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PROGRESS REPORT FOR AINGRA09112

PROJECT TITLE	**Development of TLD based nanodosimetry based on LiF:Mg,Ti**	
INVESTIGATOR(S)		**Institution and Department**
Chief Investigator	**Professor Anatoly Rosenfeld**	Engineering Physics, University of Wollongong
Other Investigators	Prof Yigal Horowitz (Ben Gurion Uni Israel, on subbatical at CMRP) Prof Atara Horowitz (on sabbatical, Israel at CMRP) Dr Michael Lerch, CMRP UoW	
Students	Jay Livingston, CMRP, Hon student PhD student (To be selected)	
ANSTO Investigators	Rainer Siegele	
Specialist Committee	Materials	

SCIENTIFIC OBJECTIVES

New technology of LiF:Mg,Ti (TLD-100) detectors allows control of the concentration of the spatially correlated trapping center/luminescent centre of nano-sized entities allowing detection of deposited ionizing energy on a nanometer scale.

The objectives of the project are the in-depth study of the nanodosimetric characteristics of LiF:Mg, Ti (TLD-100) detectors using heavy ions in a wide range of LET which is intended to fully and conclusively explore the potential of this material as an Linear Energy Transfer (LET) discriminator and nanodosimeter in various mixed radiation fields in space, avionics, reactors, accelerators and radiation therapy applications.

PROGRESS REPORT and RESEARCH OUTCOMES

The finding during this project will be further investigated and potentially will be implemented within Australian Space Program actively developed at CMRP with collaborators to introduce TLD detectors for determination of radiobiological effect of space radiation on humans during the long term space missions additionally with silicon micro-nanodosimetry developed at CMRP in collaboration with ANSTO and UNSW.

The following heavy charged particle irradiations on LiF:Mg,Ti samples were carried out at ANSTO. All irradiations were carried out on both rapidly cooled and slow-cooled materials in order to complete the investigation of the effect of cooling rate on the ratio of the intensities of glow peak 5a to glow peak 5 as a function of ionization density/LET. The ratio 5a/5 serves as the nanodosimetric measure of ionization density.

1. 1.3 MeV protons: 5 samples - 0.9 mm thick , rapid cooling
2. 2.6 MeV protons, 5 samples - 0.4 mm thick, slow cooling
3. 2.6 MeV protons, 5 samples - 0.4 mm thick , rapid cooling
4. 82.5 MeV I^{+10}, 5 samples - 0.9 mm thick, slow cooling
5. 82.5 MeV I^{+10}, 5 samples - 0.9 mm thick, rapid cooling
5. 20.7 MeV I^{+10}, 5 samples - 0.4 mm thick, slow cooling
6. 20.7 MeV I^{+10}, 5 samples - 0.4 mm thick, rapid cooling
7. 20.6 MeV Cu^{+3}, 5 samples – 0.4 mm thick, rapid cooling
8. 20.6 MeV Cu^{+3}, 5 samples – 0.4 mm thick, slow cooling

Further details of the irradiation conditions are outlined in Table 1 combined with other irradiations carried out at Tel Aviv University (low energy electrons), Ben Gurion University ($^{90}Sr/^{90}Y$ beta rays), The Millenium Institute (x-rays) and The Radiological Research Accelerator Facility (RARAF) at Columbia University.

The irradiated samples were read out at Ben Gurion University and the glow curves analysed into component glow peaks using a computerized glow curve deconvolution code based on first order kinetics. Typical deconvoluted glow curves following beta, proton and Cu irradiation are shown in Figs 1-3 in slow cooled materials and the data for all the radiation fields in the slow cooled material is shown in Fig. 4. The ratio of peak 5a to 5 for all the radiation fields/materials are shown in Table 1.

Slow –cooling following the 400^{o}C pre-irradiation anneal is shown to increase the relative intensity of peak 5a to 5 by a factor of ~ 3 thereby significantly increasing the reliability/precision of the measurement of 5a/5.

