Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 18-19, 2017

Comparison between experiment and MCNP simulation for retrospective dosimetry according to the geometry of exposure using electronic components in a mobile phone

Min Chae Kim[a,b], Hyoungtaek Kim[a], Seung Kyu Lee[a], Insu Chang, Jungil Lee[a]*, Jang-Lyul Kim[a], Bong-Hwan Kim[a], Chan Hyeong Kim[b]
[a]*Korea Atomic Energy Research Institute, 989-111 Daedeok-daero, Yuseong-gu, Daejeon, 34057, Republic of Korea*
[b]*Department of Nuclear Engineering, Hanyang University, 222, Wangsimni-ro, Seongdong-gu, Seoul, 04763, Korea*
**Corresponding author: jilee@kaeri.re.kr*

1. Introduction

In the event of an unexpected radiation accident, generally most people around the accident do not have a dosimeter to evaluate the exposed radiation dose. In this situation, measurement and evaluation of the dose by a retrospective method are required. Chromosome analysis (dicentric and translocation analysis) is most widely used method for retrospective dose estimation, however the method is suitable for a rapid triage of highly exposed victims who need immediate medical treatment.

Recently, many efforts are carrying out for the use of thermoluminescence (TL) and optically stimulated luminescence (OSL) of personal electronic devices (such as mobile phone, USB memory chip etc.) as fortuitous dosimeters in the case of radiation emergency[1,2,3]. However, the measured dose with those kinds of fortuitous dosimeters is not the dose to the human body but the dose to the devices. Therefore, a correction is required when evaluating the exposure dose to the body using the measured dose to the devices. As a starting point of this purpose, we have studied to evaluate the effects of the position of the electronic device on human body to measure the dose to the electronic device (mobile phone). We evaluated the doses to the mobile phone by using Monte Carlo N-Particle (MCNP) simulations and TL method with resistors and inductors in the mobile phone, and the results were then compared.

2. Experiments and Simulations

2.1 Samples and Setup for the Experiments

A mobile phone of Samsung Galaxy S3 model (released in 2012) was used to this experiments and resistors (RC1005 (0402)) and inductors (CIH05T4N7) were extracted for TL analysis.

To evaluate the shielding effect of the human body, the ICRU slab phantom (30 cm × 30 cm × 15 cm) was used which is composed similar to the human body. The experiments and simulation were conducted for various cases of the position of mobile phone on the phantom; front, back and left side of the phantom including the different cases of angle of the beam incident to the mobile phone. These various cases are showed in Fig. 1 and Table I. Fig. 2 shows the experimental setup of sample 1. All the irradiations were carried out using the gamma-ray irradiator (Cs-137) installed in Korea Atomic Energy Research Institute with dose of 1.2 Sv.

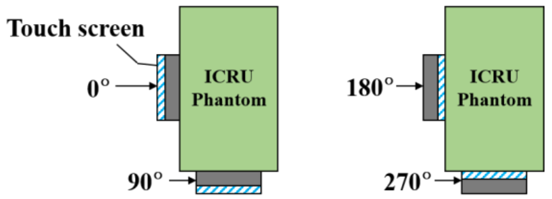

Fig. 1. The angle of the beam to the mobile phone.

Table I: Variation cases of the experimental setup

	Attached position of sample to the phantom	Incident angle
Sample1	Front	0° 1)
Sample2	Front	180°
Sample3	Back	0°
Sample4	Back	180°
Sample5	Side	90°
Sample6	Side	270°

1) An incident angle of 0° is the direction when the radiation is irradiated to the display of the mobile phone.

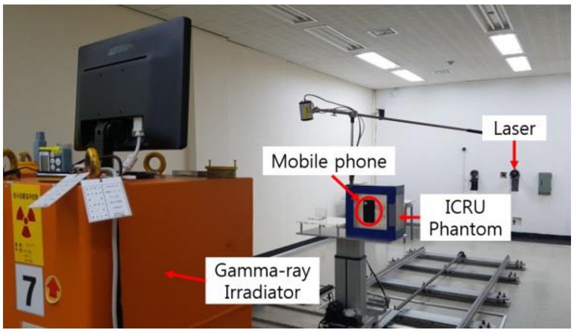

Fig. 2. The setup of the experiment. The mobile phone is attached on the front of the ICRU slab phantom.

2.2 Measurement of thermoluminescence

After the gamma-ray Irradiation, resistors and inductors were separated from the board in the mobile phone mechanically. And TL intensity of these electronic components was measured using the Risoe TL/OSL reader Model DA-20, as shown in Fig. 3.

2.3 MCNP Simulation

For evaluation of the shielding effects of the phantom, MCNP6 simulations were performed for the same conditions of the experiments for the comparison with the experimental results. The default values for the physics option were applied for the MCNP simulation.

The energy deposit tally (F6) was used, and the conversion factor was used to convert the energy transfer (MeV/g) to the absorbed dose (J/kg = Gy).

