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Second Harmonic Generation by Semi-Quasi-Phase Matching technique using monocrystalline and polycrystalline GaAs

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Abstract
The goal of this project is the experimental verification of the technique of Semi-Quasi-Phase Matching. For this purpose, samples of monocrystalline GaAs will be processed through deep etching and filled with polycrystalline GaAs powder. The experimental apparatus for measuring second harmonic generation is composed of a tunable CO_2 laser, an InSb and an HgCdTe photodetectors both operating at low temperature. This project allows beginner student in undergraduate courses to become familiar with the techniques of microfabrication and instrumentation through the study of fundamentals and technology of lasers and non-linear optics. All manufacturing and assembly work were performed at the Device Research Laboratory (LPD), Department of Applied Physics, Institute of Physics Gleb Wataghin (IFGW).

Key words:
Semi-Quasi-Phase Matching, Nonlinear optics, second harmonic generation .

Introduction

The invention of laser in the 60's allowed the interaction of high-intensity electromagnetic fields with matter, defining the start point of nonlinear optics. One type of such interaction is second harmonic generation of light which can be achieved by employing some techniques, such as Quasi-Phase Matching (QPM). The QPM requires periodic flip of the crystal, that is challenging in the context of integrated devices due to a requirement of periodic flip of the crystal. A theoretical solution for that was proposed by former LPD's professor Navin Patel[1], who suggested employing polycrystals instead of flipped stacks of monocrystals, a so-called Semi-Quasi-Phase Matching technique (SQPM). Our goal here is to demonstrate experimentally SQPM for GaAs samples pumped by a 10μm CO_2 laser.

Results and Discussion

We have developed a setup for second harmonic generation measurement, as depicted in Figure 1. Knowing the properties of GaAs, we have fabricated test cells comprised by stacked, 220μm half-etched GaAs monocrystal, each fully filled with poly-GaAs powder. Thus, using the phase matching condition, we have the second harmonic generation in the monocrystalline layers and when the light passes through the polycrystalline material we have cancelled random interactions, that is, there is only a second harmonic generation in the monocrystalline part.

The experiment starts with a tunable 10μm CO_2 laser focused by ZnSe lenses into the test cells where SHG occurs. A home-made gimbal allows the cells to free rotate, thus optimizing SHG signal. A sapphire window is used to filter out the input signal, whilst an InSb detector collect generated signal and electrically send it to an oscilloscope.

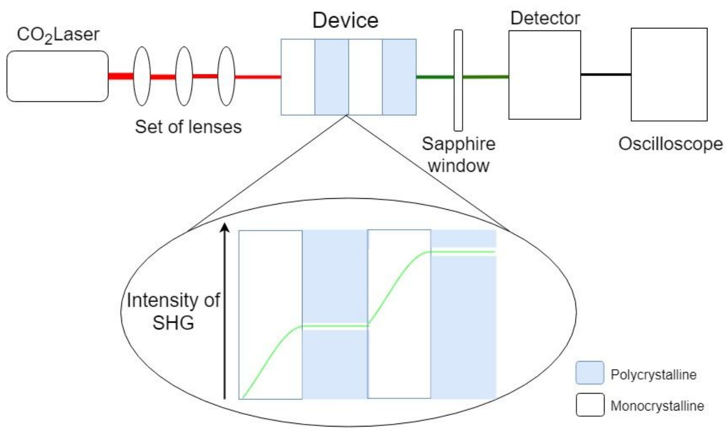

Figure 1. Setup of Second Harmonic Generation.

Conclusions

The project has been developed to experimentally demonstrate the Semi-Quasi-Phase Matching technique. We developed a technique of deep etching of GaAs to fabricate the devices. We also made a free optics setup for second harmonic characterization. This project was fully performed in the Device Research Laboratory (LPD),Department of Applied Physics-IFGW.

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[1] Patel, Navin B, "Nonlinear optical device for middle infrared generation".