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ACOUSTICAL EMISSION AT DESTRUCTION OF KCl AND TGS CRYSTALS

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Wave forms and spectra of acoustic emission (AE) signal were investigated at cracks origin under pressure in KCl and TGS crystals. Flat cracks in these crystals arose in (100)-plane (KCl) and (010) - plane (TGS). The method of self-start of storage oscilloscope scan was used to study the initial part of AE pulse. It is shown that in this region there are spectral components more than 10 MHz. The form of the initial part of AE pulse is stipulated by resonance of "new" part of cracks for Rayleigh wave reflecting from micro-thresholds arising in each act of destruction.

Acoustical emission (AE) in solids is a generation of sound arising due to fast enough change of material structure. Cracks, grains, clusters of dislocations, domains and the other mesoscopic units at their movements may radiate detectable acoustical waves. Acoustical emission is used for non-destructive control of construction materials and rocks and in some cases allows to predict the moment of destruction [1].

The main information on destructive process and statistics of defects in AE measurements gives AE activity dN/dt - the number of AE acts per time unit at uniform increase of strain ($d\varepsilon/dt = \text{const}$) or stress ($d\sigma/dt = \text{const}$). However for investigation on mesoscopic level the amplitude and spectra of single AE pulse, angle distribution of radiated waves, their polarization and other acoustic parameters are important also. The peak amplitude of AE pulse allows to estimate the energy of cracks formation and their size. For the crack opening under pressure the elastic stress is concentrated near the end of crack, then the plastic deformation and the further opening of crack take place. For isotropic solids the crack with the area $S = l^2$ under pressure σ radiates the acoustic wave with power $P = \sigma^2 l/2\rho v$, where v is sound velocity , ρ is material density. However the peak amplitude measurements have usually relative character because depend strongly on position and properties of sound transducer, on sample form and so on. Besides it is necessary to take into account, that not all energy of opening cracks transform into elastic waves, but the definite part of energy go to plastic deformation.

Frequency spectrum of single AE act extend up to 10^8 Hz HHHHc. It corresponds to resonances of grains, microcracks and the other systems having a size about 10 microns, but during the sound propagation such frequencies fast attenuate. The first shock of elastic wave contains the main information on the opening crack dynamics, further attenuation and multiple reflections and swing of sample oscillations disturb the initial picture.

KCl and triglycine sulfate (TGS) crystals are a good models for studying formation of flat cracks and acoustic emission accompanying this process. In KÑl cracks are formed in (100)-plane, in TGS they arise in (010)-plane. Acoustic emission in these crystals was studied in [2,3]

We investigated forms and spectra of the initial part of single AE impulses about 10 mcs before start of proper oscillation of the sample i.e. up to the first reflections. The frequency of these oscillation is lower than 100 kHz. The initial part of AE pulse contains high-frequency components of a signal.

As AE process is the random one we used a registration circuit represented on Fig. 1. In a cubic sample *1* with size about 4 cm the flat crack was established. Edge-form indentor *2* located in appropriate way allowed to extend the crack into the crystal.

AE signal received by $LiNbO_3$ transducer *3* for longitudinal waves, was amplified and sent to storage oscilloscope.

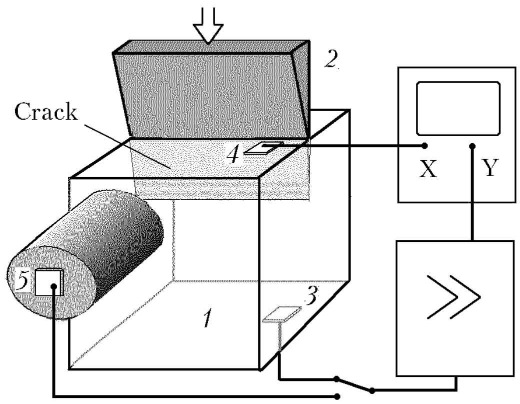

Fig. 1. Block-diagram of experiment

The main difficulty was to begin the rapid scan of oscilloscope beam earlier than the moment of signal arrival. For this purpose the circuit of self-start scan was used. The transducer 4 placed near a crack received AE pulse which was amplified and used as a synchronizing pulse for oscilloscope scan. The transducers 3 and 4 are placed so that time delay was a few microseconds. If the sample geometry did not allow to give such delay the acoustic signal went through aluminum buffer with the transducer 5. The frequency range of system limited 12 MHz (the band of storage oscilloscope) , resonance frequency of transducers was more essentially - 30 MHz and did not influence the spectrum of received signal.

When pressure on the indentor increased the length of crack grows a little, it was accompanied by the series of AE pulses. The first pulse of sufficient amplitude from transducer *3* started the single oscilloscope scan and delayed impulse from transducer *4* appeared at the screen. This pulse was operated by special graphic program allowed to obtain the spectral characteristics of AE process.

