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PHOTOLUMINESCENCE FROM SILICATE MATERIALS EXPOSED TO IONIZING RADIATION

GOVEIA, G.S., FIDELIS, D.G., GONZALES-LORENZO, C.D., GENNARI, R., CHUBACI, J.F.D. and WATANABE, S.

LACIFID, Institute of Physics, University of São Paulo, 05508-090 São Paulo, SP, Brazil

Introduction: 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 silicates can be organized by their chemical composition and their crystal structure. Great effort has been dedicated for the development of luminescent phosphors using transition metal and rare earth as emission centers. Phosphate glass doped with silver, first introduced by Yokota and Nakajima in 1961, exhibits radiation dose dependent photoluminescence (PL).

Calcium silicate is one of a group of compounds that can be produced by reacting calcium oxide and silica in various ratios. Calcium oxide acts as a stabilizer for the silica. Calcium silicate ($CaSiO_3$) possess such physical and chemical properties that can be applied in cases of high mechanical capacity, resistance to humidity and fire, chemical inertia and not abrasive or corrosive to other materials. 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. Natural or laboratory produced silicate crystals and glasses are very sensitive to the exposure of ionizing radiation. Different silicate compositions and structures ranging from crystals to glasses have been used as ionizing radiation sensors.

Photoluminescence emission measurements from silicate glasses has shown increasing response to increasing radiation doses. In this work, calcium silicate was produced as glass for the investigation as possible dosimeter for ionizing radiation.

Materials and Methods: The mixture of calcium oxide and silica were heated at temperatures up to 1500ºC during two hours for melting and uniformization. For the glass production the crucible was taken from the furnace and the melt turned into a substrate for a quenching process down to room temperature. The calcium silicate glass was produced undoped and doped with silver to emulate the same silver oxireduction process that can be seen in silver doped phosphate glass. Slabs from the glass blocks were taken for UV-VIS-NIR optical absorption and photoluminescence studies of these samples. These glass slabs were exposed to low dose of the order of mGy and high doses in the region of kGy for photoluminescence measurements.

Results and Discussion: Photoluminescence from the undoped glass slabs showed a clear emission band centered at 693 nm with dose dependence from few Gy up to kGy when excited at 450 nm. The silver doped glass slabs showed an emission band at 580 nm when excited at 370 nm independent of the silver concentration. The intensity of the 580 nm band for the silver doped glass was much higher than that at 693 nm of the undoped sample.

The 580 nm band excited at 370 nm resemble that of the silver doped metaphosphate glass showing radiation dose dependence. The intensity of the 580 nm band for the silver doped glass demonstrated almost no fading with repeated photoluminescence readings up to 200 hours after the gamma ray exposure. The excitation of the undoped samples is compatible with that used for optically stimulated luminescence.

Conclusion: The photoluminescence results indicate that it could be related to radiophotoluminescence. The results found for the photoluminescence measurements indicates that calcium silicate undoped or doped with silver could be suitable for use as RPL dosimeters. Mechanism of gamma radiation interaction and luminescence emission from the calcium silicate material will be discussed in this work. We are working to find best production condition and possible application of this material as ionizing radiation sensors. (This work is partially supported by FAPESP (Proc. 2014/03085-0), CNPq and ONR-G)

References:

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