Variations in dosimetric EPR signals induced in touch-screen glasses by ionizing radiation after their exposure to light

Małgorzata Juniewicz[1], Agnieszka Marciniak[1], Bartłomiej Ciesielski[1], Mirosław Sawczak[2], Anita Prawdzik-Dampc[3]

[1] Department of Physics and Biophysics, Medical University of Gdańsk, Dębinki 1, 80-211 Gdańsk, Poland
[2] Heat Transfer Department, The Szewalski Institute of Fluid-Flow Machinery Polish Academy of Sciences, Generała Józefa Fiszera 14, 80-231 Gdańsk, Poland
[3] Department of Oncology and Radiotherapy, Medical University of Gdańsk, Dębinki 7, 80-952 Gdańsk, Poland

RAD
rad-conference.org
EIGHTH INTERNATIONAL CONFERENCE ON RADIATION IN VARIOUS FIELDS OF RESEARCH
Eight years of science and friendship
2020 | July 20-24
Hunguest Hotel Sun Resort
Herceg Novi | Montenegro

MEDICAL UNIVERSITY OF GDAŃSK

ABSTRACT

Electron paramagnetic resonance (EPR) signals induced by ionizing radiation in touch-screen glasses have been reported as useful for personal dosimetry in people accidently exposed to ionizing radiation [1]. Stability of the radiation–induced signals (RIS) was shown to be sufficient for dosimetry even weeks after exposure of screen samples to radiation [2, 3]. However, the RIS signals induced in Gorilla Glass, in mineral glass and in tempered glass (used for protective screens) by radiation (i.e. the dosimetric signals), as well as the native, background EPR signals can be strongly affected by exposure of the samples to light [4]. This effect can lead to significant deviations of the radiation doses reconstructed by EPR from the real ones. In the presented study the EPR spectra from glass samples unexposed and exposed to X-rays and/or to natural sunlight and UV lamps were numerically decomposed into three model spectra: background (BG), RIS and light-induced signal (LIS). The results showed, that sunlight and light from common UV lamps (nail lamps, lamps from tanning salons) reduce the magnitude of the dosimetric RIS components by 50-70% of their initial values. Only five minutes of exposure of the irradiated glass to sunlight caused reduction in magnitude of the RIS by factor of three. These effects put a strong limit on achievable accuracy of retrospective dosimetry using EPR in glasses from mobile-phones, unless their exposure to light containing a UV component can be excluded or the light-induced reduction in magnitude of the RIS is quantitatively estimated. More exprimental detailes and discussion of the presented data is available in [5].

MATERIALS AND METHODS

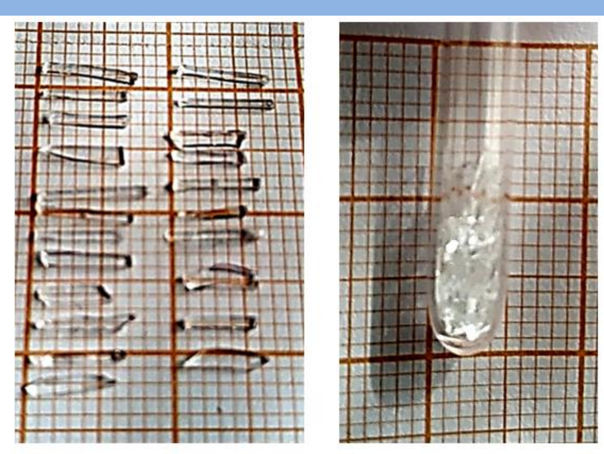

Figure 1. Crushed glass pieces and EPR sample tube filled with the sample on a graph paper.

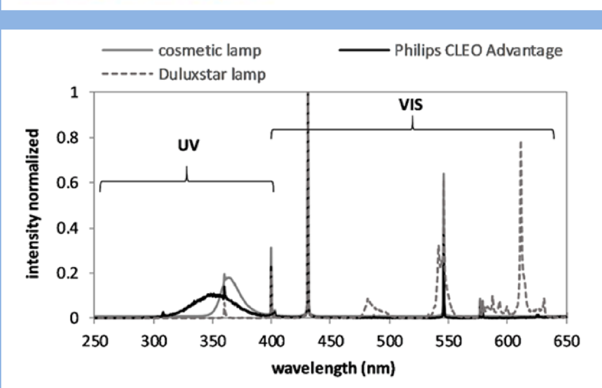

Figure 2. Emission spectra of the lamps used for illumination of the samples.