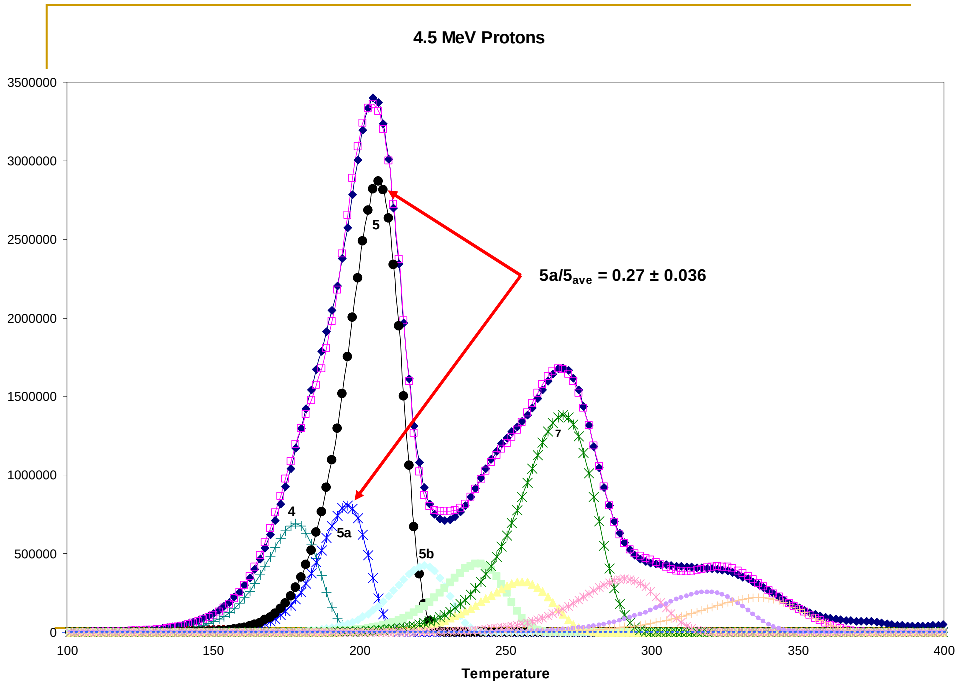
In LiF:Mg,Ti localized electron-hole recombination in sites of nm dimensions gives rise to a light signal [glow peak 5a] whose intensity increases with increasing ionization density whereas the opposite behaviour is observed for delocalized recombination (giving rise to glow peak 5). The result is a relative intensity, 5a/5, which increases by ~ 1 order of magnitude from low "LET" to high "LET" radiation fields.

The potential of solid-state ionization density dependent nano-dosimetry has been demonstrated. Further research and development is necessary to decrease the temperature "jitter" in the readout of the samples in order to further improve the precision in the measurement of 5a/5 ratios.

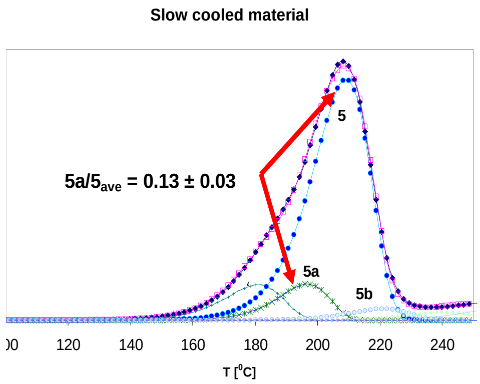
DATA

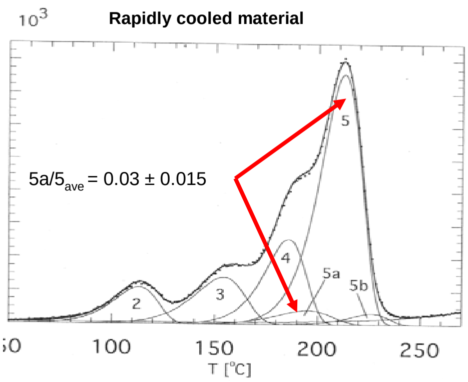
Table 1 – 5a/5 Ratios as a function of cooling rate and ionization density

Radiation	Energy (MeV)	$(LET)_{ave}$ (keV µm^{-1}) In water	Fluence/Dose (cm^{-2}) (Gy)	cooling rate K hr^{-1}		Ratio
				100[b]	1000[c]	
[e-]+	~ 0.5	(~5.6)[a]	0.5	0.13 ± 0.02	0.057 ± 0.012	2.3
[e-]	1500x10^{-6}	10		0.95 ± 0.2		
[e-]	1000x10^{-6}	13		1.02 ± 0.09		
[e-]	500x10^{-6}	19.5		1.12 ± 0.07		
[e-]	100x10^{-6}	30		1.27 ± 0.07		
[e-]##	100-1500 x10^{-6} (no significant variation with energy detected)				0.61 ± 0.08	
X-rays*	0.069		1.0		0.35 ± 0.05	
X-rays*	0.153		1.0	0.20±0.015		
X-rays*	0.040		1.0	0.19±0.014	0.089±0.027	2.1
X-rays #	0.028		0.4	0.18±0.020		
X-rays #	0.097		1.0		0.10 ± 0.016	
X-rays #	0.097		250		0.07 ± 0.03	
X rays **	0.1		1.0		0.12 ± 0.04	
Protons #	4.5	9	10^{9}	0.27 ± 0.036	0.14 ± 0.057	1.9
Deut. #	4.5	15	10^{9}	0.31 ± 0.11	0.10 ± 0.02	3.1
Protons ++	2.6		$1.26x10^{10}$	0.54 ± 0.18	0.08 ± 0.09	6.8
Protons #	1.3	22	10^{9}	0.43 ± 0.016	0.096 ± 0.027	4.5
Deut #.	1.7	30	10^{9}	0.58 ± 0.12	0.23 ± 0.05	2.5
Alpha #	7.5	67	10^{9}	0.35 ± 0.08	0.12 ± 0.03	2.9
Alpha #	2.0	150	10^{9}	0.69 ± 0.14	0.37 ± 0.14	1.9
Cu^{+3} ++	20.6	406	$4x10^{8}$	0.78 ± 0.13	0.33 ± 0.095	2.4
I^{+10} ++	82.5	711	$2.3x10^{9}$	0.60 ±0.08	0.27 ± 0.08	2.2
I^{+10} ++	20.7		$4x10^{9}$	0.80 ± 0.04	0.35 ± 0.07	2.3

