# 太赫茲光柵之頻域響應設計

# Spectral Design of Terahertz Grating

指導教授：黃衍介　　組別：A29　　組員：麥家銘

## Abstract

Nowadays, generation of terahertz radiation has become a popular research topic. Though there are many approaches to generate terahertz radiation, each with their advantages and specialties, the common problem they face is low efficiency. A reason for this comes from materials. The selection of gain medium often leads to large Fresnel loss. Therefore, design and fabricate an effective anti-reflection (AR) coating is one way to increase efficiency.

We proposed a terahertz grating which can be attached to the surface of gain medium, serving as output coupler. The grating is in square-wave shape, with the period of 125um, fabricated on a dicing saw in HOPE lab, NTHU.To examine its property, we used a THz-TDS pumped by a femto-second Er-doped fiber laser, constructed in The labortory of Informational Optics, SB RAS. After collecting the data in time domain, we can then perform Fourier transform and obtain the spectral response of our grating. In this presentation, we will show both simulation result, done with HFSS, as well as experimental results. Comparison between them will also be included.

## Introduction

Terahertz radiation, or simply terahertz (THz), has become a popular research topic among both fields of Photonics and Microelectronics. Terahertz radiation includes electromagnetic waves from 0.1 THz to 10 THz. Presently, terahertz radiation is considered as a promising light source, whose application includes biology, medicine, chemistry, security… and so on.

A common method to generate terahertz radiation is through nonlinear crystal. Since the refractive index of these crystals, or materials, are much larger than air, terahertz radiation would thus suffer from huge Fresnel loss, anti-reflection (AR) coating is required. However, wavelength of terahertz can be as long as 100um, which makes traditional means such as quarter-wave AR coating impractical. Therefore, we developed certain pattern cut of high resistive float zone (HRFZ) silicon wafer, which is highly penetrable for terahertz. We proposed a structure shaped like a square wave, or a binary structure, whose spatial period is 125um. By using a dicing saw, we would be able to cut such pattern on a silicon wafer. In this experiment, We not only cut the pattern in 1D but also 2D, since the property of 2D structure is thought to be polarization independent but 1D would be easier to fabricate.

Furthermore, we put the fabricated structure into a terahertz time-domain spectrometer (THz-TDS), and measure the transmission, reflection properties. Aside from the experimental results, we also computed the expected properties of such structure, both 1D and 2D, with HFSS. In addition to the actual structure we fabricated, we also simulated several possibilities, including single/double sided, as well as half-period shifted ones.

