The Response of the Radiophotoluminescence Glass Dosimeter for Charged Particles and Its Microscopic Consideration

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1. Introduction

- High energetic carbon ions are attractive as a cancer therapy modality (C-ion RT)[1] due to localized dose delivery to deep-seated target associated with elevating biological effect toward the target.
- The production of fragment particle from carbon ions would cause unwanted exposure to normal tissues nearby.[2] It is necessary to evaluate the distribution of particles in the human body.
- Radiophotoluminescence glass dosimeters (RGDs) can be a candidate as an *in-vivo* dosimetry[3] in C-ion RT; however, its response to carbon ions[4] has not yet been well understood.

2. Objectives

- To clarify the response of the RGD for ions in the therapeutic range experimentally.
- To model the derived response regarding the microscopic track structure of the ions.

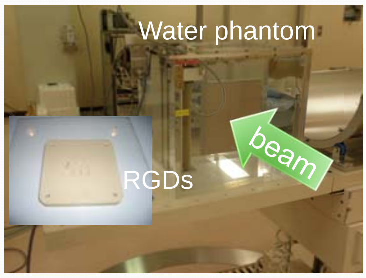
3. Experiment

Experiments were carried out at HIMAC for ion beams and ^{60}Co irradiation facility for γ-ray of NIRS. For ion beams, irradiation depth (LET) was adjusted by upstream PMMA plates. The output of the RGDs was normalized with that for Co-γ (CGE) and compared with a standard IC dosimetry.

- RGDs: GD-302M-W[5] (Asahi Glass Co., Ltd.)
- Radiation: H, He, C, O, Fe and ^{60}Co-γ

Ion	Energy [MeV/n]	LET [keV/μm]
H	160	0.5～14.8
He	150	2.2～72.0
C	290	13.2～366
O	400	18.2～440
Fe	500	183～2790

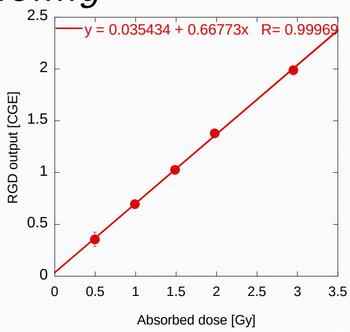
- Given absorbed dose: 0.5 – 3.0 Gy



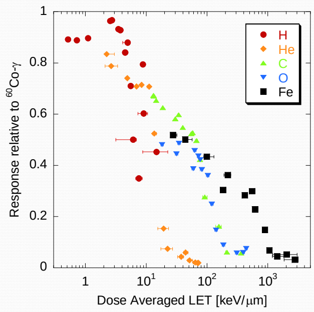
Experimental setup at HIMAC

4. Results and modeling

- The RGDs showed superior linear dose response for carbon ions in the dose range of 0.5 – 3.0 Gy; however, also showed strong dependency for various energy and species of incident particle.

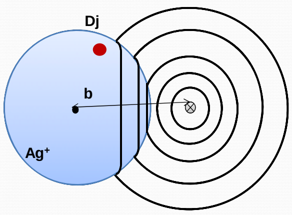


Dose response of RGD



Radiation-quality dependency

- The observed RGD response was modeled with the Local Effect Model (LEM)[6, 7] based on the response for ^{60}Co (m_{Co}) and radial dose distribution of each ion, and succeeded in reproducing the experimental results.



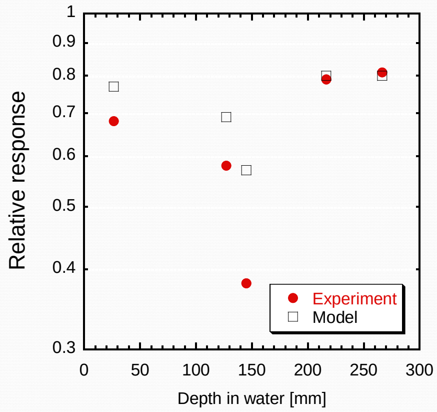
Average number of hits

$$q(b) = \sum m_{Co} D_{j,AgBr} \frac{dV_j}{V}$$

Activation probability

$$P(F) = 1 - exp\left(-\sum q(b)\right)$$

LEM modeling



RGD response for carbon beam

5. Conclusion

- The result reveals that the RGD retains excellent dose linearity for carbon beam at the therapeutic dose range as well as the strong LET and particle species dependency.
- The tendency was well understood with LEM which takes into account the microscopic spatial distribution of energy deposition by ions.
- The RGD can be applicable for relative dosimetry when the change in radiation quality is negligible. For the application for absolute dosimetry or when the radiation quality changes drastically in the irradiation field, it is required to obtain the information on radiation quality at the point of interest by simulation or supplemental experimental modalities.

References

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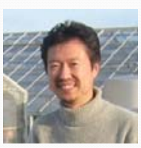

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