Peak of Acoustic Relaxation in CsI(Na) Single Crystals at Liquid Helium Temperatures

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Crystals CsI (Na) belong to the most effective scintillation materials. It is well known that the structural state of CsI crystals influences essentially their main operational parameters. In particular, structure imperfections and the state of the activator substantially determine conversion efficiency and radiation stability of scintillators. Therefore, the study of processes of structure rearrangements in crystals CsI of a different degree of perfection and impurity content is an important problem of the scintillation materials science and the solid state physics.

In the present work, the defect structure of the single crystals CsI(Na) with $1\cdot10^{-4}$, $8\cdot10^{-4}$ and $1.3\cdot10^{-3}$wt.% Na was investigated by means of the low-temperature acoustic spectroscopy. Measurements of the logarithmic decrement $\delta(T)$ and the dynamic Young's modulus *E(T)* were carried out over the temperature interval 2 K < T < 20 K using the two-component vibrator technique [1]. Longitudinal standing waves were excited in the samples along <110> crystallographic direction at the fundamental vibrator frequency $f \approx 77$ kHz, and also at the third and fifth harmonics of the piezoelectric transducer.

In the samples with $8\cdot10^{-4}$ and $1.3\cdot10^{-3}$ wt.% Na content, a pronounced peak was observed in the dependences $\delta(T)$ in the interval 8-12 K. The location temperature T_m of the peak shifts towards higher temperatures when increasing the vibration frequency. In the vicinity of T_m, well expressed "steps" of the modulus defect were observed in the dependences *E (T)*. The peak height increased when increasing Na content, and in the pure samples the peak was not observed. This gives a clear indication of possible connection of the observed acoustic anomalies with Na dopants. The shape of the absorption peak is close to the shape of the Debye-type relaxation peaks. Therefore, we may conclude that the peak is apparently connected with the relaxation process caused by almost identical elementary relaxators which are not subjected to appreciable influence of random factors and have a small spread of the activation parameters. It is shown, that the relaxation resonance found corresponds to a thermally activated process with the activation energy of $U \approx 10 - 13$ meV and the attempt period of $\tau_0 \approx 5\cdot10^{-12} - 8\cdot10^{-14}$s. It is established that annealing at T = 424 K leads to essential increase in the peak height, and plastic deformation of the order of 1 % at room temperature weakly influences parameters of the resonance investigated. Possible mechanisms of the low-temperature acoustic anomalies registered in single crystals CsI(Na) are discussed.

References

1. V.D. Natsik, P.P. Pal-Val and S.N. Smirnov, Acoust. Phys. 44, 553 (1998).