# The Injection of the Charge Carriers in Energy Materials Stimulated by Magnetic Field

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**Abstract – The one of features of energy materials is high sensitivity exterior actions of a various nature therefore, processes of an aging may considerably will be sped up and quite often to result in to explosions and fires. In this connection, there is actual an examination of the influence of magnetic fields on the decomposition of energy materials initiated by activity of the strong electric field in a mode of monopolar injection of holes. The opportunity of boost of the slow decomposition of the given materials (on an example of silver azide) with the help constant (H=100÷10$^4$ kOe) and variable (H=100÷10$^3$ kOe) magnetic fields is experimentally shown. The possible mechanisms of boost of injection of charge carriers by activity of the magnetic fields, the forces of Lorentz based on activity, magnetoelectrical and magnitoplastical effects, and also an induced electric field are offered. It set, that the variable magnetic field accelerates process of the decomposition and leads up it to the explosion at much smaller intensity of a magnetic field (approximately in 3 times). On the basis of that, the deduction about more efficient influence of a variable magnetic field on passing solid-state reaction that is bound to acceleration of the injected charge carriers in an induced vortex electric field was made.**

Distinctive feature of heavy metals azides is saturation energy which is the reason of that at the external technogenic influences of an electric, mechanical or magnetic nature, while in service, at the transportation or storage, processes of ageing may be accelerated considerably. The result of that is refusal of the work of a product, that essentially limits a scope of the given materials and quite often entails a significant material damage.

It was earlier established, that action of a contact electric field promotes course various physico-chemical processes in the given materials, in particular, to reaction of slow and explosive decomposition [1].

Therefore the research of the influence of constant and variable magnetic fields on the process solid-phase decomposition initiated by the action of a contact electric field in crystals of silver azide that is the purpose of the present work is actual.

The material was silver azide, crystals grown according to the technique describe in [2] with an average size 10×0,1×0,03 mm$^3$. The crystals were glued to a mice support the gallium contacts were attached at a distance of 1 mm. The voltage applied to the contacts was 300 V. The prepared samples placed between poles of a constant magnet or an electromagnet in the special cell made of a not magnetic material. Two variants of geometry of the appendix electric (E) and magnetic fields (H) – crossed. (E⊥H) and parallel (E||H) were used (Fig. 1). An induction of a magnetic field changed in limits from 0,5 Oe up to 10 kOe.

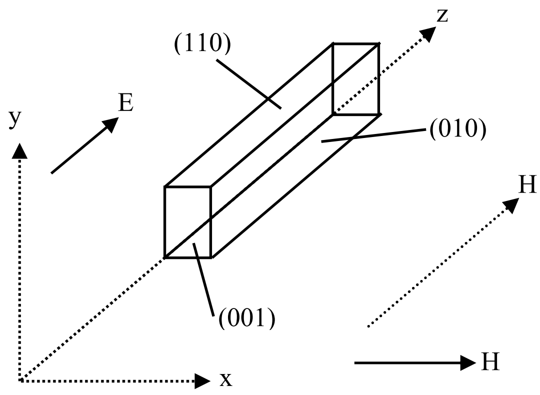


Fig. 1. Orientation of a crystal silver azide in the crossed electric and magnetic fields

The variable magnetic field with frequency 0,2÷2 kHz and at the intensity of a magnetic field 1 kOe represents the transformer consisting of two windings, in magnetic circuit which is made a backlash where placed specially made cell with a sample. On the ends of an initial winding submitted a variable voltage with the given frequency.

Electric and magnetic fields were included and switched off simultaneously.

The products of decomposition in an anionic sublattice analyzed methods Hilla [3] and the external gas evolution.

The gas evolution from a crystal was observed under the microscope in transmitting red light in a dish during the energy effect when an active part of the crystal was coated with a vaseline layer with the thickness ~ 1 mm. According to the preliminary experiments the vaseline oil does not dissolve the gaseous product evolved from the crystal and it does not decompose under the effect of the field. Our construction of the cell allowed us to observe and estimate the volume and the rate of evolving nitrogen gas bubbles

($\nu_r$) into the oil when magnified 100 times as much. The sensitivity of the given method is $10^{-13}$ mole.