SAMPLES

The samples were obtained from touch-screens of mobile phones:

- **mineral glass** from Sony Xperia L, model C2105 (marked MG);
- **Gorilla Glass** (marked GG) the type which was also used in the intercomparison study reported by Fattibene et al. 2014;
- screen glass from **iPhone 6S** (marked iP_6S);
- After separating the glass screen from LCD layers and after separating the **TG plates** from the adhesive plastic foil, the samples were washed with ethanol and crushed in a mortar into pieces (Fig.1).

Between irradiations, illuminations and EPR measurements the samples were stored in closed Eppendorf tubes in darkness at room temperature.

X-RAY IRRADIATIONS

The samples were irradiated by 6 MVp photons using Clinac 600 C/D.

The delivered doses were 2 Gy, 4 Gy, 10 Gy and 20 Gy.

LIGHT EXPOSURES

The artificial light sources (spectra in Fig. 2) were:

- a lamp made of **two parallel CLEO Advantage 80W-R bulbs (Philips)** with a power of 80 W each. The total irradiance was 48 W/m².
- an **UV lamp commonly used in cosmetic nail salons for hybrid nail polishing** (Ultraviolet Radiant Lamp AP-111, Alle Paznokcie) with four bulbs, 9 W each. The irradiance at the sample position was 164 W/m².
- a lamp made of **six fluorescent bulbs Duluxstar (OSRAM)**, 24 W each. The irradiance was 110 W/m².

The exposures of the samples to sunlight were done by placing them on a white paper attached to a window sill outside the building at about noon. The irradiance measured during the exposure was about 800 W/m².

EPR MEASUREMENTS and SPECTRA ANALYSIS

The EPR measurements: a Bruker EMX – 6/1 (Bruker BioSpin) spectrometer, in X-band (9.85 GHz) at room temperature.

Spectrometer parameters: modulation frequency=100 kHz, modulation amplitude=1.5 G, microwave power=22.3 mW.

The experimental spectra were numerically decomposed using two sets of model spectra:

1) **a set denoted as B-R** consisting of BG (native background spectrum) and RIS spectra used for all examined types of sample **(ignoring the effects of light)**;
2) **a set denoted as B-R-L** consisting of BG, RIS and LIS (light-induced signal) spectra **(takes into account the light effects in determination of the dosimetric signal)**.

The model BG, RIS and LIS components were determined experimentally: BG was the spectrum of un-irradiated sample not exposed to light, RIS as the difference between spectra of irradiated and un-irradiated sample, and LIS as the difference between spectra of un-irradiated sample exposed and not exposed to a givel the light source.

