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A preliminary study on thermoluminescence of AMOLED glass from mobile phones for retrospective dosimetry

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1. Introduction

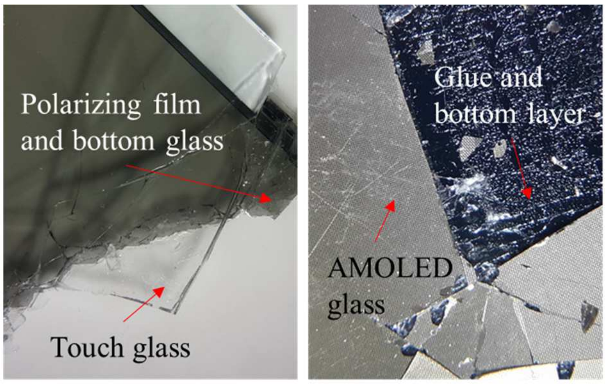
Radiation workers have to wear a dosimeter to assess individual exposure during their works. This monitoring system facilitate a fast medical treatment for highly exposed workers in case of a radiation accident. In the event of large-scale radiation accidents, where most of the subjects are ordinary people, it is difficult to evaluate the individual dose due to the absence of dosimeters. A technique for dose evaluation using a radiation dependency of various materials in the absence of a dosimeter is called retrospective dosimetry.

Since mobile phones are always carried by individuals, the retrospective dosimetry using thermoluminescence (TL) and optically stimulated luminescence (OSL) characteristics of elements in mobile phone is intensively developing nowadays due to its advantages over conventional biological dosimetry techniques. Using a TL and OSL method on resistors and inductors in a mobile phone, a low background dose (zero dose) about tens of mGy is acquired in previous study [1, 2]. In spite of higher zero dose around 340 mGy a display glass can be advantageous in some points [3]. The use of resistors and inductors is accompanied by the destruction of mobile phones but the use of display glasses ensures reusability through replacement of the glass. This increases the acceptability of collection of mobile phones in the case of radiation accidents. Moreover, there is an advantage on glasses in terms of material size because it tends to be larger as the mobile phone industry develops while resistors and inductors becomes smaller.

Although the previous research focuses mainly on display glass using LCDs [3, 4], it is necessary to evaluate the TL characteristics of AMOLED (active-matrix organic light emitting diode) display panel as the number of mobile phones using an AMOLED is highly increased. In this study, preliminary results of TL characteristics on AMOLED glass are presented.

2. Materials and method

A display glass of Samsung Galaxy-S3 model which was released in 2012 was used. The display is called "super AMOLED" and the surface is made of Corning Gorilla glass [5]. Unlike LCDs that use various layers, AMOLED display panel consists of an OLED substrate that controls the light and a polarizing filter that blocks the reflected light. A disassembled display glass is shown in Fig. 1. The glass was divided into an upper part and bottom part. The upper part consists of a touch glass, polarization filter and a substrate glass in order from the top. In this part only touch glass was used because the bottom glass is very fragile. The bottom part consists of very thin AMOLED layers, a substrate and bottom layer in order from the top. Since the substrate is made of SiO_2, the dosimetric properties are expected [6, 7].



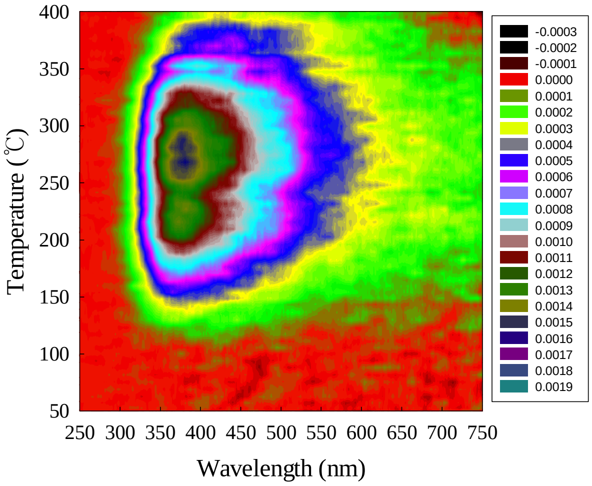
(a) (b)

Fig. 1. Disassembled display glass of upper part (a) and bottom part (b) of a Galaxy-s3.

