OPTICAL GENERATION IN CDGEAS$_2$ CRYSTAL

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Tuneable parametric sources of coherent radiation in combination with the effects of frequencies mixing permit to extend considerably the field of tuneable wavelengths of laser radiation. The optical multipliers of frequency serve this task too. For this purpose there are successfully used $CdGeAs_2$, $ZnGeP_2$, $AgGaS_2$, $AgGaSe_2$ and other crystals. $CdGeAs_2$ crystals are attractive ones among the existing crystals due to the high nonlinearity of the second order. On the force of transparency of these crystals in the IR-range of spectrum they look attractive from the point of view for their applications for elaboration of frequency converters in this range of spectrum, where two windows of atmosphere exist [1-8].

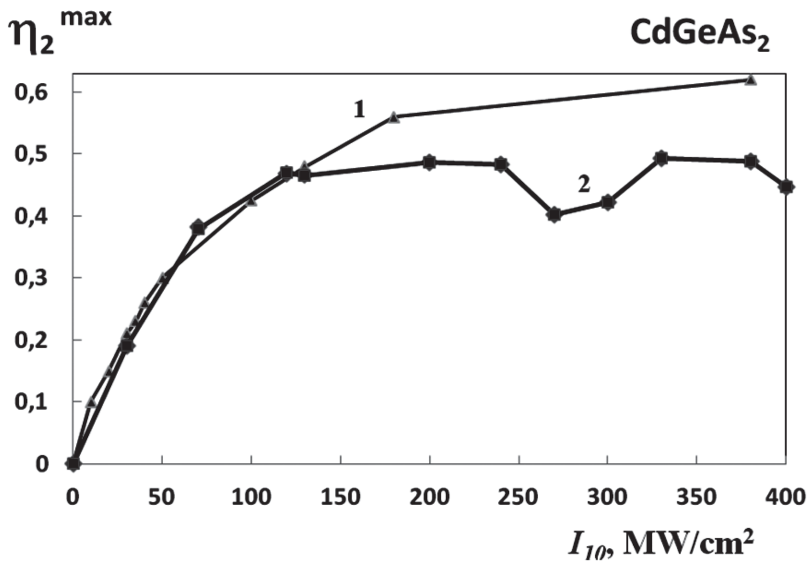

Fig. 1. Dependences of conversion efficiency of radiation energy of pump wave energy of wave of second harmonic in $CdGeAs_2$ crystal as a function of the pump intensity $\eta_2\left(I_{10}\right)$ calculated in the constant-intensity approximation for l=0.7 см [2], $\delta_2=2\delta_1$=0.05cm^{-1} [2], D=0.0028 cm^{-1}. Experimental dependence is curve 1 and envelope the maxima of theoretical dependences $\eta_2^{\max}(I_{10})$ – curve 2.

Nonlinear interaction of optical waves is being investigated in theory mainly in the constant–field approximation [9]. In this approximation the coherent length of nonlinear medium depends exclusively on mismatch of wave vectors, while amplitude and phase of basic radiation are adopted unchanged. But this simplification is just only in the initial stage of interaction, when it is possible to ignore both the influence of excited wave of harmonic on basic radiation wave and exhaustion of pump. As a result a number of the qualitative features of nonlinear process are lost.