RESULTS

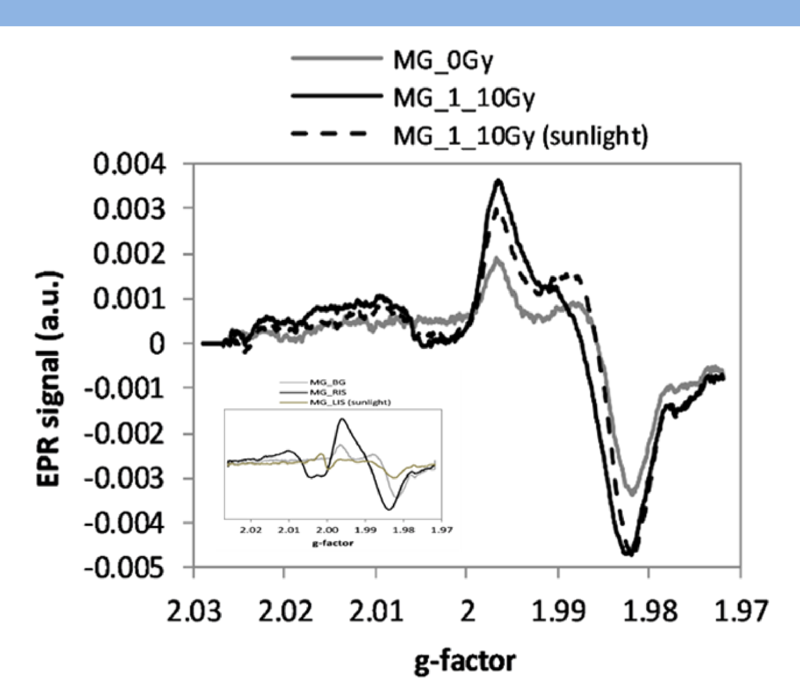

Figure 3. EPR spectra of MG samples: unirradiated (0 Gy), irradiated (10 Gy) and subsequently exposed for 5 min to sunlight). The inset presents the BG, RIS and LIS model spectra.

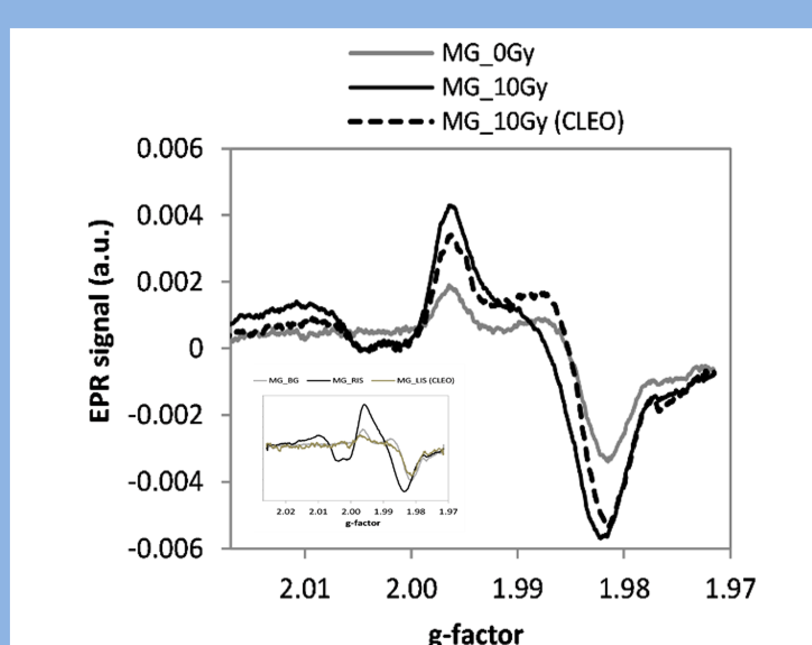

Figure 4. EPR spectra of MG samples: unirradiated (0 Gy), irradiated (10 Gy) and subsequently exposed for 45 min to CLEO UV lamp). The inset presents the BG, RIS and LIS model spectra.

