Enhancement of second harmonic generation in $LiNbO_3$ crystals with polysynthetic domains

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The largest non-linear optical coefficient in $LiNbO_3$ is d_{33} (about 7.5 times larger than d_{31} which is the coefficient ordinarily used) which can not be phase-matched. During Czochralski growth, doping with about 1% of yttrium, and intentionally making the rotation axis noncoincident with the symmetry axis of the temperature field, so crystals with pronounced striae are grown, then cooling through Curie point, $LiNbO_3$ crystals with periodic ferro-electric domains in alternate signs are obtained. Growth axis is along a-axis which is perpendicular to the polar axis of crystals. In genera l_p, the width of the positive domains and l_n, those of negative domains, are unequal, however by adjusting rotation periods and pulling rates, so that $l_p+l_n\sim 2l_c$ may be achieved (l_c is the coherence length, $l_c\sim 3.4\,\mu$ for $1.06\,\mu$ fundamental wave).

Using the output of a continuously pumped acousto-optically Q-switched YAG laser as fundamental wave, we have measured the intensity of S. H. G. out of cavity due to quasi-phase-matching for b_{33} in crystals with polysynthetic domains. For comparison, we have also measured the intensity of S. H. G. in mono-domained crystals with same thickness and similar optical quality under angle phase-matched condition for d_{31}. Enhancement of S. H. G. output relative to ordinary phase-matched crystals is observed. The enhancement factors for some crystals are found in the range 1.5–12, while the maximum theoretical value is $(7.5\times 2/\pi)^2\sim 23$.

We also try to verify the relationship between the intensity of S. H. G. and number of domains, i.e. $I(2\omega)=I_o(2\omega)N^2\cos^2(|l_p-l_n|\pi/2l_c)$. The results are shown in table 1. The deviations may be due to the irregularity of spacings and extra scattering of domain walls.

Table 1 $I(2\omega)/I_o(2\omega)$

N (No. of domains)	40	48	58	64	76
Theoretical value	1550	2240	3260	3960	5600
Experimental value	1500	1900	2200	3000	3200

聚片多畴 $LiNbO_3$ 晶体的倍频增强效应

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在 $LiNbO_3$ 晶体中最大的非线性光学系数为 d_{33}（其数值为通用的 d_{31} 的7.5倍）是不能位相匹配的。我们在提拉法生长中掺入1％左右的钕，并使籽晶转轴与温场对称轴相偏离，长出的晶体具有明显的生长条纹，在通过居里点降温时诱发出正负交替的周期性聚片多畴 $LiNbO_3$ 晶体。生长轴沿 a 轴，极化矢量与之垂直。通常正畴厚度 l_p 和负畴厚度 l_n 不等，但可通过调节转速和拉速使 $l_p+l_n\sim 2l_c$（l_c 为相干长度，对应于 1.06μ 的基波 $l_c=3.4\mu$）。

应用连续泵浦声光调Q的YAG激光器输出的激光为基波，在腔外测量了聚片多畴 $LiNbO_3$ 晶体由于 d_{33} 准位相匹配所产生的倍频光强。为了对比，我们也测量了厚度相同、光学质量相仿的单畴 $LiNbO_3$ 晶体在 d_{31} 角度位相匹配条件下的倍频光强。观测到了准位相匹配相对于正常位相匹配的倍频增强效应，实测到的增强因子在 1.5～12 之间，增强因子的最大理论值为 $(7.5\times\frac{2}{\pi})^2\sim 23$。

我们也对聚片多畴晶体的倍频光强和片数N的关系式 $I(2\omega)=I_0(2\omega)N^2\cos^2(\frac{\pi|l_p-l_n|}{2l_c})$ 进行了检验，结果见表1，偏差是随片数增长的，可能是畴间距不规则及畴界散射所引起的。

表 1　$I(2\omega)/I_0(2\omega)$ 的实验值和理论值

片　数　N	40	48	58	64	76
理　论　值	1550	2240	3260	3980	5600
实　验　值	1500	1900	2200	3000	3200