SCIENTIFIC BULLETIN OF THE TECHNICAL UNIVERSITY OF LODZ
No. 1010 Physics, Vol. 28 2007

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WHAT IS THE TRUE ORDER OF MAGNITUDE OF THE QUADRATIC ELECTROOPTIC COEFFICIENT $|g_{1111}-g_{1122}|$ IN RDP CRYSTAL?

Measurements based on the dynamic polarimetric technique of the electrooptic coefficient $|g_{1111}-g_{1122}|$ are applied to determine the order of magnitude of the quadratic electrooptic effect in RDP. The results obtained confirm that the effect is two orders of magnitude smaller than widely quoted in the literature data obtained previously by the static polarimetric method.

Keywords: quadratic electrooptic effect, KDP-type crystals.

1. INTRODUCTION

RDP (rubidium dihydrogen phosphate) crystals belong to the well-known KDP (potassium dihydrogen phosphate) family of ferroelectrics (antiferroelectrics). Other members of the family like DKDP (deuterized potassium dihydrogen phosphate) or ADP (ammonium dihydrogen phosphate) are well recognised as crystals with marked nonlinear properties. Thus the crystals are often applied in different electrooptic devices. At room temperature the materials are paraelectric and their point group symmetry is $\bar{4}2m$. Up to now, in the crystals at room temperature, many experimental results for the quadratic electrooptic effect have been published (see, e.g. Refs. [1-9]). Considering results obtained for the coefficient $g_{eff} = |g_{1111}-g_{1122}|$ in various members of the family (KDP, DKPD or ADP) one may observe a large spread in measured values. For instance, the experimental data reported for the coefficient g_{eff} in

KDP vary from 2.6×10^{-18} m^2V^{-2} [1] to 4.2×10^{-20} m^2V^{-2} [6], for DKDP are between 3.0×10^{-18} m^2V^{-2} [1] and 3.4×10^{-20} m^2V^{-2} [7], and for ADP vary from 1.7×10^{-18} m^2V^{-2} [1] to 5.8×10^{-20} m^2V^{-2} [8]. According to previous experimental and numerical findings this discrepancy can be explained in terms of applied experimental methods which are sensitive in a different way to errors resulting from inaccuracies cutting and/or alignment of investigated crystal sample (see, e.g. Refs. [10,11]). One may note that the largest values of g_{eff}, these of the order of magnitude of 10^{-20} m^2V^{-2}, have been obtained employing the static polarimetric technique. In this method the changes of intensity of light proportional to a dc voltage applied to the crystal sample placed between crossed polarizers have been analysed. It has been shown previously (see, e.g. Refs. [10,11]) that results obtained using the static polarimetric technique are usually overestimated and should be re-measured using other experimental method like the dynamic polarimetric or interferometric techniques. Unfortunately, according to our knowledge, for RDP crystals, no re-measurements have been performed yet.

The aim of this work is to check if the order of magnitude of the coefficient $g_{eff} = |g_{1111}-g_{1122}|$ in RDP crystal is of the order of magnitude 10^{-18} m^2V^{-2} or 10^{-20} m^2V^{-2}. In order to estimate the magnitude of the $|g_{1111}-g_{1122}|$ coefficient in the RDP crystal the dynamic polarimetric technique was employed.

2. EXPERIMENTAL

The crystal sample was cut in the form of a right parallelepiped with its axes directed along crystal's crystallographic axes. The parallelepiped was of dimensions $26\times18\times4$ mm^3. The electrodes were deposited onto crystal faces, i.e. the largest face, this one perpendicular to the [100] direction, was covered by a low resistance conducting paint. Thus the distance between electrodes was 4 mm. The sample was placed between crossed polarizer and analyzer with He-Ne laser beam travelling along the [001] direction perpendicularly to the applied ac electric field of the angular frequency 417 Hz for which we found relatively low noises in our experimental set-up. Since such frequency is much lower than any piezoresonance frequencies of our sample, the crystal under investigation was considered to be mechanically free.

