行政院原子能委員會

委託研究計畫研究報告

以質子束在鈮酸鋰晶體上製作光電倍頻晶體（2^{nd} harmonic generator）之實驗研究

On realization of the 2^{nd} harmonic generation on lithium niobate using the proton beam and the standing laser poling

計畫編號：952001INER048

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報告日期：Dec. 13, 2006

中文摘要

用鈮酸鋰製作倍頻晶體的一種方法是準相位匹配(quasi-phase-matching)。然而要將 850 nm 波長的近紅外光倍頻為約 420 nm 波長的藍光時，所需要的電極性（亦即，電偶極之極化密度）區域反轉週期約為 1.6 μm。我們提出兩種製作如此短週期區域反轉的研究方法，一是利用高強度的雷射駐波進行週期性極化，另一是利用質子束轟擊的方法進行。不論是利用哪一種方法進行製作倍頻晶體的研究，要實現短週期區域反轉，需要對鈮酸鋰微觀的極性反轉過程有細部的瞭解。我們利用電腦模擬的方式，計算各種不同機制下，進行反轉所需的 coercive field。和現有文獻上記載的 coercive field 值互相比較，得出鈮酸鋰反轉過程的定量微觀過程，特別有助於短週期極化方法的開發。為了詳細地瞭解質子束轟擊對材料內部電偶極矩的影響。我們在清華大學原科中心的協助下，進行了玻璃試片的質子束轟擊實驗。而為了分析處理後試片內部產生的永久電偶極矩的大小和方向，我們利用自行建立的光學系統，量測試片 Brewster angle 的改變，以知電偶極之極化密度所造成的改變。由量測結果發現，以這樣能量的質子束轟擊效果雖然不大，但確實會對試片的 Brewster angle 產生小幅度的改變。

由這個實驗結果以及前述電腦模擬所得的鈮酸鋰微觀反轉過程的資訊，我們對於使用質子束和雷射駐波進行短週期電極性區域反轉，有了更明確的瞭解與掌握。

Abstract

Quasi-phase-matching is a well-established method for causing second harmonic generation in the ferroelectric lithium niobate crystals. In order to convert part of the energy of the incident near-infrared light of 850 nm wavelength into a blue light of 420 nm wavelength, the needed ferroelectric domain inversion period by electro-poling must be around 1.6 μm, according to existing literature. To possibly achieve such a short period, we propose two novel research schemes. One is by utilizing a high-intensity laser's standing wave pattern combined with a strong DC background field, and the other is by using the low-energy proton-beam bombardment. However, for whichever method, the ultimate understanding of microscopic evolution details during the electro-poling process within the lithium niobate would be a great advantage. By way of first-principle quantum mechanical simulations, we obtained various coercive fields required to reverse poles in different inversion mechanisms. Then, the microscopic dynamics of the poling process was revealed after comparing this information with existing literatures.

Proton-beam treatments on glass samples were conducted under the assistance of the Accelerator Center of the National Tsing-Hua University in order to assess this means of creating permanent dipoles of desired properties and hopefully in the end to be able to manipulate the polarization pattern on lithium niobates. Changes on Brewster angles were evidenced even though by merely a small amount. Nevertheless, this opened a new door to the patterning of all types of frequency

doublers, particularly when the combining effect of a standing laser pattern could really be made available.