To analyze the gaseous products captured by the crystal lattice (so-called "trapped gas") the sample was washed, dissolved in a 0,36 N $Na_2S_2O_3$ aqueous solution at the volume of gas bubbles evolved into solvent was measured. The process of dissolution was observed in a confined volume under the microscope with a micrometer scale in transmitting red light, the diameter and space coordinates of the evolving gaseous product (nitrogen) being recorded. The volume of the gas (V) bubbles related to the surface area (S) subjected to the energy exposure was calculated. The sensitivity of the given method was $10^{-12}$ mole.

Earlier in work [1] it was shown, that at the voltage 250–300 V and 1 mm in system Ga-$AgN_3$-Ga is realized by interelectrode distance a mode of monopolar injection holes. Also, experimentally established, that the development of the reaction of the slow decomposition and its transition in explosion is characterized: the allocation of the heat; the formation and the development in the process of course of the reaction volumetric macrodefects; the electric breakdown and the ignition of a sample. And the intensity of the gas evolution depends on quantity of the volumetric defects in a sample.

In the present work research of the influence of a constant magnetic field in a various configuration on the injection of the carriers of a charge is carried out.

As a result of the carried out researches on the influence of a magnetic field in various configurations on the electrofield decomposition of the silver azide, it is established (See Fig. 2), that, both at parallel, and at crossed magnetic and contact electric fields are observed the effect of the strengthening of the decomposition at the intensity of a magnetic field (H) more than 4 kOe. Thus in case of parallel fields, more expressed character of transition of the slow electrofield decomposition in explosion is observed.

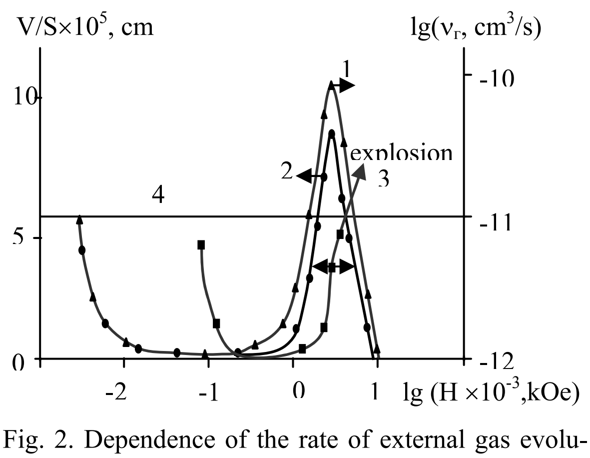


Fig. 2. Dependence of the rate of external gas evolution (1) and the relative volume "trapped gas" from intensity of a magnetic field: 2-E⊥H, 3-E||H; a straight line – 4 at H=0

Also from the Fig. 2. it is visible, that there is an interdiction on the chemical reaction in the field of the values tensions a magnetic field 500–1000 Oe, that also it is typical and of a case of the crossed fields.

Visual supervision have shown, that the gaseous product is allocated on a side (110) where leave hole under the action of the force of Lorentz. While in absence of a magnetic field gas is allocated from a surface (010).

Proceeding from the results given in work [1], the external power influence promotes curve of zones in the near-the-surface to area and by that removes a barrier to an output holes in reactionary area where chain the chemical reaction of the decomposition proceeds. Also it is known, that the magnetic field changes a trajectory of the movement of carriers of a charge. Hence, it is logical to assume, that at intensity of a magnetic field more than 4 kOe there is a drift which the results in destruction of last stage, namely the diffusions interstitial cation or own, or impurity from volume to a surface of a crystal through vacancy clusters, consequence of that is seen reduction of the quantity of the external gas evolution, also other process, accumulation of the products of the decomposition in the volume of a sample that results in increase of the internal pressure which in addition promote reduction of a power barrier of the reaction of decomposition also is probable. Besides the magnetic field promotes redistribution of the reactionary areas on a surface of a sample. So during experiment it is marked concentrating reactionary areas on a lateral side of a crystal in case of the crossed fields and their displacement to one of the ends of the top side (010), in case of parallel fields (magnetoelectric and magnnetoplastic effects [4]). The result of the above described the processes are the observably phenomena, namely: the sharp increase of speed of reaction and its transition in explosion in case of the parallel fields, caused by that dispositions by virtue of their negative charge concentrate at one of sides. Thus, to arise a congestion of reactionary areas which results in local allocation of the heat as a result of chemical reaction that stimulates explosive decomposition. Also as a result of experiment reduction of speed of gas evolution is observed, both in case of crossed, and at parallel fields (Fig. 2), that is connected to reduction of diffusion of reagents from depth of a sample.

