A comparative study of energy density (ED) due to silicon oxidation and black body radiation in silicon ball-lightning-like luminous balls

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Abstract – In this work, we have calculated the mean value of energy density due to silicon oxidation and black body radiation of silicon luminous balls (Figure 1). The energy density due to black body radiation was estimated by the spectrum emitted by the luminous balls (Figure 2). Considering a mean radius for silicon luminous balls as being *R* = 1.25 cm, *ED* obtained by the using both physical methods (silicon oxidation and black body radiation) are approximately equivalent.

Ball lightning can be defined as a glowing, self-luminous sphere and usually associated with lightning strokes or thunderstorm activity. We have submitted pieces of 2-inch diameter, p-type doped, (111) or (100), 350μm ± 50 μm thick, 0.02 to 1Ω.cm resistivity Si wafers to electrical discharges of 23VAC and 100 A, where Ball-Lightning-Like Luminous Balls were produced, with diameters between 1 and 4 cm and lifetimes ranging between 5 and 8 seconds, which showed many features of natural ball lightning [1]. In this work, we have calculated the mean value of energy density (*ED*) due to silicon oxidation and black body radiation of silicon luminous balls (*SLB*). *ED* values for both methods are compatible.

In modeling the silicon luminous ball as a metal core surrounded by an atmosphere of silicon atoms, we have considered two equivalent sources of energy: the silicon oxidation enthalpy (W_1) and black body radiation (W_2). We have observed that in our experiments the SLB leaves a white powder trail of silicon dioxide (SiO_2) identified through Fourier Transform Infrared system operating in transmission. The mean mass of the white powder collected in the trail left by selected luminous ball was measured as 7×10^{-3} g for each SLB.

The energy released due to oxidation (~31.9 J) was calculated by using the SiO_2 heat of reaction (ΔH) in gas phase. The ΔH was calculated through *ab-initio* coupled-cluster (CC) method, including basis sets CCSD(T)/cc-pVTZ that gives accurate reaction enthalpies [2]. On the other side, the black body radiation was estimated as being W_2 = 19 J through the spectrum. Considering a mean radius for silicon luminous balls as being *R* = 1.25 cm, *ED* obtained by the using both physical methods (silicon oxidation and black body radiation) are approximately equivalent: *ED* (W_1) = 3.9 MJ m^{-3} and *ED* (W_2) = 2.4 MJ m^{-3}.The thermal energy content of BL may be alone sufficient to explain several high energy events of the natural phenomenon. It seems quite plausible that BL could contain within its small volume sufficient *ED* to deliver such events.

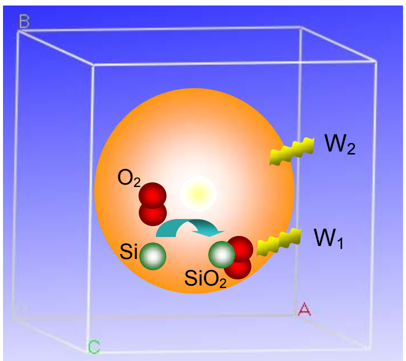

Figure 1: The SLB model showing a hot condensed core surrounded by oxidizing silicon atmosphere.

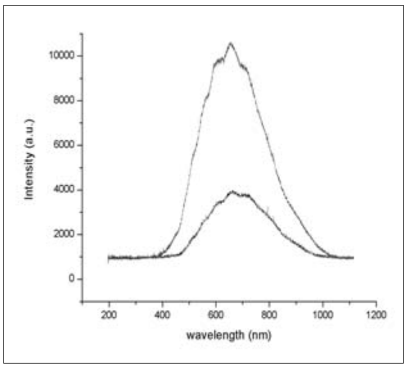

Figure 2: Optical spectra of two distinct SLB.

[1] G.S Paiva, A. C. Pavão, E. A. Vasconcelos, O. Mendes Jr. , E. F.da Silva Jr., Phys. Rev. Lett. 98 (2007) 048501.
[2] G. D. Purvis, R. J. Bartlett, J. Chem. Phys. 76 (1982) 1910.