Abstract

Terahertz (THz) radiation is defined in the 0.1–10 THz range of the electromagnetic spectrum. It corresponds to the 30–3000μm range of the wavelength spectrum, which is an important region between the optical wave and the microwave. THz radiation finds many applications in biomedicine, cancer inspection, inspection systems in airports, and molecular science. The THz wave can be generated through optical rectification, free electron laser, and nonlinear frequency mixing in nonlinear crystals.

In this thesis, our experiment uses the nonlinear difference frequency generation (DFG) process in periodically poled $LiNbO_3$ (PPLN) to generate the THz wave. The useful crystal length in the DFG process is believed to be limited by the absorptive length in the strongly absorptive materials. In this thesis, we use different lengths of PPLN with the same period to generate THz wave. Results show that the use of crystal length is not limited by absorptive length.

However, in long lengths, the THz wave diffracts fast in the crystal and has weak interaction with the pump and signal wave, which decreases the power of the THz wave. In our previous work, we have demonstrated that there is two times the conversion efficiency in the non-collinearly phase-matched THz generator. In the experiment, we use a thin crystal called one-dimensional (1D) waveguide and a rectangular crystal called two-dimensional (2D) waveguide to enhance the power of the THz wave. The result shows that the power of the THz wave in the two-dimensional waveguide is about 1.82 times than that in the 1D waveguide.

中文摘要

兆赫波段就是頻率為 0.1 到 10 兆赫茲，波長為 30 毫米到 3000 毫米的電磁波段。近幾年來，這部份的波段逐漸被大家重視與發展。兆赫波可以運用在很多方面，例如生物醫學、癌症檢測、機場安全偵測、分子科學等。在產生兆赫波上有許多方法，例如光整流方式、自由電子雷射、非線性光學差頻效應等。

在我們實驗室使用非線性差頻效應來產生兆赫波。然而，在普遍大家認之中，利用差頻效應產生兆赫波，兆赫波的功率會受到有效晶體長度的限制，有效長度等於單位吸收係數的倒數，以至於當增加晶體長度後，無法獲得更高功率的兆赫波。本實驗目的是為了打破如此的想法，於是我們設計了長度從 1㎜ 到 25㎜ 極化反轉的鈮酸鋰($LiNbO_3$)晶體，利用非線性差頻效應來產生兆赫波。實驗中，我們觀察到，在幫浦光與兆赫波在時間上分開前，兆赫波功率會隨著長度變長而增加。這結果直接證明了我們可以利用增加晶體長度來增加兆赫波功率。

再者，由於兆赫波在鈮酸鋰晶體內產生後，會有很大的發散，使得幫浦光與兆赫波交互作用的區域變小了，加上鈮酸鋰晶體在兆赫波段有強烈的吸收，導致產生的兆赫波功率降低。爲了提高兆赫波功率，之前我們有設計不同厚度的晶體，發現兆赫波在厚度為 0.5㎜ 晶體內的轉換效率是在厚度為 1㎜ 的 2 倍。於是，本實驗進而一步，設計了厚度為 0.5㎜, 寬度為 0.6㎜，長度為 25㎜ 的鈮酸鋰波導，我們稱為二維的波導，來產生兆赫波，比較另一個一維的鈮酸鋰波導，厚度為 0.5㎜, 寬度為 2㎜，長度為 25㎜。我們發現，在二維波導內產生的兆赫波功率是在一維波導內的約 1.82 倍。這次實驗證明了，利用二維波導結構，可以減少兆赫波在傳播時的損耗。