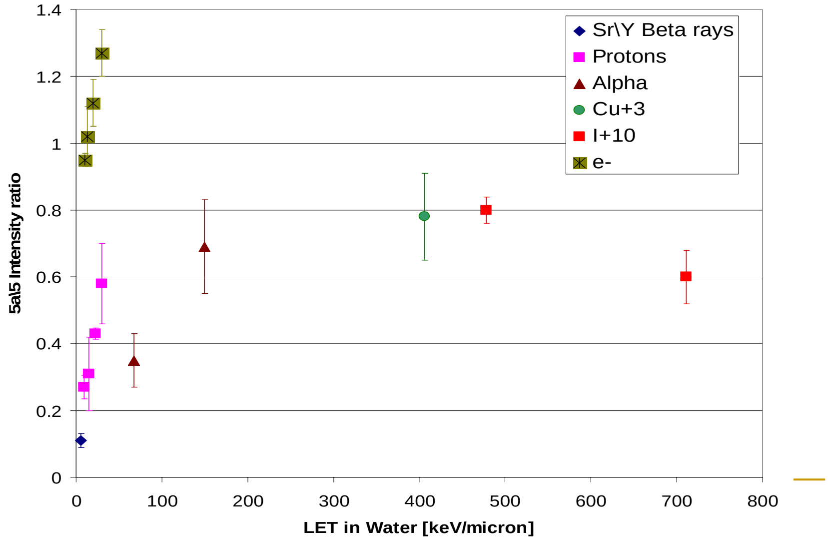


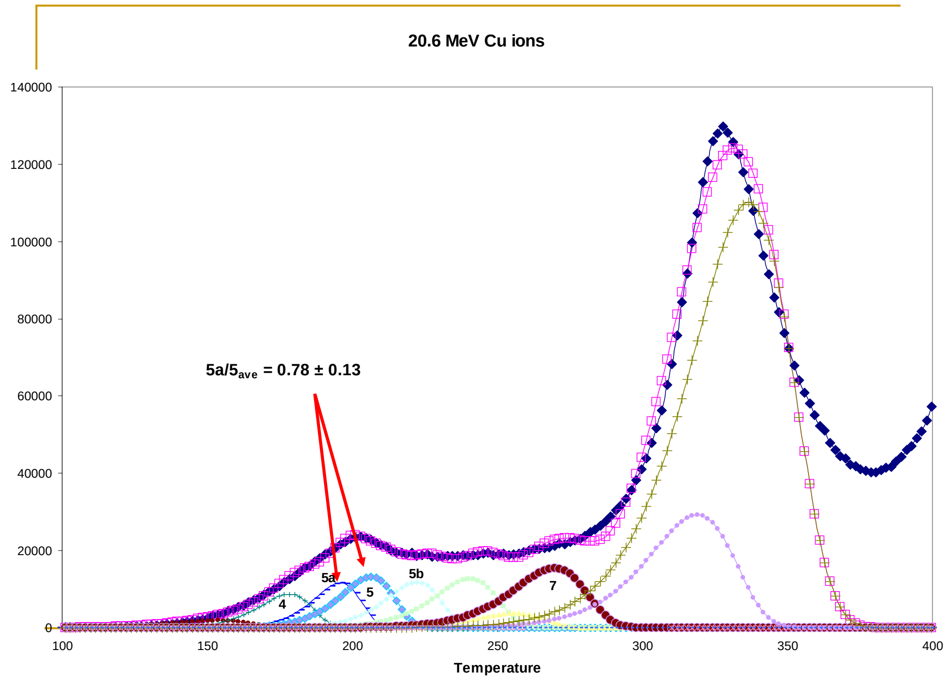
$^{90}Sr/^{90}Y$ *β rays*





5a\5 intensity ratios as a function of LET for different charged particle species





Signature of Investigator preparing the report for After signing this report please fax this page with your signature for our files	Proj: AINGRA09112 Date: 18 October, 2009
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PUBLICATIONS / REPORTS arising as a result of your work.

A preliminary report has been presented at the 15th Int. Symposium on Microdosimetry, Oct. 25-30, Verona Italy and will be published in Radiation Protection Dosimetry.

A more comprehensive report will be presented at the 16th Int. Solid State Dosimetry Conference in Sydney, Oct. 2010 and published in the conference proceedings.

PhD STUDENTS

Ms Jayde Livingston, CMRP UoW will present her Honours Thesis in October 2009. She will start her PhD program on this topic in January 2010.