Kasumova R.J.,
Dr. of Mathematical and Physical sciences, full Prof.
Kerimova N.,
Cand. of Mathematical and Physical sciences
Baku State University, Azerbaijan

Conference participant, National championship in scientific analytics

# OPTIMAL LAYER STRUCTURE AT QUASI-PHASE-MATCHED INTRACAVITY SECOND HARMONIC GENERATION

*Intracavity conversion of frequency presents the most efficient way of frequency conversion. At intracavity conversion phase changes of interacting waves within one and the same cavity will strongly influence on conversion efficiency [1-5]. Therefore, it is expedient to carry out the investigations of quasi-phase matched intracavity interaction [6] in the constant-intensity approximation [7] taking into regard the changes of all interacting waves in contrast to constant-field approximation.*

Theory of quasi-phase-matched generation of second harmonic in a laser resonator in a dissipative medium at the phase mismatch has been developed by us in [8]. It is shown that by choosing layers lengths with regard for corresponding values for coherent lengths and optimal phase relationship between interacting waves, it is possible to receive more higher efficiency of conversion at the outlet of RDS (regular domain structure) -crystal in comparison with case without resonator.

Let us consider a practical example of quasi-phase-matched generation of optical harmonic. Up to present, intracavity generation of second-harmonic has been realized. Therefore, for this case, i.e. for the generation of second-harmonic in RDS-crystal Nd:Mg: $LiNbO_3$ arranged in a laser cavity, we will make our estimations. Apparently, in this compound the crystal $LiNbO_3$, responsible for nonlinear properties of a structure, plays the role of matrix. They use ee-e interaction in lithium niobate, what is connected to nonlinear coefficient $d_{33}$, ranking practically above the rest nonlinear coefficients of the given crystal [3, 4, 9]. In crystal Nd: Mg:$LiNbO_3$, the most intensive laser generation has a wavelength 1.084 mcm [10]. In the process of quasi-phase-matched doubling, the generation of radiation in green light on a wavelength in 0.542 mcm takes place.

Let us estimate the maximum efficiency of conversion to this wavelength for experimentally realized value of laser generation intensity equal to $2 \cdot 10^7$ W/cm$^2$ [3]. The numerical calculation of the analytical expressions got in the constant-intensity approximation on the optimum length of the first domain equal to 58.75 mcm gives a value of efficiency $\eta_2 = 0.1248$. At optimum length of the second domain equal to 59.8 mcm, maximum efficiency at the outlet of the second domain is equal to 0.3967, at the outlet of the third domain $\eta_2(l_{3,opt.} = 62.5$ mcm$) = 0.6115$, after the fourth domain $\eta_2(l_{4,opt.} = 65.66$ mcm$) = 0.833$, after the fifth domain $\eta_2(l_{5,opt.} = l_{4,opt}) = 0.8751$, and after the sixth domain $\eta_2(l_{6,opt.} = l_{3,opt}) = 0.8936$.

From the analysis in the constant-intensity approximation it follows that the length of each domain, at which conversion efficiency in the RDS-crystal is maximum, depends on a value of pumping intensity at the entrance to a domain. As far as laser radiation is being extended in a structure, there takes place a gradual decrease of pumping intensity on the account of transfer of fundamental radiation energy to second-harmonic energy.

Application of the constant-intensity approximation to a layer taken separately, permits to take into account the given fact and make more strict analysis of nonlinear interaction in the process of frequency conversion [12-13]. Hence, with an increase in the number of domains, pumping intensity diminishes at the entry to each subsequent domain, while the optimum length of domains increases, what is just observed in our case.

As a result, the optimal dimension of the considered domain structure from the active-nonlinear crystal Nd: Mg:$LiNbO_3$ is equal to 246.7 mcm in domain structure period in 123.35 mcm. For comparison, [3] examines a similar structure at crystal length equal to 0.5 cm with nonlinear period of 7 mcm. In [4] such structure is considered for quasi-phase-matched intracavity mixing of frequencies at length of 7 mcm and period in 4 mcm. At consideration of linear absorption in crystal Nd:Mg: $LiNbO_3$ conversion efficiency, as it should be expected, decreases. For the loss values $2\delta_1 = \delta_2 = 0.1$ cm$^{-1}$ [3], the fall of efficiency makes up about 20%.

With elaboration of similar frequency intracavity converters on the basis of new nonlinear crystals with mixtures of rare earth elements it is possible to realize compact sources of coherent radiation.

**References:**

1. V.G.Dmitriev, and L.V.Tarasov, Prikladnaya Nelineynaya Optika [Applied Nonlinear Optics] Moscow, Radio i Svyaz, 1982.
2. Z.H.Tagiev, R.J.Kasumova, and Sh.Sh.Amirov, Opt. Spektros. 75 (1993) 535-537; R.J.Kasumova, J. Opt. B: Quantum Semiclas. Opt. 2 (2000) 334-337.
3. G.D.Laptev, A.A.Novikov, and A.S.Chirkin, JETP Letters [Pis'ma v Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki], 78 (2003) 45-58.
4. N.I.Kravtsov, G.D.Laptev, I.I.Naumov, A.A.Novikov, V.V.Firsov and A.S.Chirkin, Quantum Electronics, 32 (2002) 923-924; C.Q.Wang, Y.T.Chow, W.A.Gambling et al., Opt. Commun. 174 (2000) 471-474.
5. P.Dekker, J.M.Dawes, J.A.Piper et al., Opt. Commun., 195 (2001) 431-435.
6. M.M.Fejer, G.A.Magel, D.H.Jundt, and R.L.Byer, IEEE J. Quantum Electron., 28 (1992) 2631-2654.
7. Z.H.Tagiev, R.J.Kasumova, R.A.Salmanova, N.V.Kerimova, J. Opt. B: Quantum Semiclas. Opt., 3 (2001) 84-87.
8. R.J. Kasumova, A.A. Karimi. Az. National Acad. Sc. Fizika, XV (2009) 102-105.
9. E.Y.Morozov, and A.S.Chirkin, Quantum Electronics (Moscow) 34 (2004) 227-232.
10. T.Y.Fan, A.Gordova-Plaza, M.J.F.Digonnet, R.L.Byer, H.J.Shaw, Opt.Soc.Amer. B, 3 (1986) 140-148.
11. V.G.Dmitriev, and R.Singh, Quantum Electronics (Moscow) 34 (2004) 933-940.
12. Z.H.Tagiev, and R.J.Kasumova, Opt. Commun., 281 (2008) 814-823.
13. З.H.Tagiev, R.J.Kasumova, and G.A.Safarova, J. Rus. Las. Res., 31 (2010) 319-331.