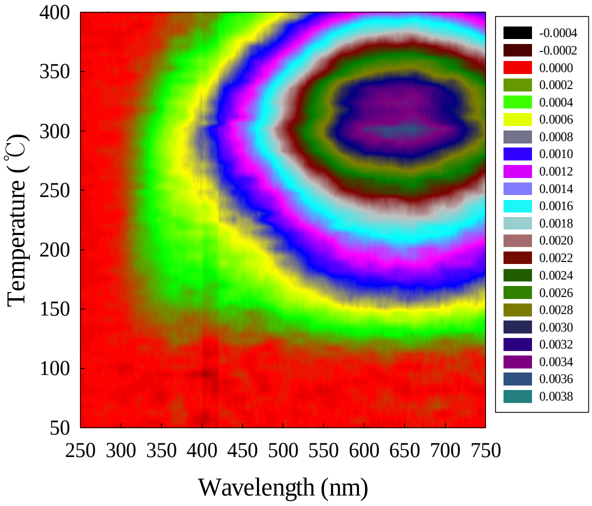
The touch glass and substrate glass were cleaned in acetone solution and cut into small pieces less than 0.5 × 0.5 cm^2. TL emission spectra of the glasses in a range of 250 to 750 nm were recorded by PIXIS-256E-CCD with a heating rate of 5 °C/s. Highly exposed samples about 1 kGy with Cs-137 gamma rays were used due to the low sensitivity of the system. A TL from the samples was measured using a Risoe TL/OSL-DA-20 reader with a U-340 filter in front of the PM tube and a heating rate of 5 °C/s. Irradiations were carried out by using a built-in 150 MBq $^{90}Sr/^{90}Y$ reference source in the Risoe reader (^{137}Cs gamma equivalent air kerma rate of 6.5 mGy/s). The samples were pre-bleached with a built-in 470 nm blue LED for 500 s to reduce unstable signal [3].

3. Results and Discussion

A contour of TL emission spectra of an AMOLED glass and a touch glass are shown in Fig. 2. Significantly different spectra were observed in two materials. A glow peak of AMOLED glass was observed at 270 °C with a peak wavelength of 380 nm while a glow peak of touch glass was observed at 300 °C with a peak wavelength of 650 nm.



(a)



(b)

Fig. 2. Contour of TL emission of an AMOLED glass (a) and touch glass (b)

In Fig. 3 TL glow curves of an AMOLED glass and a touch glass with irradiation of 0 mGy and 650 mGy are shown. In case of the touch glass, very high zero dose was observed that can not be applied to retrospective dosimetry. However, small zero dose was observed in the AMOLED glass throughout entire temperature range. These results can be emphasized compared to LCDs which shows very high zero dose over 300 °C [3]. In Fig. 4 zero dose and minimal detectable dose (MDD) of AMOLED glasses according to the maximum integration temperature are presented. The integration range is started from 100 °C and MDD is calculated by 3σ of 3 AMOLED glasses in a same phone. At the maximum temperature less than 150 °C, minimum zero dose about 10 mGy are ensured but MDD is relatively increased. Therefore, the maximum temperature should be set around 180 °C to ensure the lowest MDD value as well as relatively lower zero doses.

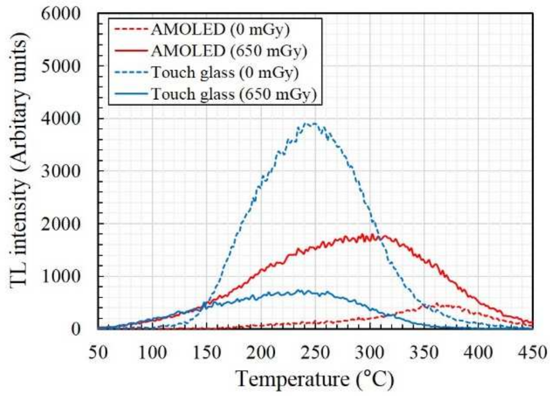


Fig. 3. TL glow curves of an AMOLED glass (Red) and a touch glass (Blue) with irradiation of 0 mGy (dot) and 650 mGy (line)

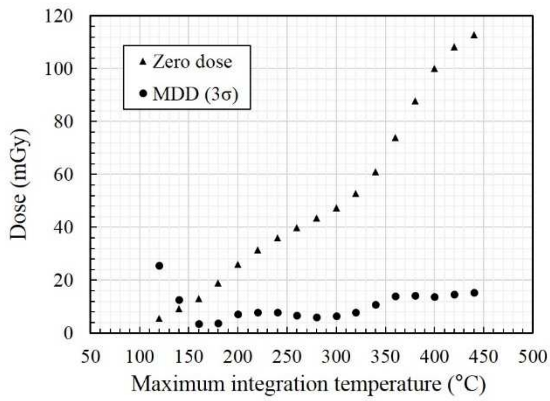


Fig. 4. Zero dose and MDD (3σ) of AMOLED glasses according to the maximum integration temperature. The minimum integration temperature is 100 °C

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