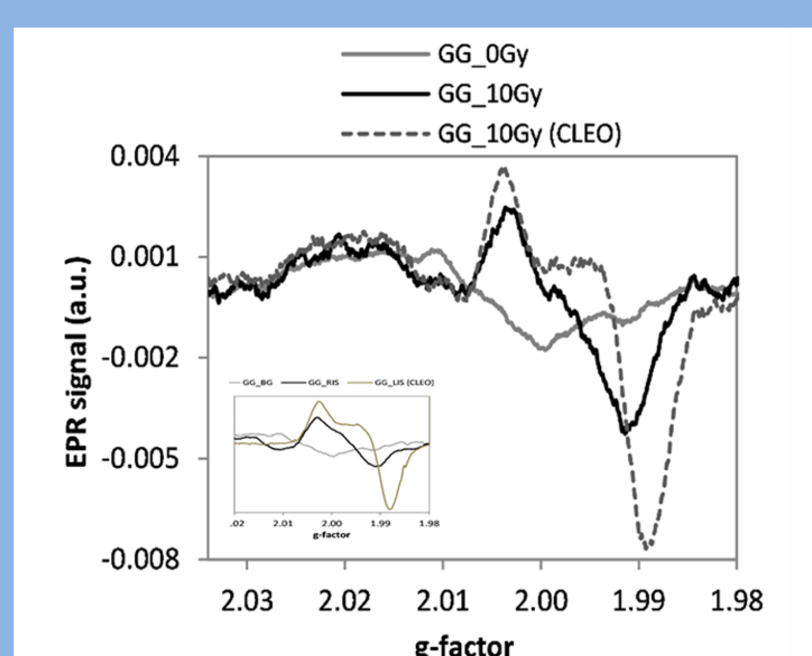

Figure 5. EPR spectra of GG samples: unirradiated (0 Gy), irradiated (10 Gy) and subsequently exposed for 45 min to CLEO UV lamp). The inset presents the BG, RIS and LIS model spectra.

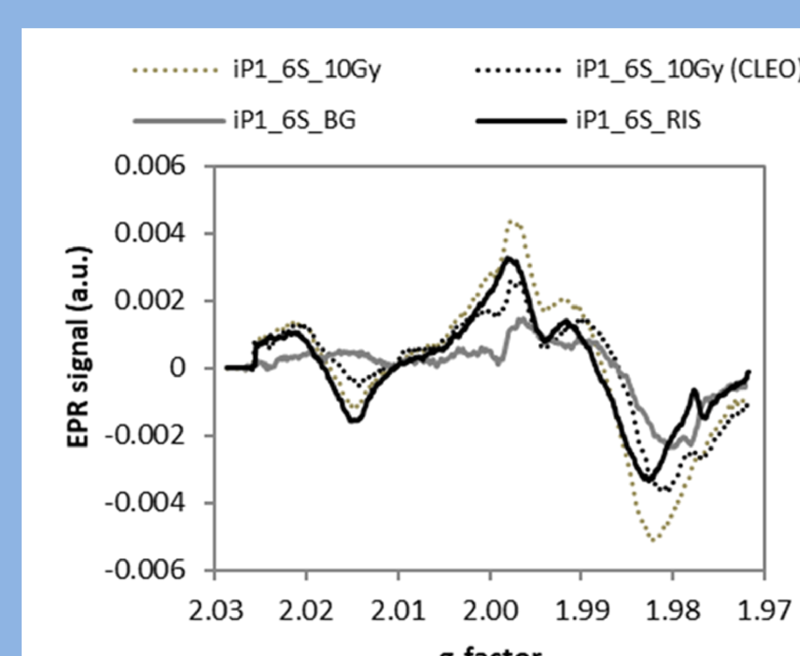

Figure 6. EPR spectra of iPhone 6S samples: unirradiated BG (0 Gy), irradiated (10 Gy) and subsequently exposed for 60 min to CLEO UV lamp). The solid line presents the RIS model spectrum.