The research of the influence of a variable magnetic field on explosive sensitivity was carried out. It is known, that the varied magnetic field or movement of a material through a field results in occurrence of a vortical electric field. Induced currents (vortical currents) cooperate with a magnetic field therefore force which the influences movement of the charged particle [5] operates. The dependence of the quantity of the "trapped gas" on frequency of a variable magnetic field was received at joint action of a contact electric field in crystals of silver azides (See Fig 3). Visual supervision have shown, that a gaseous product in crystals of the silver azide, processed by a variable magnetic field, also, as well as in constant, is allocated from a side (110) that confirms action of magnetic making force of Lorentz on topography of the products of decomposition.

It is necessary to note, that the variation of intensity of a variable magnetic field (within the framework of opportunities of used installations) has not resulted in significant changes. The effect of dependence of the slow decomposition from frequency of a variable magnetic field (See Fig. 3) is received. At the frequency of a variable magnetic field from above 1 kHz smooth strengthening of the decomposition with the subsequent output on a hospital is observed, and at frequency more than 1,5 kHz slow decomposition passes in explosive.

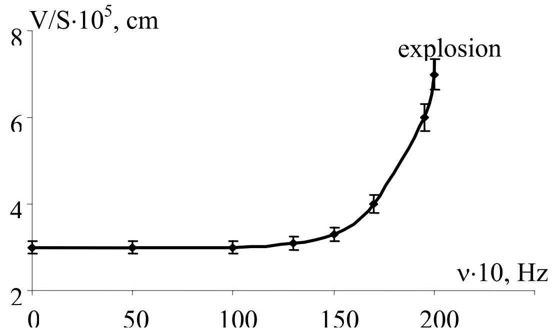


Fig. 3. Dependence of the relative quantity of the allocated gas on frequency of a variable magnetic field (H = 1 kOe) at joint action with a contact electric field (E=300 V/mm) in crystals of silver azide

The increase of probability of the explosive decomposition in a variable magnetic field, probably, is connected to influence of a vortical electric field.

The movement of a particle in a vortical electric and variable magnetic field is determined following by two basic equations [6]:

$$\frac{\partial p}{\partial t} = -eE\,, \quad (1)$$

$$p = eRH\,, \quad (2)$$

where $p$ – a pulse of a particle, $E$ and $H$ – intensity of electric and magnetic fields in an orbit, $R$ – radius of an orbit, $\upsilon$ – speed of a charge's carriers, $e$ – charge of electron.

At the increase of frequency, the magnetic field in the area of movement of a particle quickly accrues for small time $dt$, thus, apparently from the equation (2), the pulse of a particle is increased. Thus, to increase of a pulse there is an increase of the speed, and, hence, and kinetic energy. Under action of a vortical electric field the particle increases speed of movement, and the magnetic field in this area quickly accrues, and the moveзment of a particle will occur on a pulled together spiral [5]. Hence, the increase of the frequency of a variable magnetic field will result in "twisting" of the carriers of a charge and to increase of their kinetic energy that causes explosive decomposition of a sample. Apparently from Fig 2, the stimulation of electrofield decomposition with the help of a constant magnetic field occurs at intensity of a magnetic field 3÷4 kOe while the variable magnetic field accelerates process of the decomposition and leads up its explosion at value of at intensity of a magnetic field 1 кOe (Fig. 3).

Thus, it is possible to draw a conclusion on effective stimulation of electrofield injection with the help of constant and variable magnetic fields in crystals of heavy metals azides. Also, the methods of guidance designed by the slow and explosive decomposition initiated by the strong electric field in crystals of silver azide.

## References

[1] V.I. Krasheninin, L.V. Kuzmina., V.Yu Zakharov, and A.Yu. Stalinin, Chem. Phys. Reports, 14, 4, 126 (1995).

[2] F.I. Ivanov, L.B. Zuev, M.A. Lukin, and V.D. Maltsev, Rus. J. Crystallography, 28, 1, 194 (1983).

[3] H. Heal, Nature, 172, 30 (1953).

[4] L.V. Kuzmina, V.I. Krasheninin, and V.E. Khramchenko, Rus. Journal of a scientific and applied photo, 47, 4, 43 (2002).

[5] S.V. Vonsovskiy, *Nature of magnetism,* Moscow, Znanie, 1964, pp. 36.

[6] L.A. Artzimovich, S.Yu. Lukianov, Movement of the charged particles in electric and magnetic fields, Moscow, Science, 1972, pp. 224.