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Ideas for Explaination of an Electrical Signal Generation at Interaction between Electromagnetic Field and Matter

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Abstract. In our investigations of interaction between electromagnetic field and matter experimental results were observed, which were grouped under the working name “Surface Photo Charge Effect” (SPCE). The important point is that the interaction of any solid with electromagnetic field induces an alternating electric signal with the same frequency as the frequency of the incident field [1]. The voltage between the irradiated sample and a second solid, whose potential is assumed to be zero, is measured contactlessly. The SPCE represents generation of an alternating voltage when a solid interacts with a modulated electromagnetic field. The potential difference between the irradiated sample and the common ground of the system is measurable and depends on many factors. The name Surface photo charge effect has been kept historically. It does not reflect the newer experimental results.

1 Introduction

Possible mechanisms causing SPCE are proposed and analyzed, but they could not be considered determinative or complete. A detailed theoretical interpretation of the SPCE has not been developed yet. Several hypotheses in various types of solids, were proposed [1, 2]: (i) for conductors, the incident radiation decaying in the medium depth leads to the generation of a force directed perpendicularly to the illuminated surface and redistributing the charges in the conducting medium; (ii) for non-conducting media, the incident radiation leads to redistribution of the charges, accumulated into surface energy states; (iii) the incident light redistributes dipole molecules absorbed on the surface of the dielectrics; (iv) photo desorption or surface sputtering induced by the incident radiation. The above hypotheses cannot be considered determinative or complete. The explanation of the SPCE will probably require new ideas.

2 SPCE Features

SPCE is a very fast effect. For example, an irradiation with 20 ns laser pulse results in a signal response which reproduces precisely the waveform of the incident pulse. As the experiments have shown, the arising of a signal from a solid after electromagnetic irradiation is an universal feature of solids. SPCE has been measured in the frequency range 1Hz-1Gz, infrared, visible and the beginning of ultraviolet. Our hypothesis is that the effect exists in the whole frequency range of the electromagnetic radiation. SPCE can be induced only by modulated incident radiation. The lack of response upon non-modulated field is evidence that the detected signal is induced by the SCPE.

Possible mechanisms causing SPCE are proposed and analyzed [2]. Since the electron properties of the solid are influenced by the incident electromagnetic radiation, it is expected that excited changes will provoke measurable SPCE signals. In this way, with all other conditions fixed, it is possible to detect changes in the solid properties. Experimental study shows that the sensitivity of the proposed method is high.

An important feature of SPCE is it's significant dependence on the specific properties of the irradiated samples. For example, each body can be characterized by it's weight, determined by the interaction between the body and the gravitational field of the Earth. In a similar way, it can be characterized by the SPCE which is determined by the interaction of the body with an electro-magnetic radiation. This fact reveals opportunities for a fast and contactless analysis, not only applicable for solids, but also for liquids, gases and even foods [1, 3].

As mentioned above, one of the features of SPCE is that every solid generates a specific signal. The amplitude and the phase of this electric signal depends on the specific peculiarities of the solid. Most frequently we monitor the amplitude. This means that we could monitor the state of variety of samples quickly and without any physical contact.

3 Experimental Setup

A schematic diagram of the experimental setup for SPCE observation used in our research is shown in Figure 1. (L) is the source of incident radiation. The radiation was modulated by using a modulator (M). The studied sample is placed in the measuring arrangement (S). The measured signals are in the nano- and micro-volt scale and were amplified by the preamplifier (A). The detected signal had very low amplitude, thus a lock-in nanovoltmeter (N), capable of extracting the signal from the background noise was utilized. The configuration was described in detail elsewhere [2].

Since SPCE exists in any matter, it can be applied for the development of sensors and control systems in all areas, for example in fog. Figure 2 shows an impurity control system based on SPCE.

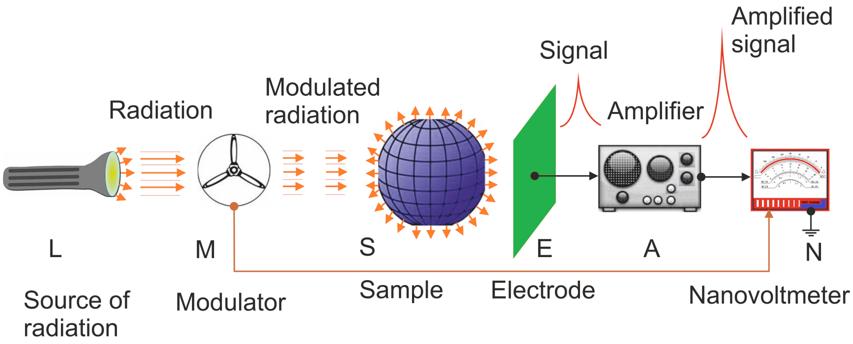

Figure 1. Experimental setup for SPCE observation: L - source of radiation; M – modulator; S – measuring structure; E - electrode; A – high impedance amplifier; N – lock-in nanovoltmeter.

