Netiesinio dielektrinio jautrio matavimo metodo taikymas feroelektrinėms medžiagoms

Application of non-linear susceptibility measurement method to ferroelectric materials

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The relationship between polarization *P* and external electric field *E*, is well known:

$$P = \varepsilon_0 \chi_1 E, \qquad (1)$$

where ε_0 – electric permittivity of the free space and χ – the linear electric susceptibilityof a dielectric materialunder test. Such relationship is valid, where condition of small external electric field applies. Experiments, where large electric field is introduced, the *P*(*E*) relationship is no longer linear and higher order susceptibilities have to be taken into account:

$$P = \varepsilon_0 \left(\chi_1 E + \chi_2 E^2 + \chi_3 E^3 + \ldots \right), \qquad (2)$$

here χ_i – are non-linear susceptibilities(where *i* – positive integers). These non-liner components show the non-linear contribution to the polarization.

The measurements of the non-linear dielectric susceptibility of polar dielectrics give useful information on phase transitions [1]. Namely, it is possible to unambiguously recognize the type of the phase transition. Ferroelectric systems, which display continuous or second order phase transition, have negative third order susceptibility (χ_3) in paraelectric state and, with decrease of temperature, χ_3 change sign to positive at the temperature of the phase transition. In case of a discontinuous phase transitionor a first order transition the sign of χ_3 is positive and remains unchanged throughout the vicinity of temperature of the phase transition. So is explained by the theory of Landau Ginzburg Devonshire and was proved by measurements of Triglycine Sulfate and Barium Titanate [2]. As well, it may prove to be a useful tool to investigate essential differences between relaxor ferroelectrics and dipolar glasses. [3]

The usefulness of measurements of non-linear susceptibility in characterizing phase transitions of polar dielectrics is clear, the problem is that such susceptometer is not available commercially, thus we made one ourselves. The concept of our susceptometer is based on equipment presented in [4]. It utilizes zero biased alternating voltage signal with amplitude, which allows to observe nonlinear response, but is rather small in comparison with coercive field. We use data acquisition module to generate the excitation signal and to gather the response of the sample under test. The current of the response signal is converted to measurable voltage signal using low-noise current preamplifier with wide range of sensitivities. Our equipment allows us to perform measurements of samples with capacitance in range of 10 pF up to10 nF. Estimated frequency range of excitation signal is 8 Hz – 20kHz and we gather data of harmonics up to 5th. As the sample is put in separate cryostat, it is possible to perform measurements in wide temperature range 100 K –500 K. In order to obtain a large signal to noise ratio, the equipment is implemented with averaging algorithm. The novelity of our implementation is calibration procedure using Solartron dielectric reference module, which consists of four high quality linear capacitors. The calibration allows to take into account the phase and amplitude distortions of the equipment. The characteristics of the equipment and experiment performance is the goal of the presentation.

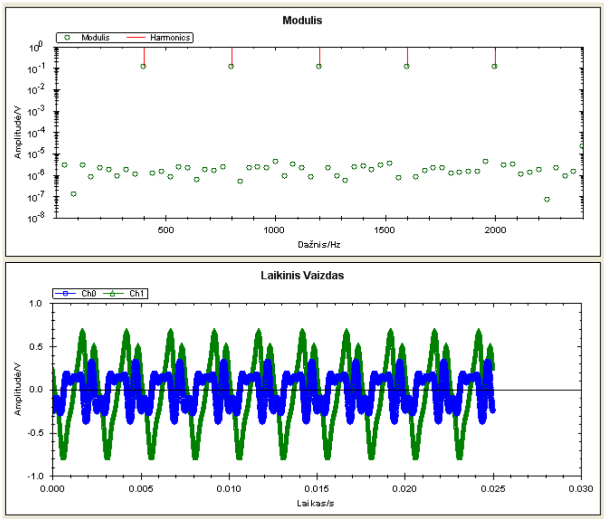

Fig. 1. Calibration signal, calibration response and spectrum

Key words: phase transition, dielectic spectroscopy, non-linear susceptibility .

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