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OSL and TL of Resistors of Mobile Phones for Retrospective Accident Dosimetry

J. I. lee*, J. L. Kim, A. S. Pradhan, I. Chang, B. H. Kim
Korea Atomic Energy Research Institute
Corresponding author: jilee@kaeri.re.kr

1. Introduction

Optically stimulated luminescence (OSL) and thermoluminescence (TL) of ubiquitous materials continue to draw wider attention for individual dosimetry in nuclear and radiation accidents. Use of ubiquitous objects for radiation dosimetry is prefereed because the affected persons in such unexpected events are usually not covered by personal dosimetry services and do not carry personal dosimeters. Often accident sites do not have area monitoring system in place. As the main concern of the dosimetry is health effects, a quick distinction of level of exposures of the affected persons for the required medical care becomes important in all accidents involving radiation. Both in large scale nuclear accidents such Fukushima, Chernobyl or Hiroshima & Nagasaki where large population around the accident site get exposed to radiation (evacuation is based on doses) and in smaller but panicky events, such as misuse of radiological exposure device (RED), radiological dispersive device (RDD; "Dirty Bomb"), improvised nuclear device (IND) and deliberate dispersal of radioactive contaminants, a need for an ubiquitous personal dosimeter is well recognized. As biological dosimetry systems are yet to become viable for measurements of doses with required accuracy and speed, use of physical dosimeters is often explored. Among the various types of physical dosimetry systems, use of TL and OSL by processing common material such as bricks or tiles and measuring the doses cumulated for long periods of time has already become an accepted tool for large scale nuclear accidents such as Hiroshima & Nagasaki or Chernobyl involving higher doses. In the other potential cases of unexpected situations where the doses encountered could be much lower (even to escape the range of remotely installed area monitors), the need to measure even the low doses in shortest possible time becomes important. It is often realized that in such situations, the main problem could become the panic at the work place and in the public rather than actual health hazard due to radiation exposure. Therefore, a quick demonstration of measurement of doses following the accident is needed to reassure those receiving insignificant or low level of exposures that they are quite safe and need no treatment. This confidence building also becomes an important aspect of dosimetry. As the ranges of doses which could be encountered in such situations may vary from the background level to significantly high doses depending on the type of accident / incident and the location of personnel, it becomes important that the techniques used in retrospective dosimetry should be very sensitive and should be able to measure doses in a wide range from background level to several Gy. More recently, with the increasing apprehensions of nuclear terrorism / dirty bomb, research and developments in retrospective dosimetry has gained a new momentum the world over. Among the TL and OSL sensitive materials, the extraction and the processing of the materials from bricks and roof tiles is a very time consuming process and gives indirect estimate of individual doses. On the other hand, TL and OSL properties of components of electronic devices mobile phones, i-pods, black-berries, mp3 players and USB sticks containing ceramics with luminescence properties (e.g resistors, capacitors, resonators, antenna switches, transistors etc.) and chip cards containing silica epoxy (e.g. creditd cards, bank cards, social security card, telephone card, SIM cards, ID cards e.g) are being considered very attractive and being evaluated [2,3]. In this study, the TL and OSL properties of the electronic components of mobile phones are investigated and dose recovery potential is evaluated with a presumption that a mobile phone has become a part of body belongings masses of almost ages.

2. Methods and Results

Mobile phones from different manufacturers were procured and the electronic components were removed. IC chips, resistors (chip type), packaging white and black ceramic of the clock component, quartz crystals of the clock, capacitors, glass on CMOS device of the camera and epoxy resin on circuit board were tested for the OSL. Resistors (chip type) were mechanically picked out from the circuit board one by one by using a sharp bar (-) type screw-driver and no additional treatments were applied. It was noted that at least 40 chip resistors could be obtained from one mobile phone. For the IC chips, the surface was polished by using a grinder followed by cleaning with propanol. Packaging white and black ceramics for clock components were also obtained by pulverizing the components. All measurements were performed using a Risø TL-OSL-DA-15 reader and the samples were irradiated using the integrated 1.48 GBq (40 mCi) $^{90}Sr/^{90}Y$ irradiator. Light beam filtered through GG-420 filter from blue LEDs (50 mW/cm^2 power) were used for optical stimulation and violet/UV emission through a U-340 filter was recorded as OSL signal. TL readouts were taken on a Harshaw 4500 TLD reader system under the recommended flow N_2 gas.

3. Results and Discussion

OSL response of IC Chips, packing ceramics and chip resistors was found to increase linearly with dose in the studied range from 10 mGy to 1 Gy. The chip resistors are the most promising components in Mobile Phones Fig. 1 shows the typical dose response of OSL of chip resistors which is linear in a large dose range.

The OSL signal was far more intense than TL signal. However, the OSL signal exhibited strong fading of about 60% in 24 h. For testing the practical applicability, mobile phones were exposed to 150 mGy and 500 mGy of ^{137}Cs gamma rays. IC chips and the resistors were removed from the mobile phones after the exposures and the dose evaluation was attempted by using SAR (single aliquot regenerative) protocol. The resistors exhibited much better sensitivity and the reproducibility than other components. The estimated average doses for resistors were within 15% for an exposure of 150 mGy and within 10 % for 500 mGy exposure. The variation was much larger from chip to chip in the case of ICs and other components. There is a significant scope to improve the dose measurement.

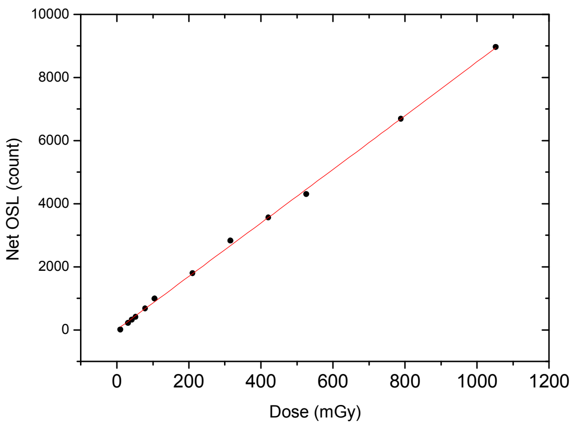

Fig.1 OSL (Net OSL) versus dose for the chip resistors of Mobile Phones.

4. Conclusions

The use of electronic components of Mobile Phones as "fortuitous" dosimeters following a radiological accident or terrorist event has been evaluated. The resistors which can be quickly removed from the mobile phone equipment and readout on a set reader, exhibit a linear dose response in the range from a few mGy to several Gy. However, the OSL signal exhibited a pronounced fading attributable to both the thermal fading and anomalous / athermal effects. For the dose reconstruction, OSL of resistors of mobile phones offer a promising and handy tool for retrospective accident dosimeter. This study indicates that the electronic components of all modern type of electronic products have a potential of accident dosimetry.

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