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Advancements on the Development of Glass Dosimeters

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The development of new multifunctional materials is stimulating the combination of different methodologies for the production of specially designed materials. Nowadays it is possible to combine advancements in electronic and photonics for the development of sensors for a wide range of applications. Silicates are the most abundant, the most interesting and the most complicated class of minerals. According to geologists 90% of the crust of the earth is made of silicates. The advancements achieved in thin film production are one of the best examples of the combination between basic studies and practical applications. The ion beam assisted deposition (IBAD) method, for thin film formation, combines electron beam evaporation of metal or compounds with the simultaneous bombardment by low energy ion beams. Recently, our research group has been working with silicates for a comprehensive study of the physical characteristics of this class of minerals for potential application as ionizing radiation sensors.

Soda lime silica glass is the most common form of industrial produced glass. It is known that these glasses are sensible to ionizing radiation exposure and as a silicate compound their properties can be modified to match innumerous applications. In this work, soda lime glasses were produced with 60 to 75% of SiO_2, 12 to 18% of NaO, 5 to 12% of CaO and 2 to 6% of AgO. The mixtures were heated at temperatures up to 1500ºC and fast cooled after processing. Most of the material was sieved to obtain grains between 0.080 and 0.180 mm size diameter, packed in small amounts and exposed to ^{60}Co gamma radiation down to mGy dose range. The IBAD system was used to produce thin films from evaporated chunks of these silicate glasses bombarded with oxygen ions beam to form silicate glass thin films. The melted glass chunks was evaporated, at a rate of 0.2 nm/s and simultaneously bombarded by oxygen ion beam of 500 eV. The films were produced in a vacuum chamber, with base pressure of 10^{-5} Pa, with 50 nm thicknesses on Si(100) and sliced glass. The sieved and sliced glasses were analyzed by thermoluminescence (TL), photoluminescence (PL), UV-Vis-Nir optical absorption (OA) and the thin films by PL, OA and Rutherford backscattered (RBS).

TL glow curves showed linear response with increasing radiation dose in the range mGy do kGy. The PL emission from these silver doped soda lime silica glasses showed the presence of the PL peaks that can be attributed to the silver oxireduction process present also in the phosphate glasses doped with silver. Figure 1 shows the PL emission spectra of silicate glasses doped with silver and exposed to gamma rays at mGy doses. Photoluminescence (PL) and UV-VIS-NIR optical absorption were studied for the thin films, for some slices of the glasses and showed similar properties. Figure 2 shows PL from glass thin films produced over glass and exposed to gamma rays at Gy doses excited at 335 nm. The PL emission spectra for these thin films showed bands at 480, 550 and 580 nm. The 550 and 580 nm bands showed a linear dependence with gamma dose from mGy up to kGy.

The results of these studies on silicate minerals based materials are promising for radiation sensors. The PL emission from the silver doped soda lime silica glasses showed the presence of the PL peaks that can be attributed to the silver oxireduction process present in the phosphate glasses. The PL emission from these thin films showed the presence of the PL peaks similar to those from bulk glasses exposed to ionizing radiation. PL and TL measurements from the studied materials showed increasing response with increasing radiation dose. The optical properties of these glass thin films are indicating the possibility to use this material as passive radiation dosimeters expanding its applications. These results are promising and this material may become suitable also as a radiophotoluminescence dosimeter. Further studies of UV-Vis optical absorption, ESR and PL are under analysis.

Figure 1

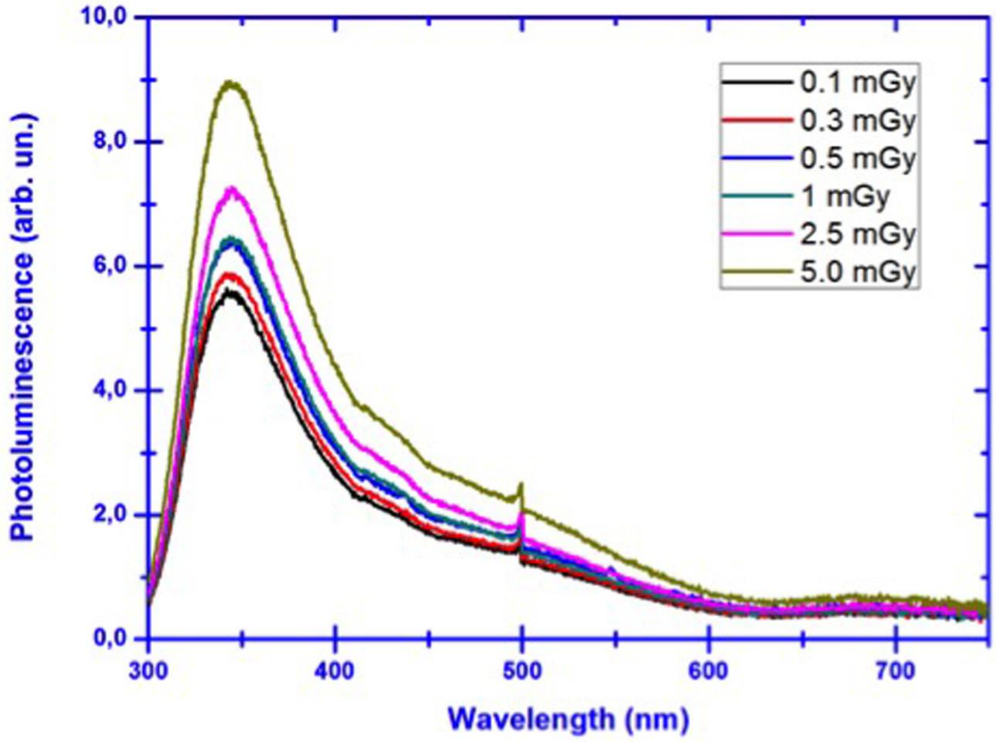

Figure 2