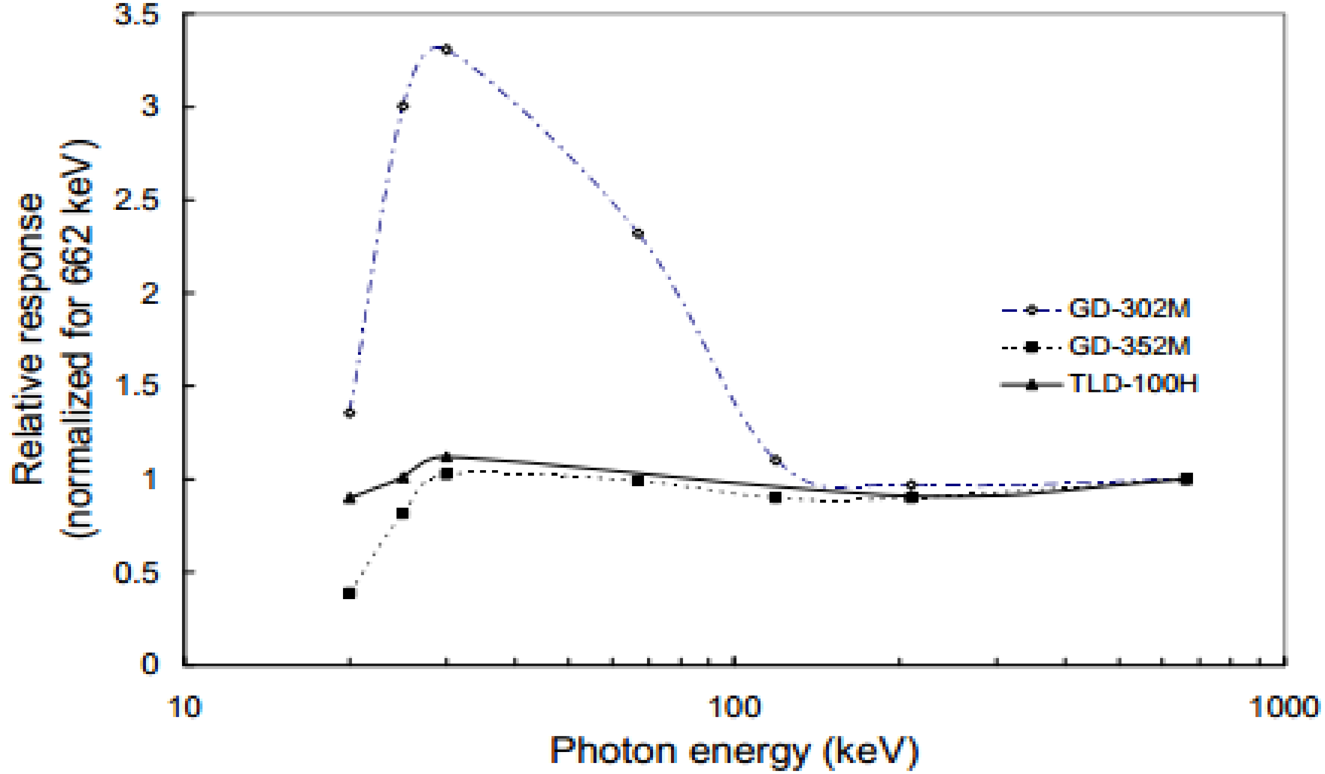

The energy dependence curves for GD-302M, GD-352M, and TLD-100H

THE CHARACTERISTICS COMPARISONS OF TLD, OSLD, AND RPL

	TLD	OSLD	RPLGD
Principe of measurement	luminescence signal	optically stimulated luminescence signal	radiophotoluminescence signal
Luminescence material	crystal	crystal	glass
Excitation source	heat	visible light	ultra-violet laser
Sensitivity	material-dependent	material-dependent	good
Repeatable readout	no	yes, but intensity reduced	yes, with the same intensity
Range of measurement	material-dependent (10μGy - 10 Gy)	material-dependent (10μGy - 10 Gy)	10μGy - 10 Gy 1 Gy - 500 Gy
Geometrical shape	chip and powder	powder	various shapes
Fading effect	material-dependent (5 - 20 % / quarter)	material-dependent (0 - 10 %/year)	less than 5%/year
Energy dependence	material-dependent	material-dependent	± 20% (having energy compensation filter)

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Thank You