## Results and Comparison

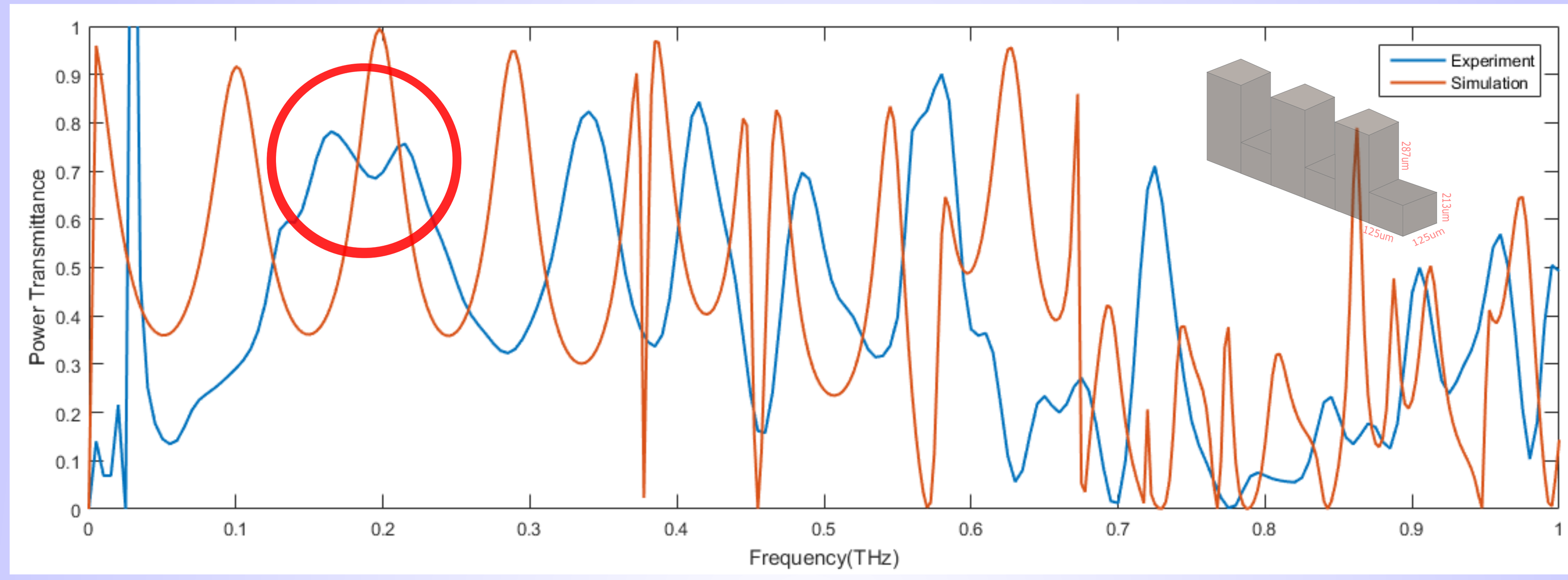


Fig. 2-1 The comparison of transmittance between experiment and simulation in 1D. Note the transparent window near 0.2 THz

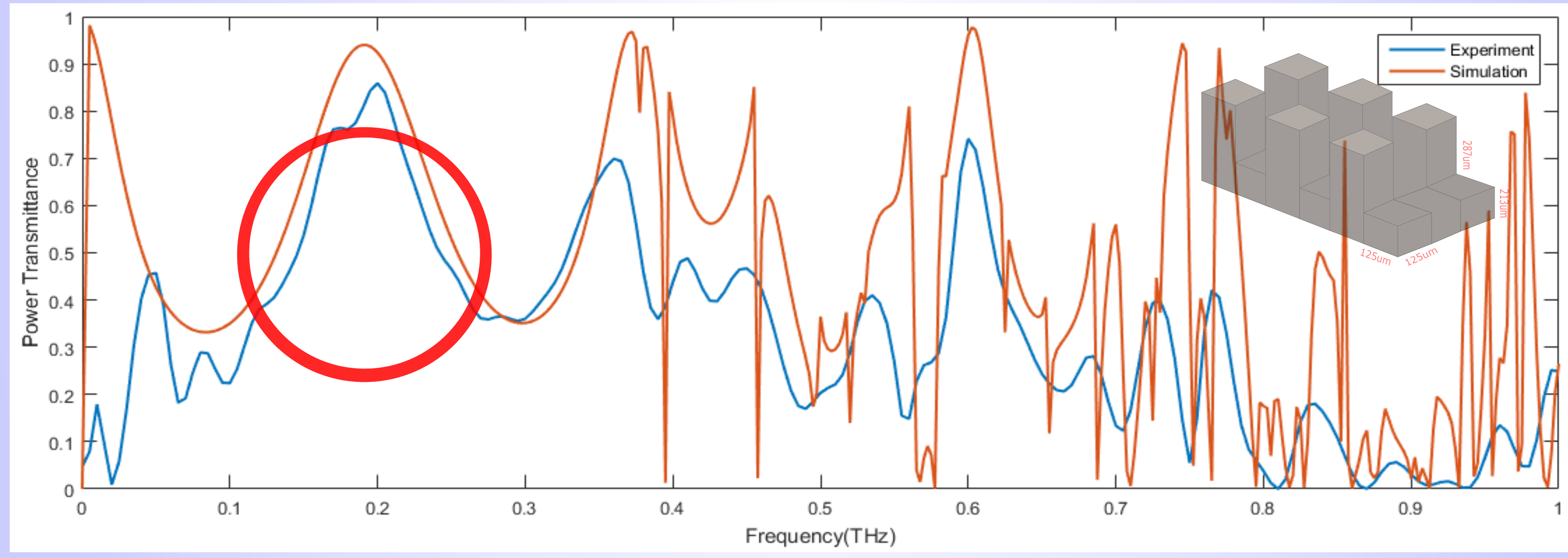


Fig. 2-2 The comparison of transmittance between experiment and simulation in 2D. Note the transparent window near 0.2 THz