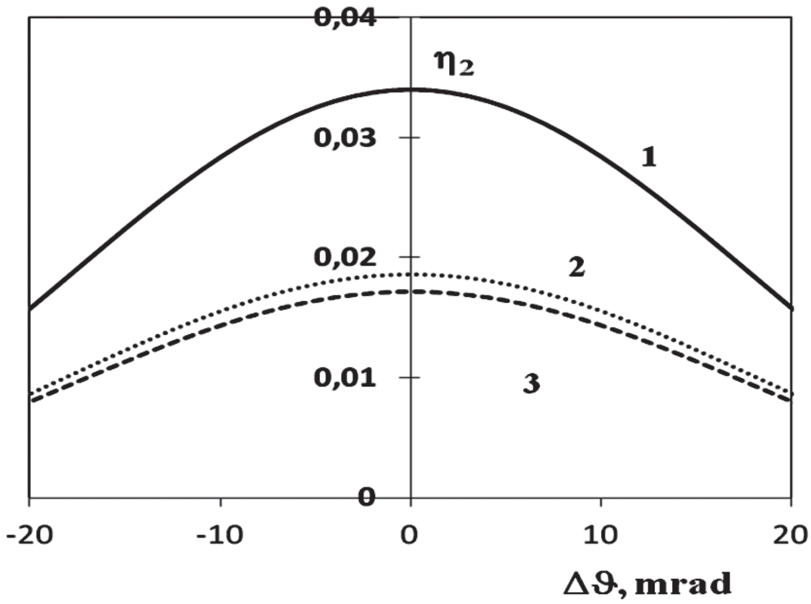

Fig. 2. Dependences of conversion efficiency of radiation energy of pump wave ($\lambda = 10.6$ mcm [3]) to energy of wave of second harmonic in $CdGeAs_2$ crystals as a function of the phase mismatch $\eta_2\left(\theta\right)$ calculated in the constant-intensity approximation at l=0.57 см [3], $\delta_2=2\delta_1$=0.03 cm^{-1} (curve 2), 0.1 cm^{-1} [3] (curves 1 and 3), I_{10}=0.0012 MW/cm^2 [3] (curves 2 and 3), 0.0024 MW/cm^2 (curve 1).

For the analysis of nonlinear process the use of the direct numerical account of reduced equations is possible. However, the development of the analytical method will allow one to obtain the concrete analytical expressions and determine the optimum parameters of the task with the aim of obtaining maximum conversion efficiency. The simultaneous account for changes of phases and losses of interacting waves works well in the constant –intensity approximation [10-11] taking into regard the reverse reaction of excited wave to pump wave.

In the present work cited are the results of investigation of pump intensity impact on conversion efficiency in

$CdGeAs_2$ crystal in conditions of existing experiment. Comparison has been made of the received results on conversion efficiency with the analogous results obtained in the experiment [2-3]. The applied analytical method permits to calculate the optimum parameters of both crystal–converter and a source of radiation. Thus, for example, optimal crystal length at the given losses and pump intensity what makes possible an estimation of expected efficiency of conversion.

To investigate the nonlinear process we solve traditionally the system of differential equations, depicting generation of optical harmonic [9-11]. An analysis is made of ee→o type of scalar phase matching. We'll consider as a source of radiation in particularly the laser on free electrons [2], generating radiation on wavelength $\lambda = 10$ mcm.

Let's define conversion efficiency of pump wave to second harmonic with wavelength $\lambda = 5$ mcm. For this purpose we seek for solution by using the constant –intensity approximation with the corresponding boundary conditions. The subsequent move is a numerical calculation of the analytical expression for conversion efficiency received in the considered approximation. We carry out investigation in conditions used in the experiment for nonlinear frequency conversion in $CdGrAs_2$ crystal.

In Fig.1 the comparison of theoretical dependence $\eta_2^{\max}(I_{10})$ (curve 2) with experimental dependence received in [2] is shown. Here curve 2 is built as envelope the maxima of dependence beatings at change of pump intensity according to conditions of the experiment, in the range from $0 \div 400$ MW/cm^2. In this case good agreement of the results is observed at pump intensity to 130 MW/cm^2. At the given length of crystal–converter maximum efficiency conversion according to the result in the constant – intensity approximation reaches a value of 50% at pump intensities in the range from 130 to 400 MW/cm^2. In [2] it is reported on the achievement of 62% conversion efficiency to second harmonic at $I_{10} = 380$ MW/cm^2 in the experiment.

Dependence of efficiency of conversion to second harmonic from phase mismatch in case of $CdGeAs_2$ crystal is presented in Fig.2. For the given crystal the angle of phase matching on wavelength $\lambda = 10$ mcm is equal 32^0. From the graph near phase matched it is seen that dependence is of gently sloping character at phase change caused by angular mismatch near direction of phase matching.

Angular width of phase matching of ½ maximum efficiency by level, calculated in the constant –intensity approximation at length of $CdGeAs_2$ crystal equal to 0.7 cm, makes up value in 1.4^0. For comparison, in the experiment the analogous value is 1^0 [2]. The facts of difference in the results be explained by the absence of detailed and precise information on conditions and parameters of the experimental studies.

The angular width of phase matching calculated theoretically and experimentally measured testifies to uncritical nature of the examined crystals in relation to the accuracy of putting of an angle of phase matching. This fact was noted earlier in [2] for $CdGeAs_2$ crystal and is of importance at selection of a crystal – converter in the IR–region of spectrum.

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