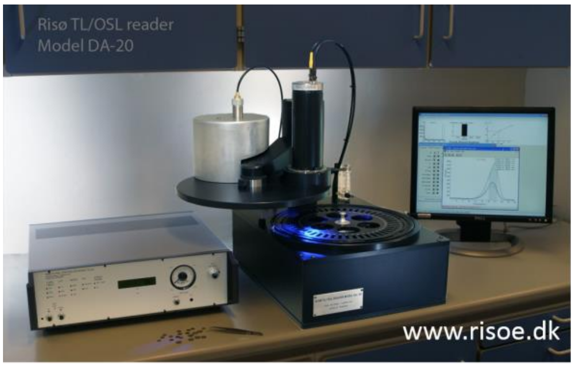

Fig. 3. Risoe TL/OSL reader Model DA-20 with a bialkali EMI 9235QA PMT

3. Results and Discussion

Fig. 4 shows the typical TL glow curves of the resistor and the inductor. One main peak was observed in the case of resistors (180°C), whereas two dominant glow peaks were observed in the case of inductor (175 °C and 260 °C).

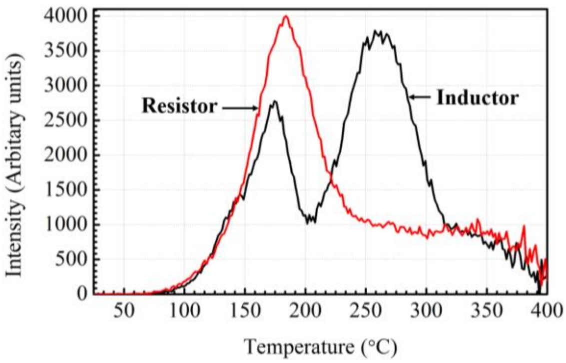

Fig. 4. The typical TL glow curves of the resistor and inductor

To evaluate the exposed dose, the TL signals were integrated for the temperature range from 100 °C to 260 °C for the resistor, whereas two temperature ranges from 100 °C to 210 °C and 210 °C to 300 °C for the inductor due to its two dominant peaks.

Fig. 5 shows the normalized doses evaluated by the TL signals from resistors (a) and inductors (b), respectively. It also shows the results of dose evaluated by MCNP simulation for the resistors and inductor and for the comparison with the results by TL method. It is worth to emphasize that the results obtained by the both methods show the same tendency for the both samples. The evaluated dose reduced about 55 % and 30 % in the cases of back and side of the position of the phone, respectively. There was little difference in the incident direction of the radiation beam.

4. Conclusion

We have studied to evaluate the effects of the position of mobile phone on human body to measure the dose to the phone with TL method and MCNP simulation method, and then compared. The results obtained by the TL experiments showed excellent agreement with the simulation results. With these results, it is expected that the retrospective estimation of the exposure dose to human body is possible by using the dose to mobile phone measured by TL analysis of resistors and inductors in phone.

For the further study, we are going to conduct experiments and MCNP simulations studies on more variety of exposure conditions, and develop an analysis algorithm using a computer code.

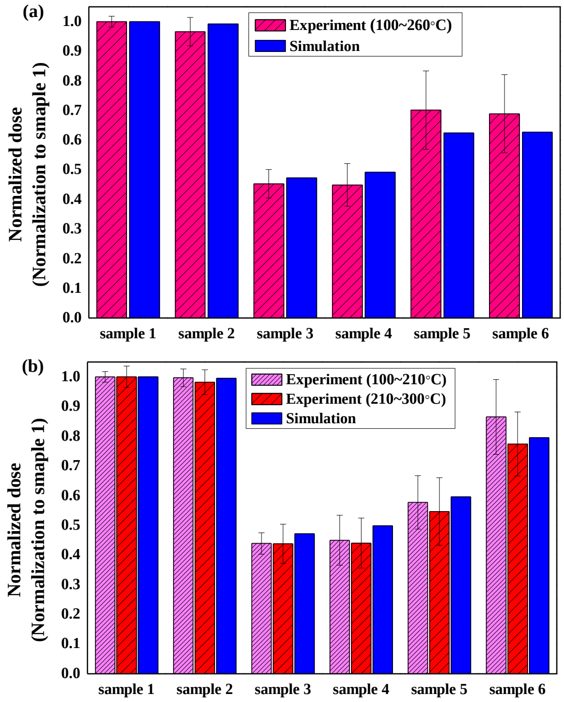

Fig. 5. The normalized doses evaluated by TL method from resistors and inductor in mobile phones attached different positions on the ICRU slab phantom; (a) resistors, (b) inductors.

REFERENCES

[1] J.I. Lee, I. Chang, A.S. Pradhan, J.L. Kim, B.H. Kim and K.S. Chung, On the use of new generation mobile phone (smart phone) for retrospective accident dosimetry, Radiation Physics and Chemistry, Vol.116, p.151, 2015

[2] J.I. Lee, I. Chang, A.S. Pradhan, J.L. Kim, B.H. Kim and K.S. Chung ,Dose re-estimation using thermoluminescence of chip inductorts and resistors following the dose estimation by using optically stimulated luminescence readout for retrospective accidents dosimetry, Radiation Measurements , Vol.90, p.261, 2016

[3] Michael Discher, Mauritius Hiller and Clemens Woda, MCNP simulations of a glass display used in a mobile phone as an accident dosimeter, Radiation Measurements, Vol.75, p.21, 2015