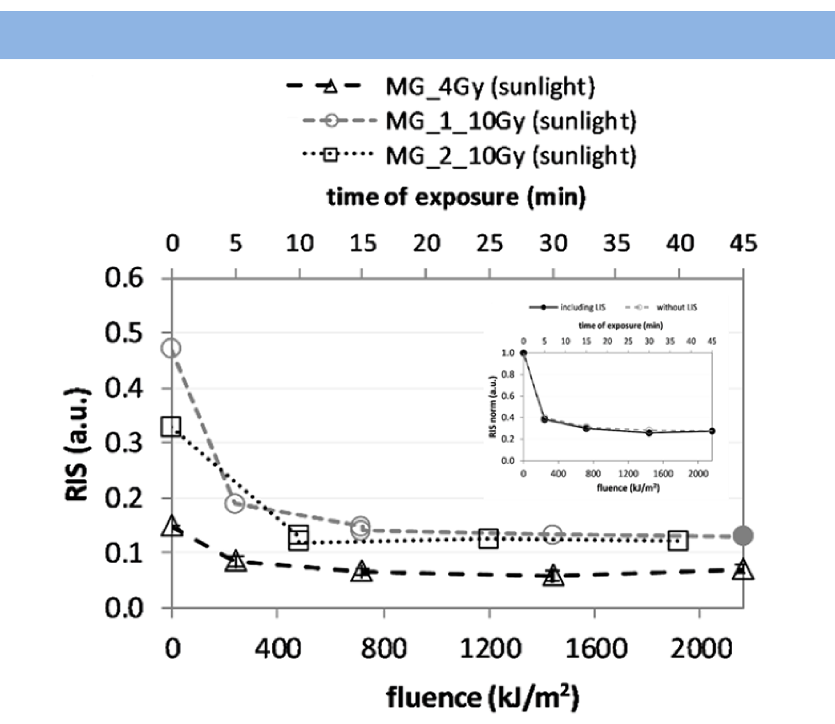

Figure 7. The dependence of RIS (B-R decomposition) on sunlight fluence (or time of exposure) in MG samples irradiated by X-rays to 4 Gy and 10 Gy and subcequently exposed to sunlight). The inset compares respective data for the MG_1_10 Gy sample for two decomposition procedures: using B-R and B-R-L model spectra sets).

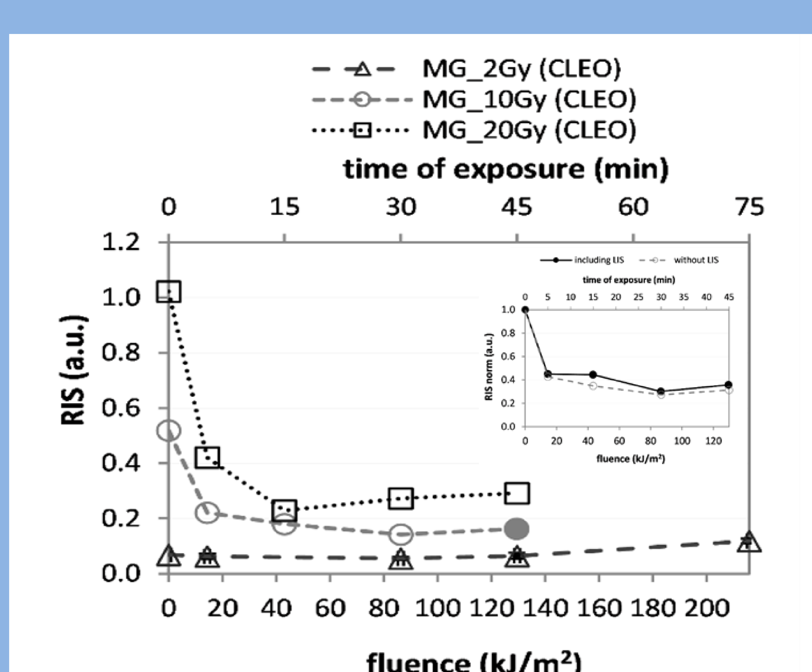

Figure 8. The dependence of RIS (B-R decomposition) on light fluence (CLEO UV lamp) and time of exposure in MG samples. The inset compares respective data for the MG_1_10 Gy sample for two decompositions: using B-R and B-R-L model spectra sets).