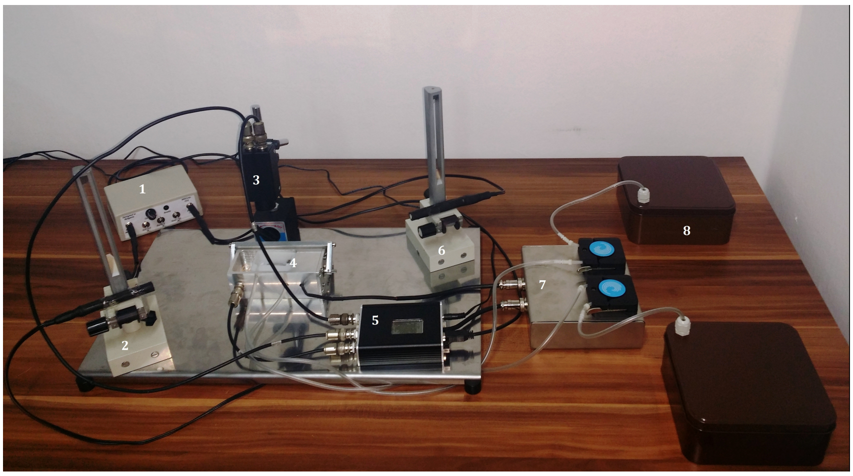

Figure 2. System designed for evaluation of fog contamination and detection of dispersed agents.

As a matter of fact effects, due to charging of conductive medium upon irradiation with electromagnetic field, have been known for a long time. A specific feature of the SPCE is that it can be induced in all solids. The SPCE literally surrounds us each solid is charged by the electromagnetic fields, which exist in this space region and, thus, can reveal information about processes taking place at a considerable distance.

4 Explanation

The explanation of SPCE will probably require new ideas. It is not impossible to seek an explanation, within a theory dealing with field - matter interactions.

The approach will involve quantum-mechanical, semi-classical and statistical considerations on the interaction of an electromagnetic field with the surface of a material, which may be a metal, a semiconductor or an insulator. Density Functional Theory (DFT) including external electromagnetic fieldseffects is one of the possible approaches considered at present for the description of SPCE physical mechanisms. Standard DFT for non-degenerate ground states [4, 10] has already been extended to open-shell and excited states [5]- [9]. In order to include an external electromagnetic field in the Kohn-Sham equations, the theory of the density of the electron flow induced by the electromagnetic field will be further developed. It will be applied to the definition of the one-particle and two-particle charge and spin density matrices [11]. The Kohn-Sham equations defined in this manner will be used to describe the interaction of the electromagnetic field with the particles on the surface and in the bulk. The calculations will be based on techniques already developed in the DFT for surfaces. Approaches along the scheme of Blochs theory for oscillations in the induced electron density [12] will also be considered.

Other DFT studies are possible. In particular, the changes in the observed voltage can be described in the linear regime within time-dependent DFT, recently developed for diverse finite Fermi systems (atomic clusters [13], atomic nuclei [14]). This microscopic approach demonstrates a high accuracy in the description of the linear response. At the same time, it is physically transparent and very convenient for the analysis of numerical results. It is very flexible and can incorporate the necessary relevant ingredients (pseudopotentials, pseudo-Hamiltonians, interface interactions,etc) [15]. Together with the control of non-uniformities at metal surfaces, the monitoring and control of microstructures supported by (or embedded in) insulator matrices are very important for practical aims. The approach [16] can be generalized for these aims. It could be considered both one-photon (photoabsorption) and two-photon (Raman scattering, etc) processes. The possibility to apply different two-photon processes to atomic clusters (Raman scattering, stimulated emission pumping and stimulated Raman adiabatic passage) was recently analyzed within the DFT approach [16]. It would be very interesting to perform similar study on heavy embedded clusters, which are already explored experimentally [17].

There are plans to generalize the DFT approach to the investigation of quantum transport through supported microstructures in time-dependent external fields. For this aim, density- and current-dependent TD-DFT will be used (including the current as the Lagrange multiplier in the static Kohn-Sham equations [18] with a subsequent derivation of the time-dependent linear response).

5 Conclusion

The experimental results, described above, showed that upon irradiation with electromagnetic field, an alternating potential difference, with frequency equal to that of the incident radiation, was generated in the medium. Maybe this is a fundamental characteristic of the matter a specific response to the action. It is charged with frequency, equal to the one of the incident radiation. An equation describing the relationship between the volume of the irradiated body and the generated voltage would be of great interest. The volume of the solid, a constant, accounting for the type of material and it's conductivity, and the intensity of the incident field should be taken into consideration. The outlined results pose many questions and reveal interesting possibilities. Well-known facts can be interpreted in a new way. For example, if solids can be charged with the frequency of the incident electromagnetic field, they should also emit electromagnetic waves with the same frequency. In this case SPCE could contribute to the explanation of the mechanism of vision.

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