NONLINEAR OPTICAL RESPONSE OF SMECTIC GLASSES BASED ON COBALT ALKANOATES

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The nonlinear-optical response of anisotropic smectic glasses based on cobalt-alkanoates is studied using the method of dynamic holography. Laser-induced dynamic gratings under the action of nanosecond laser pulses are observed and analyzed for such materials. It is found that a cubic optical nonlinearity of all studied anisotropic glasses is of electronic origin in the nanosecond diapason and caused by a nonlinear polarization of cobalt-alkanoates complexes.

1. Introduction

Metal alkanoates ($(C_nH_{2n+1}COO^-)_kMe^{k+}$, where Me^{k+} — metal cation, $C_nH_{2n+1}COO^-$ – alkanoate-anion, k = 1–3, $n \geq 3$), can form various states of condensed matter: solid crystalline state, liquid state, liquid crystalline, isotropic and anisotropic glasses [1–4]. Recently, such a variety of metal alkanoates and their phase states was used in order to fabricate optical and nonlinear optical materials, for instance, double-layer cells "photosensitive film – ionic lyotropic liquid crystal" [5], ionic lyotropic liquid crystals doped with electrochromic impurities [5, 6], and mesomorphic glasses with dissolved dye molecules [7].

An alternative way of the development of advanced materials is a study of the fundamental properties of pure mesomorphic metal-alkanoates which consist of d- and f-electron metal ions [1, 8, 9]. Such metal ions are widely used as active centers of laser emission and magnetic, optical and nonlinear-optical materials [1, 9, 10]. Regarding these promising applications, the detailed studies of the physical properties of the transition and rare-earth metal-alkanoates are of the most fundamental and practical importance.

Our previous results show that pure cobalt-decanoate mesomorphic glasses can be used as materials for the pulsed dynamic holographic recording [8, 9]. In this paper, we describe studies of the nonlinear-optical properties of the mesomorphic glasses based on cobalt-alkanoates: 1) homologous series of pure cobalt alkanoates; 2) binary and ternary systems based on cobalt|potassium|lithium octanoates.

2. Materials and Cell Preparation

2.1. Materials

The following types of chemical compounds were used in the studies of nonlinear-optical properties: 1) three representatives of homologous series of cobalt alkanoates $(C_nH_{2n+1}COO^-)_2Co^{2+}$ ($n = 7, 9, 11$); 2) binary systems – $(C_7H_{15}COO^-)_2Co^{2+}|C_7H_{15}COO^-Li^{1+}$, 0.5:0.5 molar ratio, and $(C_7H_{15}COO^-)_2Co^{2+}|C_7H_{15}COO^-K^{1+}$, 0.5:0.5 molar ratio; 3) ternary system – $(C_7H_{15}COO^-)_2Co^{2+}|C_7H_{15}COO^-Li^{1+}|C_7H_{15}COO^-K^{1+}$, 0.5:0.25:0.25 molar ratio.

As was shown in our previous works, all studied materials form the liquid crystal state (Smectic A) [11, 12] under melting. It should be noted that the above-mentioned liquid crystalline materials can be easy vitrified under cooling. Such a vitrified state can be considered as the "frozen" liquid crystal state and is stable for a long time at room temperature (in fact, samples are still in the glass state even after 1 year after their preparation) [12]. For this reason, the studied glasses are anisotropic and can be called "mesomorphic glasses" in contrast to the well-known isotropic glasses.

2.2. Cell preparation

Sandwich-like cells (cell thickness d_{cell} = 30–100 μm) were filled with the studied liquid crystalline materials at a hot plate at temperatures $T > T_{\text{C-LC}}$ ($T_{\text{C-LC}}$ –