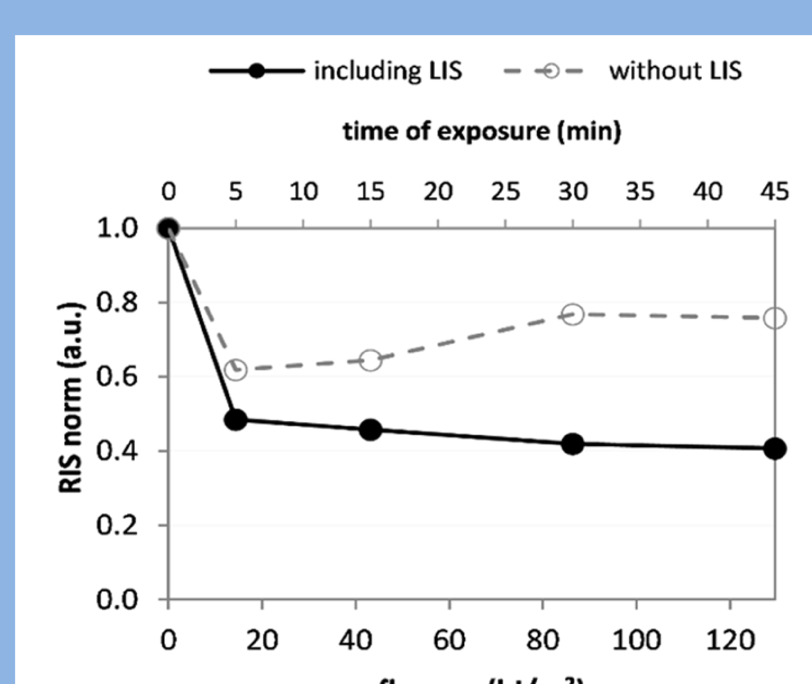

Figure 9. The dependence of on light fluence (CLEO UV lamp) and time of exposure in GG sample. The solid line represents data for the B-R decomposition (i.e. including LIS model spectrum) and the dashed line is for the B-R-L decomposition (i.e. neglecting the presence of the light-induced signal).

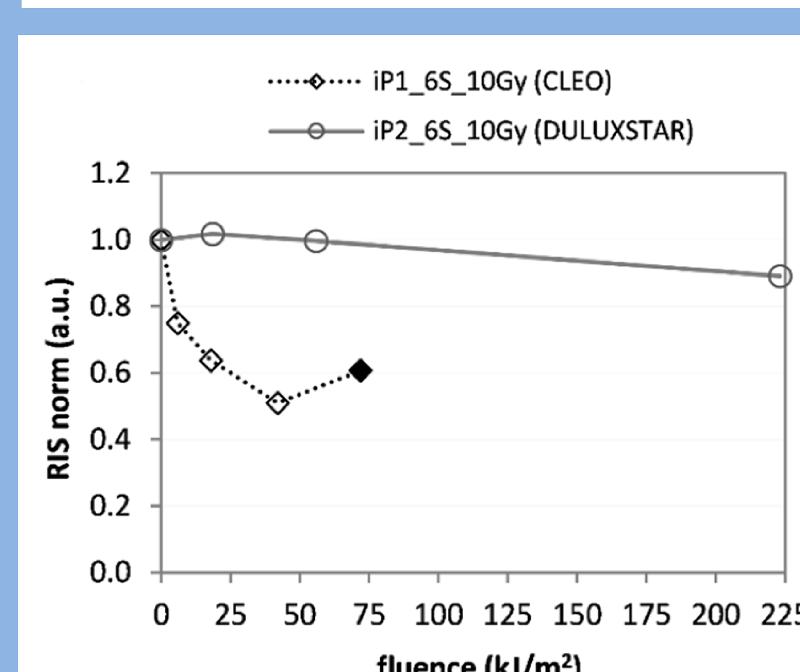

Figure 10. The dependence of RIS (B-R decomposition) on light fluence (CLEO UV lamp and DULUXSTAR) in samples from iPhone 6S. The DULUXSTAR lamp does not generate UV.

SUMMARY

- The dosimetric signal (RIS) and, censequently, the reconstructed doses of ionizing radiation can be significantly underestimated by exposure of irradiated telephone screens to light with UV component eg. sunlight or UV lamps.
- This effect should be taken into account in dosimetric procedures following radiation accidents.
- More details on the light effects presented here are available in Ref [5].

REFERENCES

[1] Ainsbury EA et al. (2011) Review of retrospective dosimetry techniques for external ionizing radiation exposures. Radiat Prot Dosimetry 147(4):573-92
[2] Fattibene P et al. (2014) EPR dosimetry intercomparison using smart phone touch screen glass. Radiat Environ Biophys 53(2):311–320
[3] Juniewicz M et al. (2019) Time evolution of radiation-induced EPR signals in different types of mobile phone screen glasses. Radiat Environ Biophys 58:493-500
[4] McKeever SWS et al. (2019) A comparative study of EPR and TL signals in Gorilla® glass. Radiat Prot Dosim 186: 65-69
[5] Juniewicz M et al. (2020) The effect of sunlight and UV lamp exposure on EPR signals in X-ray irradiated touch screens of mobile phones. Radiat Environ Biophys doi.org/10.1007/s00411-020-00858-7