Explosive Decomposition Lead Azide at Big Duration an Influencing Laser Pulse

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Abstract – Initiation of lead azide powders of various densities at laser irradiation with wave length 1,06 μm in wide range of duration (10^{-5} – 10^{-3}s) is experimentally investigated. It is shown that: 1) thresholds of ignition for poorly pressed samples with density ρ up to 2,0 g/cm^3 do not change with increase in duration of a laser pulse; 2) thresholds grow by some orders for samples with density 4,0 g/cm^3. It is revealed that products of explosion of samples with density up to 2,0 g/cm^3 contain the fused particles of lead with the sizes on the order more than similar particles at explosion of samples with ρ = 4,0 g/cm^3.

Previously in works [1,2] the data of initiation of lead azide powders by laser pulses with duration from 10^{-8} up to 10^{-6}s are resulted. Heretofore the initiation of samples by laser radiation in a range of an influencing pulse from 10^{-5} up to 10^{-3} s was not studied. Similar experiments would allow to add a picture of laser ignition of azide powders and to ascertain an initiation mechanism. In this work such investigations are carry out.

Experiments in an atmosphere of air were carried out. Examples ~ 15·10^{-3} g with bulk density ~ 0,6 g/cm^3 were allocated in a plexiglas capsule with internal diameter of 3mm, depth of 3 mm and pressed by the piston up to density no more than 2,0 g/cm^3. Samples with density 4,0 g/cm^3 were made in another way. Examples were allocated in a compression mould and pressed on manual press up to the required density. Samples look like as tablets with diameter of 3 mm. The whole of open surface of tablets face was irradiated on a normal.

Radiation of two lasers was used: neodymium, generating quasi-rectangular, quasi-continuous (depth of modulation no more than 30 %) laser pulse with duration from 0,1 up to 4 ms and the yttrium aluminum garnet laser, generating the short laser pulse with duration from 15 up to 80 μs. Non-uniform light-striking of a front surface of sample irradiated on a normal direction has made no more than 20 %. The circuit of experimental set and measurement method of power thresholds of ignition (TPI) is resulted in work [3].

As a result of experiments the dependences of ignition thresholds on duration of a laser pulse for various densities of samples (Fig. 1.) are plotted. From figure it is visible that TPI of poorly pressed samples remain at one level with increasing duration of a laser pulse, but TPI of strongly pressed samples grow in some orders.

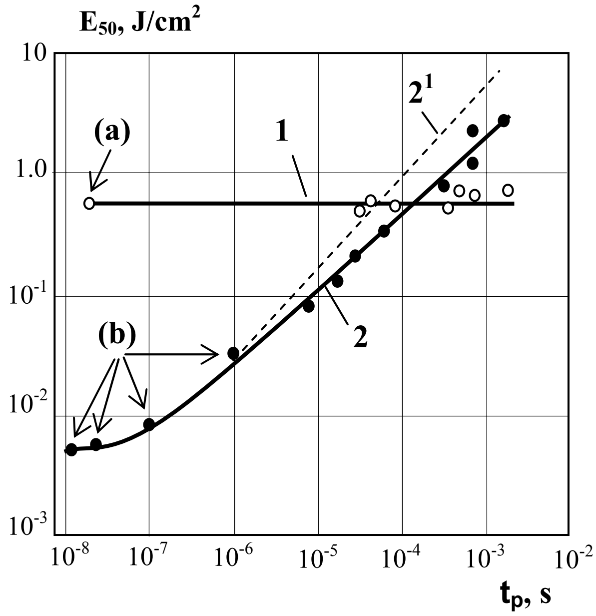

Fig. 1. Dependence of a ignition threshold E_{50} on duration of a laser pulse t_p.
1 – ρ = 0,6 – 2,0 g/cm^3; 2 – ρ = 4,0 g/cm^3; 2^1 – theoretical calculation according to model [2]; (a) and (b) – experimental points on the data [1] and [2] accordingly

To explain the received results, it is necessary to consider process of condensation of a loose material. It is conditionally possible to discriminate three stages [4]. 1) Condensation due to destruction of the particles of arches formed by coupling and the vaults creating emptiness and causing the big porosity of a bulk powder. Under pressure the particles are displaced relatively each other and filled the air voids. Only some particles, which have got in adverse conditions, can be deformed at this stage. 2) Condensation due to deformation of particles comes, when their structural stowage is came to end, is exceeded the limit of elasticity and durability, occurs destruction of particles and formation of new contact surfaces. At this stage the strong porous solid is formed. 3) A stage of creation of a solid material. For lead azide powders it is achievement of monocrystal density ρ = 4,7 g/cm^3.

The samples with density up to 2,0 g/cm^3 are corresponded with the first stage of condensation, at ρ = 4,0 g/cm^3 – to the second stage.

Independence of TPI for samples with density up to 2,0 g/cm^3 on duration of laser pulses in an interval of times 10^{-8} – 10^{-3}s explains the presence of pores which are the centers of gas-dynamics unloading. For initiation it is necessary to create pressure in pores, sufficient for lock-out of gases in the decomposition centers that promoting its development.

For the samples with density ρ = 4,0 g/cm^3 gas-dynamic the factor ceases to play an appreciable role. Unloading of the center is determined only by processes of heat conductivity. Therefore with increase in duration of a laser pulse it is necessary to spend a lot of energy as it is warm from the center leaves due to heat conductivity. The curve 2 passes a little bit below a theoretical curve that it is possible to explain presence at azide matrix absorbing inclusions of the bigger sizes, than assumes model [1].

At initiation of samples with density up to 2,0 g/cm^3 on protective glass which was on distance of 20 cm from a face surface of azide, the stiffened drops of the fused metal (Fig. 2) have been found out.

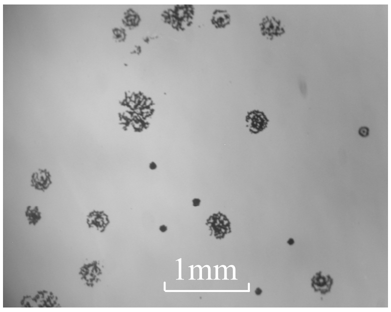

Fig. 2. A microphoto of the particles besieged on glass after explosion poorly pressed lead azide

At initiation of samples with density 4,0 g/cm^3 glass remained clean. To find out, what factors influence formation of metal drops, additional experiments have been carried out. Protective glass has been established on distance of 6 cm from a face surface of azide. Thesamples with density 4.0 g/cm^3 pressed in metal capsules with the same sizes as well as capsules from plexiglas. At initiation of poorly pressed samples alongside with large fraction the fine fraction with the characteristic sizes ~ 0,015 mm was observed. At initiation of strongly pressed samples there was only a fine fraction. If the samples of any density were located on a surface without lateral walls on glass very fine particles not distinct in a microscope were besieged. It is possible to assume that at explosion pores poorly pressed samples are the centers of condensation vapour.

At scattering products of explosion (a sample in a capsule) turbulent streams which can promote integration of drops of the fused metal are formed. Lateral walls of a capsule increase cumulative properties of a jet, that also can result in increase in the sizes of the condensed drops. The effect formation of large metal drops at explosion of poorly pressed samples in a capsule up to the end is not understood. For deeper understanding of the given phenomenon it is necessary to carry out additional researches.

Acknowledgement

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References

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