Physics Letters A 374 (2010) 588–591

Contents lists available at ScienceDirect

Physics Letters A

www.elsevier.com/locate/pla

On phenomenon of light radiation from miniature balls immersed in water

V.P. Torchigin *, A.V. Torchigin

Institute of Informatics Problems, Russian Academy of Sciences, Nakhimovsky prospect 36/1, 119278, Moscow, Russia

ARTICLE INFO

Article history:
Received 15 September 2009
Accepted 6 November 2009
Available online 12 November 2009
Communicated by F. Porcelli

PACS:
42.65.Jx

Keywords:
Whispering gallery waves
Arc discharge
Ball lightning

ABSTRACT

A phenomenon of light radiation from miniature silicon balls produced at arc discharge and immersed in water is described. Video film showing shining balls in a vessel with water is presented. An explanation of this phenomenon is considered. Similarities and differences of this phenomenon with a phenomenon of ball lightning are analyzed.

1. Introduction

Brazil scientists reported in 2007 that luminous spherical objects (LSO) can appear at conventional arc discharge with small pieces of Si wafer introduced in the discharge gap [1]. Unlike conventional sparks which accompany an arc discharge, LSOs have unusual properties. In first, their life time is essentially greater than that of the sparks and can achieve eight seconds. In second, they jump in process of their moving, can bypass obstacles, and penetrate through splits which width is smaller than their diameter. These LSO properties remind behavior of Ball Lightning. New video films where scientist from various countries repeat these experiments appeared in Internet after publication of this Letter. The most informative is video by V. Gooses, P. de Graaf and R. Dekker from Holland, Eidhoven [2]. They accompany their video by description in detail of their experimental installation and features of experiment. There are video films of scientists from USA [3] and Spain [4]. But the question whether similar LSO is a certain version of Ball lightning remains open.

Having developed own theory of Ball lightning and published above ten scientific papers in International physical Journals, we decided to investigate experimentally LSO properties at interaction LSO with various surfaces. This is not so hard problem because a necessary experimental installation is very simple and is comparable on complexity with a simple arcwelder. Having investigated interaction LSO with a surface of water we discovered a surprising phenomenon. Unlike any solid state heated up to white luminescence, which hisses, evaporates water and ceases to be shone at immersing in water, LSO behavior is different. At dropping at the water surface LSO dives on a vessel bottom and it continues to be shone. Experimental conditions, explanation of this phenomenon and analysis of similarities and differences between LSO and Ball Lightning are presented below.

2. Experimental setup

A scheme of experimental setup is shown in Fig. 1. Battery B1 of conventional 12 Volt car accumulators is used as a power supply. From one to five accumulators can be used. A circuit of discharge current consists of the following elements connected in serial: semiconductor diode D1 (500 A, 2800 V), relay K1 for currents up to 500 A controlled by switch SW1, 10 mH inductance L in a form of secondary coil of arcwelder transformer, discharge gap G with possibility to change distance between electrodes, 1 Ohm additional resistor R1 for currents up to 500 A. This resistor is shunted by shunt R2 which resistance can be changed from 2 Ohm till zero.

The discharge gap G is formed by a gap between top and bottom electrodes. The top electrode is a wolfram cylindrical rod of 2.4 mm diameter. The bottom electrode is vanadium cylindrical rod of 5 mm diameter. The distance between faces of electrodes can be changed by means of micrometer screw from zero to several millimeters. Besides, the distance between electrodes can be increased quickly at turning on current in solenoid S. There is possibility to set up limiting width of the discharge gap when quickly

* Corresponding author. Tel.: +7 499 1332532.
E-mail address: v_torchigin@mail.ru (V.P. Torchigin).

0375-9601/$ – see front matter
doi:10.1016/j.physleta.2009.11.024

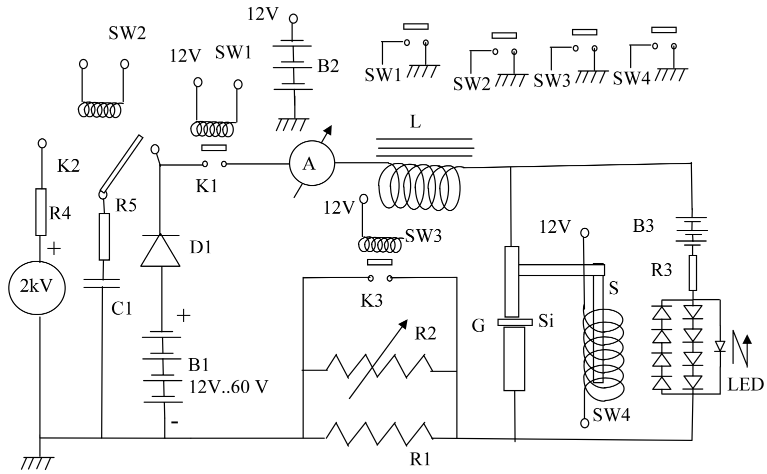

Fig. 1. Scheme of experimental setup.

