Ultrasonic and Piezoelectric Studies of new Layered Ferroelectric Compounds of Sn2P2S6 Family

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Abstract

Tin hypotiodiphosphate Sn2P2S6 is a ferroelectric-semiconductor material, exhibiting strong piezoelectric effect and suitable for applications in electroacoustics and electrooptics. Substitution of chemical elements in this material allows obtaining new compounds exhibiting rich variety of piezoelectric properties, photosensitivity and ionic conductivity. Recently were obtained layered materials of Sn2P2S6 family such as: CuInP2S6, CuInP2Se6, CuCrP2S6 and SnP2S6. The ultrasonic and piezoelectric properties of these materials are almost unknown. In this contribution, we present more extensive investigation results of ultrasonic propagation and piezoelectric properties of these layered compounds Two investigation methods: ultrasonic pulse echo and resonance-antiresonance were employed in order to measure the elastic and piezoelectric properties. It was shown, that in CuInP2S6 compound piezoelectric effect exists in ferroelectric phase below 312 K. At room temperature, for longitudinal excitation along ferroelectric z-axis the square of electromechanical coupling coefficient: K332=8%. The K352 value for shear mode is of the order of 5%. Measurements of the temperature dependencies of longitudinal ultrasonic velocity and attenuation coefficient revealed large increase of attenuation and critical slowing down in velocity in the phase transition region. We also observed the increase of elastic nonlinearity at the phase transition in CuInP2S6 sample across layers in z direction. The piezoelectric effect was observed in new ferroelectric one-dimensional CuCrP2S6 plates below 150K and the value of electromechanical coupling coefficient for longitudinal excitation is shown to be of about 2%. The temperature dependence of longitudinal ultrasonic velocity and attenuation revealed clear anomalies near phase transitions at 145K and 180K. We confirmed the existence of piezoeffect also in thin SnP2S6 plates. We have shown, that the thin plates of CuInP2S6, CuInP2Se6, CuCrP2S6 and SnP2S6 layered compounds can effectively excite and detect ultrasonic waves.