Final Report Summary - TEMESAMA (New production technology development for most efficient and more stable application of electro-optic and nonlinear optical crystalline materials)

The main objective of this project (see web-site: http://tk-lab.lp.edu.ua) was development of new production technology for highly efficient and stable crystalline materials applicable as sensitive elements of electro-optic and nonlinear optical cells. Relevant devices have in principle a broad range of optoelectronic applications and particularly may be used for control and conversion of superpowerful laser radiation.

For achievement of the project's objectives the following activities have been carried out. In the first steps it was created the interferometric setup for electro-optic measurements as well as modernized the nonlinear optical setup available at the Faculty of Electrical Engineering of the Czestochowa University of Technology [7,10] (see references list below). It was also elaborated the interferometric technique applicable to the wedge angle and surface flatness measurements of optical slabs, which lets to provide a quality control of relevant optical elements while their manufacturing [3]. In the next steps, it was developed relevant fundamental methodologies suitable for precise determination of complete sets of electro-optic tensor coefficients in crystal materials of any symmetry [7]. Particularly, by using available laboratory setups the electro-optic and nonlinear optical characteristics of langasite, pure and MgO doped lithium niobate crystals were investigated [9-12]. For these anisotropic materials, a complete tensor sets of electro-optic and/or nonlinear optical coefficients were determined. Notice that a complete sets of such tensor constants represent requiring input parameters [1,2,13] for further 3D-analysis of the spatial anisotropy of investigated parametrical optical effects. Accordingly, in the final steps there was calculated the indicative surfaces and corresponding stereographic projections of the effective electro-optic [1,13] and additionally acousto-optic [4] coefficients as well as obtained the indicative surfaces composed from maximal values of relevant effects [4,8]. On their basis the global directional maxima of the electro-optic and acousto-optic effects for the crystal materials mentioned above were determined and for these directional maxima an angular stability analysis has been performed using improved our own software [2]. The main technological solutions and approaches were protected by Ukrainian patent [5] and we have in plan to protect it also by a Polish patent. Relevant patent publication form currently is under consideration [6]. During the return phase, which is the final stage of actual project, it is planed to design the laboratory prototype of highly efficient and stable electro-optic cell made of mentioned above crystalline materials.

The main results and conclusions obtained during the project execution are the following:

1) Creation of the laboratory interferometric setup for the electro-optic measurements [7,10] and modernization of the nonlinear optical setup;
2) Creation of the laboratory interferometric setup applicable to the control of samples quality while their preparation (measurements of the wedge angle and surface flatness of optical slabs; evaluation of samples inhomogeneity and/or imperfections) [3];
3) Elaboration of the methodology for measurements and calculations of all electro-optic coefficients in the crystalline materials of any symmetry [7];
4) Interferometric electro-optic and additionally piezo-optic investigations of langasite, pure and MgO doped lithium niobate crystals.
crystals [9-12] providing determination of the full set of electro-optic and/or piezo-optic tensor constants; 

5) Exploration of the spatial anisotropy 3D-analysis of electro-optic and additionally acousto-optic effects for selected crystal materials basing on the results of interferometric electro-optic and piezo-optic measurements. Result of this analysis provides directional maxima related with the most efficient geometries of relevant electro-optic and acousto-optic interactions. It was shown theoretically and in several cases proved also experimentally that for the interaction geometries being optimized relevant effects rise from about 1.5 to 2.7 times [1,4,8,9,11,12] comparing to standard geometries (usually the direct crystal cuts) widely used in most applications. In other words, the directions of electric field, polarization and wavevector of light or acoustic wave, which ensure the best electro- or acousto-optic efficiency usually, do not coincide with principal crystalophysical directions. This, in fact, opens hidden possibilities for further increase of the application efficiency of electro-optic and/or acousto-optic crystal materials in relevant optoelectronic devices.

6) Exploration of the directional stability of electro-optic and piezo-electric devices against uncontrolled deviations of material parameters. For this purpose basing on full sets of electro-optic and piezo-electric constants we have performed the spatial stability analysis [2]. Amazingly, it turns out that parametrical optical effects along the directional maxima are characterized by enhanced stability of their effective characteristics as well. Obviously, it appears to be very important from the practical point of view.

The final result of this project is elaborated new production technology applicable both for a search of new prospective electro-optic, piezo-optic or nonlinear optical crystals likewise an improvement of application efficiency and/or parameter stability of already existing crystal materials being used as sensitive elements in high performance electro-optic, acousto-optic or nonlinear optical devices including the systems for control and/or conversion of the superpowerful laser radiation, which in many aspects appear to be a key problem of the optoelectronic industry in the European Union. No doubt that relevant devices represent high technology and knowledge based products provided by scientific innovations and technological advances of European Union. The technological solutions elaborated in this project can be successfully used in the manufacturing of highly efficient electro-optic, acousto-optic or nonlinear optical devices where their basic working elements (i.e. relevant cells) may be made both from novel or widely applicable crystal materials. Moreover, the innovations implemented here may appear to be very useful and important for many branches of practically whole optoelectronic industry starting from different kinds of high performance light modulators and deflectors, applicable in modern communication systems, to specialized highly efficient sensor techniques the working principle of which are based on parametrical or nonlinear optical phenomena. In addition, the technological solutions drawn within this project may be characterized as market competitive taking into account that, on the one hand, they appear to be much cheaper comparing to existing other solutions and, on the other hand, they are time saving and more accurate since there is no need to prepare a large number of different crystal samples (cuts) likewise perform relevant measurements on different samples which usually rises considerably errors in evaluation of actual material parameters. The competitiveness of our technology is caused also by the fact that its implementation in practice does not require any serious reorganization of technological process while manufacturing of the electro-optic, acousto-optic or nonlinear optical cells. The final results of this project have a social effect too. Project elaborations, that are generally based on optimized applicability of already existing or new crystal materials, inevitably bring us to material and power saving technologies since the geometry optimization of electro-optic or acousto-optic interactions leads in each case to a reduction of cell size likewise a decreasing of operational power.

The elaborated methodological and technological solutions may be interesting for companies producing devices which use crystal materials as working elements, namely

with optical crystal materials requiring express measurements of optical parameters in crystalline materials.

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List of the publications published or submitted during the project realization:

Simple and cost-effective control of crystal preparation

Reported by
POLITECHNIKA CZESTOCHOWSKA
Poland
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Subjects
Coordination and Cooperation - Social sciences and humanities

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