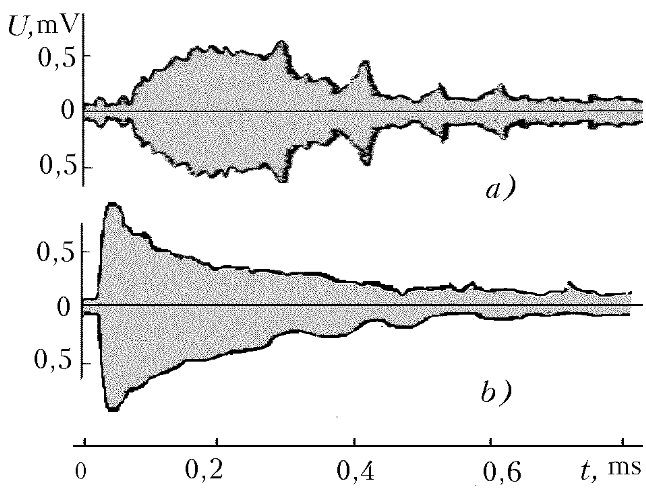

Fig. 2. Form of AE pulse in ÊCl.

It is necessary to note that the beginning of scan depends on the signal amplitude because scan starts when a signal reaches the some level. Therefore the delay on the screen was indefinite. The spectrum of AE signal contains the components up to 10 MHz and probably higher ones. The general form of AE pulse is represented on Fig. 2. For TGS the increasing part is more than for KCl , may be this oscillogram corresponds to a series of AE acts.

All pulses have the increasing part, the maximum corresponded to swing of proper oscillation of sample which attenuate during 1 ms, their frequency is lower than 100 kHz.

On Fig. 3 the initial parts of four AE pulses in KCl are represented. The first shock has the exponential front and then oscillation process with the frequency 0.5-1.5 MHz begin. This frequency does not depend on the length of main crack. When the crack is formed, the excitation of resonances of Rayleigh waves propagating along the crack surface takes place. However, these resonance of the main crack lay in the region 100 kHz and typical times of process development is more than 10 mcs. It is probably that for each destruction act due to the different local concentration of defects the plane of the crack changes a little. Thus the micro-thresholds arise which reflect surface waves and only "new" part of crack about 1 mm is acoustic resonator. The length of Rayleigh resonators at the initial region is determined not by total length of crack l , but by extension during the last destruction $\Delta l \sim 1$ mm, that corresponds to frequencies about 1 MHz.

As shown in [2], for KCl small AE pulses before opening of cracks are observed, that was controlled by optical measure-ments. Author of [2] explains the appearance of such pulses by emission from dislocation clusters. In our experiments in some cases we also observed precursors (Fig. 3 c,d), but it is difficult to

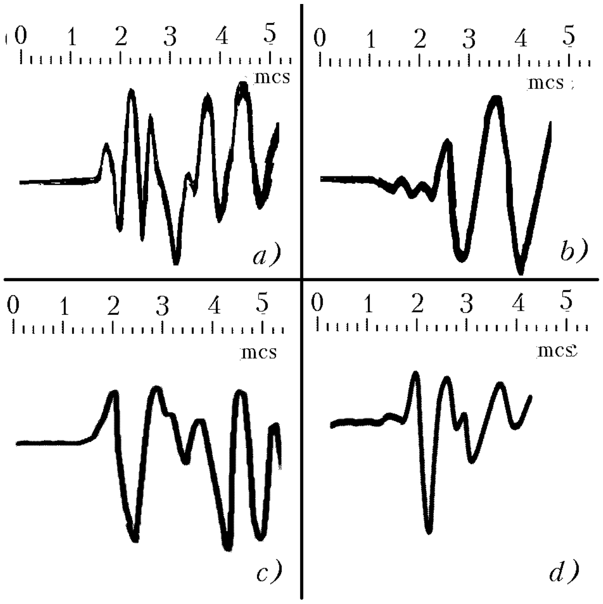

Fig. 3 Initial part of AE pulse in ÊÑl

After multiple reflections of AE signal the high-frequency components attenuate, and the end of pulse contains only low-frequency components and noise with spectral density about 10.

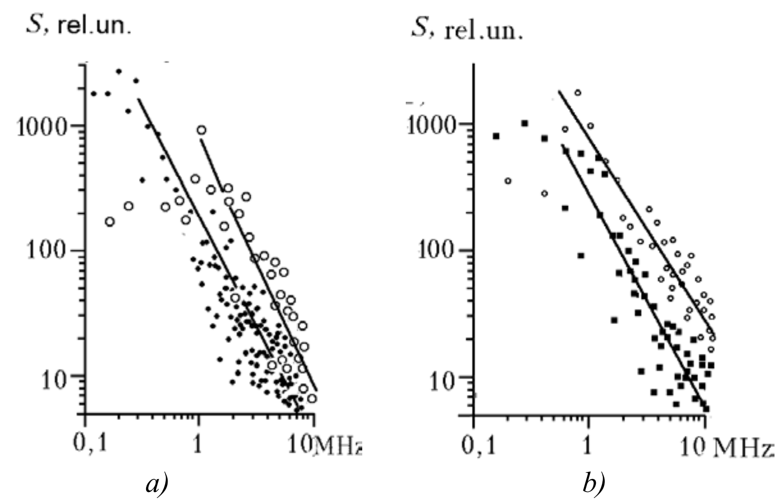

Fig. 4. The spectra of initial part of AE pulses *a)* KÑl , *b)* ÒÃÑ

Probably the initial spectrum of AE extends considerably higher than 10 MHz, but due to spherical divergence and large attenuation coefficient it is difficult to detect these component by acoustic methods.

R E F E R E N C E S

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