## Experimental Setup

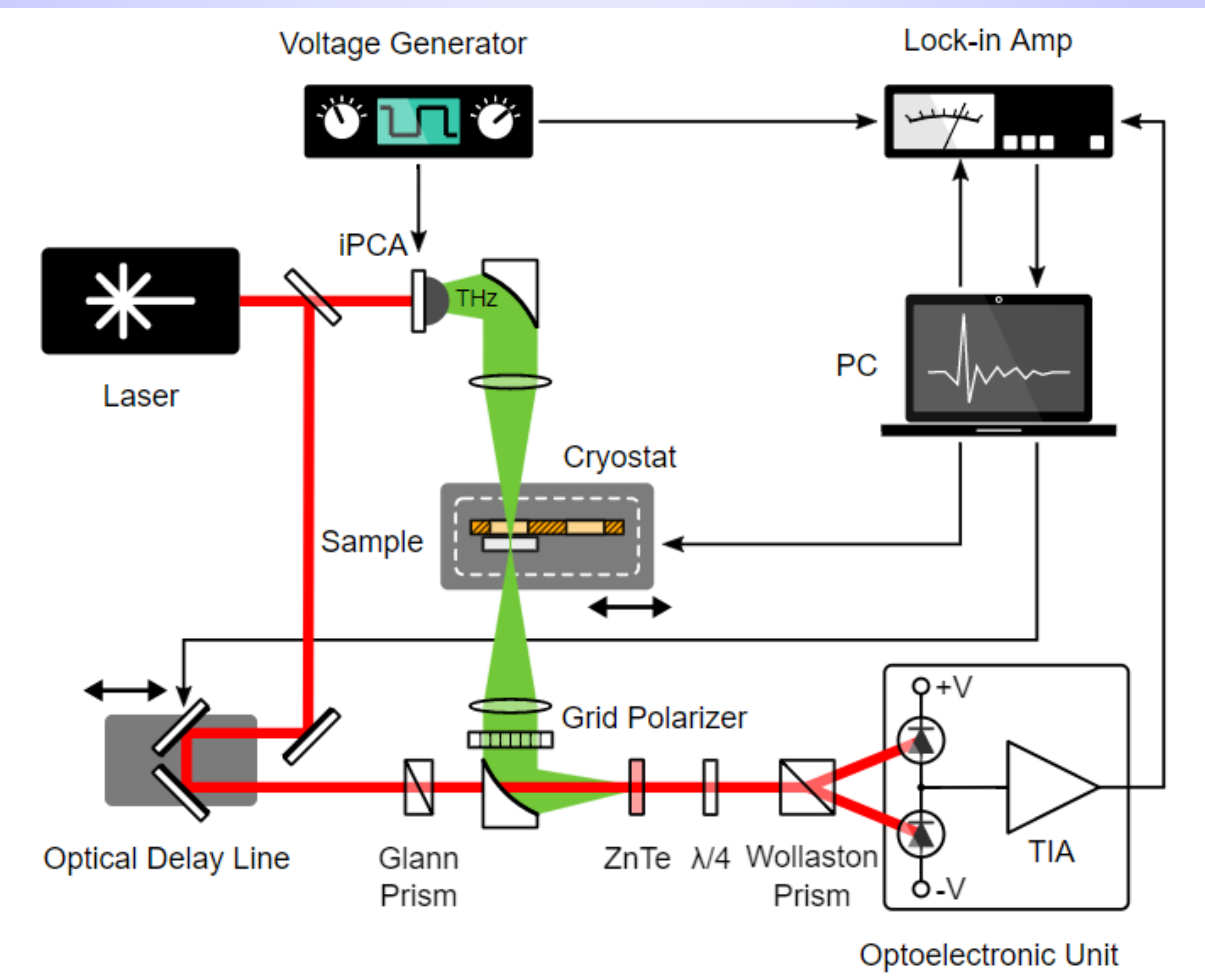


Fig. 1-1 The illustration of our experimental setup. Red line stands for optical laser pulses and green one is for terahertz.