In our measurements, the order of the absolute value of g_{1111}-g_{1122} was evaluated from the modulation index for the second harmonic of the emerging light intensity detected by the photodiode by means of the lock-in technique. In order to provide measurements at the most sensitive part of the transmission characteristic of our experimental system, the modulator was based to the middle of the transmission characteristic by a mica quarter-wave plate. The angle between the direction of polarizer and analyzer and principal axes of quarter-wave plate was 45^0.

3. RESULTS AND DISCUSSION

The dependences of the modulation index $m_{2\omega} = I_{2\omega}/I_C$, where I_C is the constant component of the light intensity transmitted by the system and $I_{2\omega}$ is the transmitted intensity of second harmonic of the modulated signal, plotted against the square of amplitude of the high voltage (in volts) are presented on Fig. 1. Plot (a) was obtained for high voltage applied to the RDP sample. In turn, plot (b) was obtained assuming that the magnitude of the coefficient $|g_{1111}-g_{1122}|$ is about 2.6×10^{-18} m^2V^{-2}, i.e. as quoted in Ref. [1].

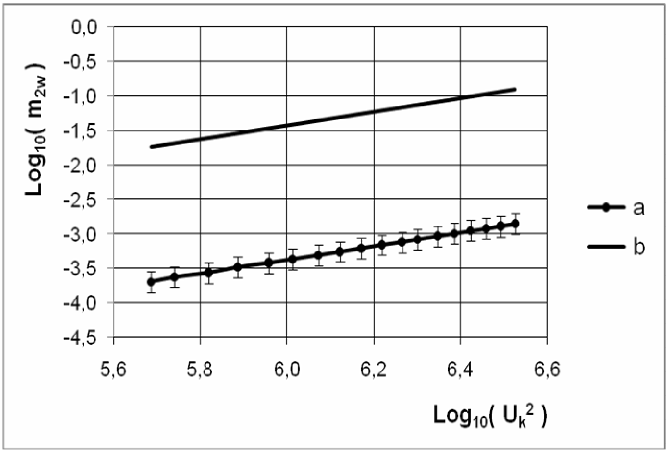

Fig. 1. Modulation index $m_{2\omega} = I_{2\omega}/I_C$ in RDP plotted against the square modulated voltage. (a) – measured modulation index, (b) – theoretical modulation index obtained employing the value of quadratic electrooptic coefficient $|g_{1111}-g_{1122}|$ = 2.6×10^{-18} m^2V^{-2} reported in Ref. [1]

The results obtained show that the order of magnitude of the quadratic electrooptic coefficient $|g_{1111}-g_{1122}|$ in RDP is 10^{-20} m^2V^{-2}, i.e. the coefficient is comparable in its magnitude to the $|g_{1111}-g_{1122}|$ coefficients in other members of the KDP family crystals. Thus it is nearly two orders of magnitude smaller than the value $|g_{1111}-g_{1122}|=2.6\times10^{-18}$ m^2V^{-2} obtained by the static polarimetric technique [1].

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JAKI JEST PRAWDZIWY RZĄD WIELKOŚCI KWADRATOWEGO WSPÓŁCZYNNIKA ELEKTROOPTYCZNEGO $|g_{1111}-g_{1122}|$ W KRYSZTALE RDP?

Streszczenie

Przedstawiono wyniki pomiaru rzędu wielkości kwadratowego współczynnika elektrooptycznego $|g_{1111}-g_{1122}|$ w krysztale RDP dynamiczną metodą polaryzacyjno-optyczną. Otrzymane wyniki wskazują, że wielkość tego współczynnika jest około dwa rzędy mniejsza niż powszechnie cytowana wielkość zmierzona wcześniej statyczną metodą polaryzacyjno-optyczną i porównywalna z innymi kwadratowymi współczynnikami elektrooptycznymi w kryształach grupy KDP, do której należy kryształ RDP.