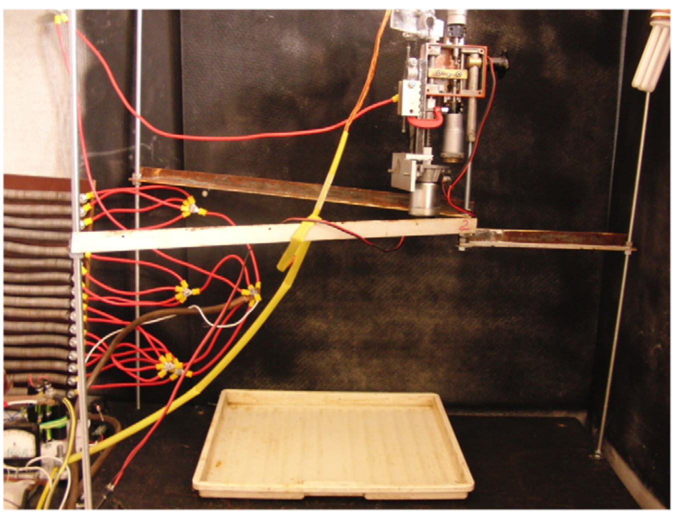

Fig. 2. General view of experimental setup.

increasing is used by means of another micrometer screw. A general view of the setup is shown in Fig. 2.

Usually initial resistance discharge gap G when Si wafer plate is inserted between electrodes is great enough and no discharge takes place at turning on relay K1. In this case the voltage between electrodes is equal to the voltage of battery of accumulators B1 (from 12 till 60 Volts in dependence on number of accumulators used). This voltage is not sufficient to break down the discharge gap. Additional high voltage circuit is used for this purpose. The circuit consists of power supply of 2 kV voltage, 3 μF capacitor C1, resistors R4, R5, and relay K2 which is controlled by switch SW2. If SW2 is turn of, capacitor C1 is connected with 2 kV power supply. When SW2 is turn on, capacitor C1 is connected with relay K1 through resistor R5 and 2 kV voltage is applied to the discharge gap provided relay K1 is turn on. 2 kV voltage is sufficient to break down discharge gap with one Si wafer inserted between electrodes. This voltage is sufficient also to break down discharge gap G with two silicon plates inserted between electrodes if three or greater accumulators are used. High voltage diode D1 is required to prevent shunting 2 kV voltage by battery B1. Resistor R5 can be changed from 0 to 50 Ohm and used to set up initial discharge current from capacitor C1. Resistor R4 of 18 kOhms is used to charge capacitor C1 gradually.

The third auxiliary circuit is used for indication of situation when the distance between electrodes is equal to zero and they touch each other. The circuit consists of 12 V power supply B3, LED, resistor R3 of 5 kOhms and set of diodes that prevent over voltage on LED when 2 kV voltage is applied to discharge gap G. When electrodes touch one with another, LED begins to light.

Typical steps of experimental study are the following. Electrodes with clear faces are inserted in corresponding clamps in such a way that necessary distance is provided. The top electrode can be lifted by hand. It takes its previous location after being released. When the top electrode is lifted by one hand, one or several Si wafer plates of 3×3 mm size are placed on the face of the bottom electrode by another hand and the top electrode is released. The plates are obtained from Si wafer used for IC production. Their thickness is in the range 0.3–0.36 mm. A degree of compression of the plates depends on initial distance between electrodes. Usually zero distance is used and a force about 1 kg is required to lift the top electrode overcoming resistance of a spring and the weight of electrode with its clamp.

Then SW1 is turn on. Since Si wafer plate have oxide films, no discharge takes place.

Then SW2 is turn on and 2 kV voltage is applied to the discharge gap. In this case a break down of films takes place and current though discharge gap is determined by sum of the following resistance: resistance of discharge gap G, active resistance of inductance L, additional resistance R1 and R2, inner resistance of accumulator battery B1. This current is proportional also to the number of accumulators in battery B1. Usually this current is about 50 A. In this case the Si wafer plates and fragments of electrodes near the plates become red color but usually no discharge takes place.

At the next step SW3 is turned on and additional resistors R1 and R2 are shorted. The current increases up to 200 A and luminous spherical objects (LSO) appears often. Possibly in this case Si wafer plates begin to liquate and splash because the electrodes tend to near each another.

If no LSO appeared, SW4 is turned on. The distance between electrodes increases and resistance of discharge gap increases abruptly. Because the current through inductance L can not be changed abruptly, the voltage at discharge gap increases and a typical arc discharge appears. In this case resistance of discharge gap depends on the distance between electrodes. Appearance of LSOs is observed often.

Thus, described installation is not differed principally from that used in [1,2]. But possibilities to control currents, moments of break down of discharge gap, distance between electrodes and a degree of their compression enable to obtain LSOs at each attempt almost.