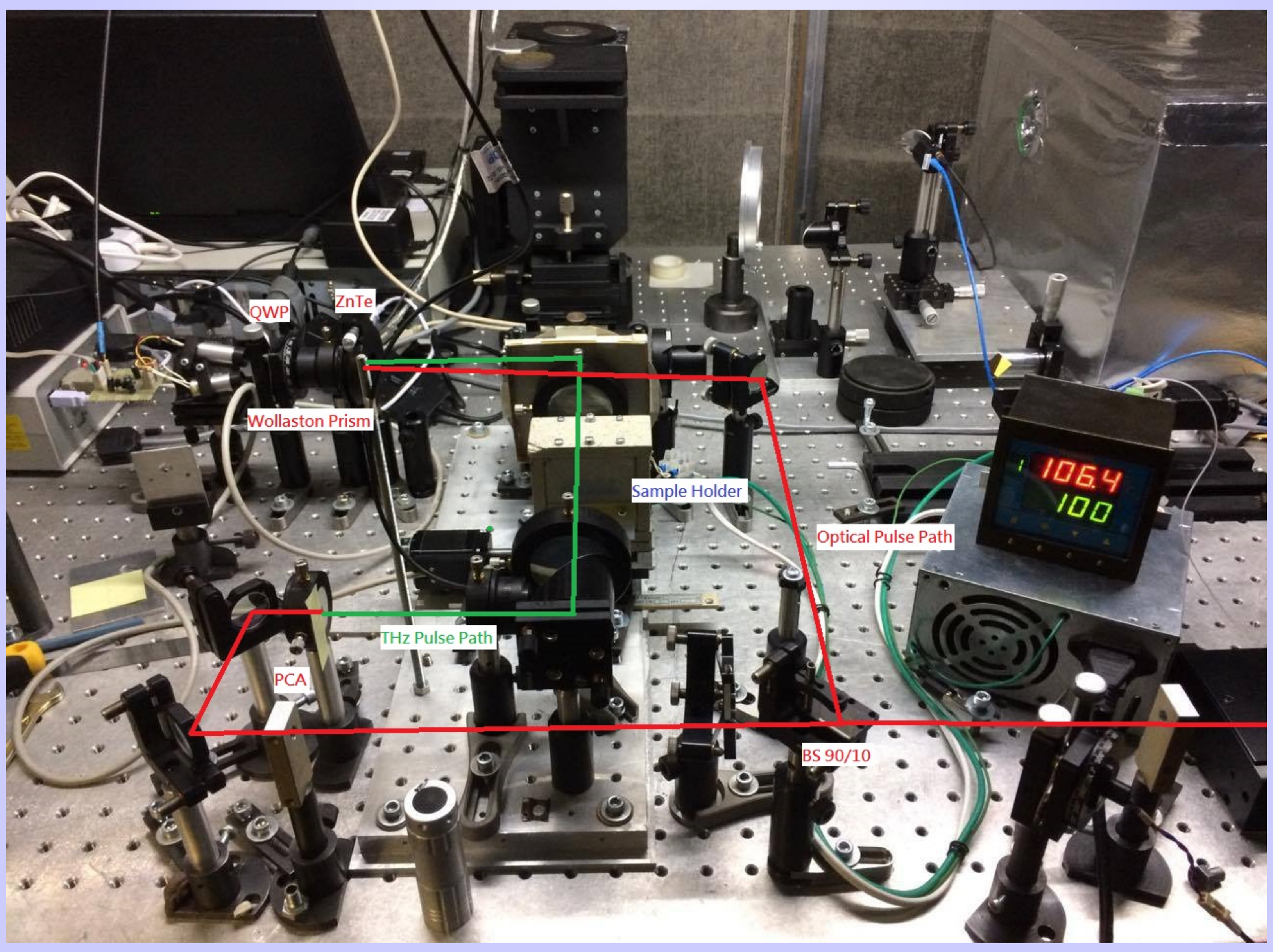


Fig. 2-2 The image of experimental setup. Optical Paths are labeled, red stands for optical pulse and green for terahertz pulse. Some important components are labeled as well.

## Conclusion

Generally speaking, both simulation results and experimental results shows that our structure works at 0.2THz. Given the fact that our goal is to shift the central operation point to 2.0THz, we may need to shrink the structure 10 times than present one.

Roughly speaking, the results between experiment and simulation share much common, especially in low frequency regime under 0.5THz. Since the diffraction would be a problem for higher frequencies, in this work we mainly focus on lower frequencies.

Also, the structure did not work as we expected, a broadband AR coating. Therefore, in the future, we may as well as try to modify the shape of the structure into one with wider bandwidth.

## References

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