Photonic Crystals: Part I
Photonic Crystals for High Power Microwaves

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OUTLINE

- Introduction
- High Power Microwave Experiments
- Infrared Experiments
- Conclusions

INTRODUCTION

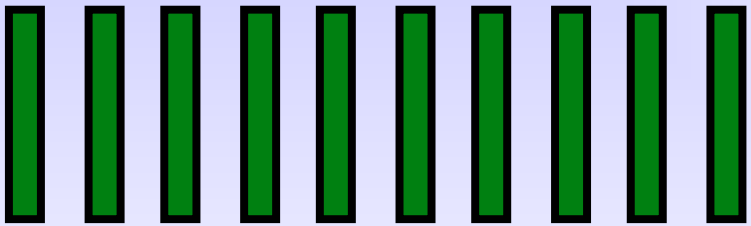
Brief History of Photonic Crystals (PCs)

- Originally proposed by E. Yablonovitch and S. John (1987)
- PCs are to EM waves as real crystals (i.e. semiconductors) are to electronic waves
- Helmholtz equation <-> Schrodinger equation
- Concepts from solid state physics are used for PCs
- Differences exist between EM waves and electronic waves (e.g. rest mass, spin, charge, etc.)

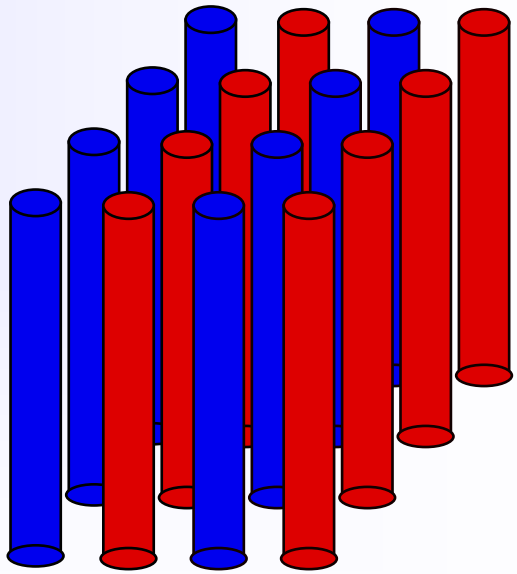
INTRODUCTION

Multi-Dimensional Photonic Crystals

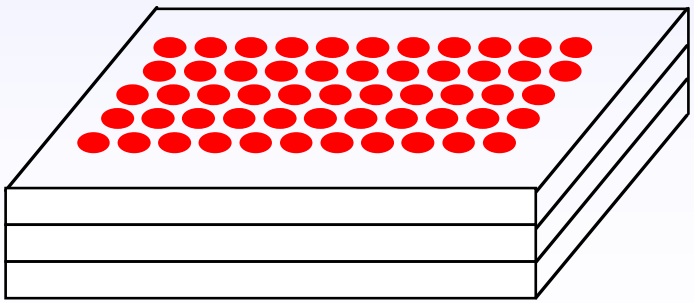
One-Dimensional PC



Two-Dimensional PC



Three-Dimensional PC



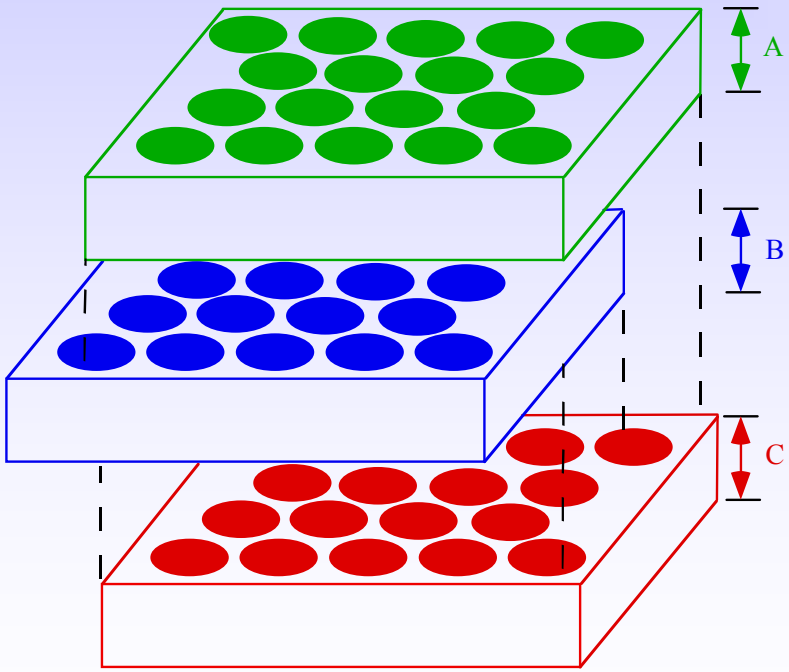
INTRODUCTION

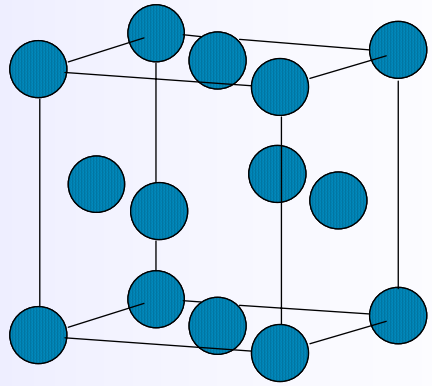
Applications

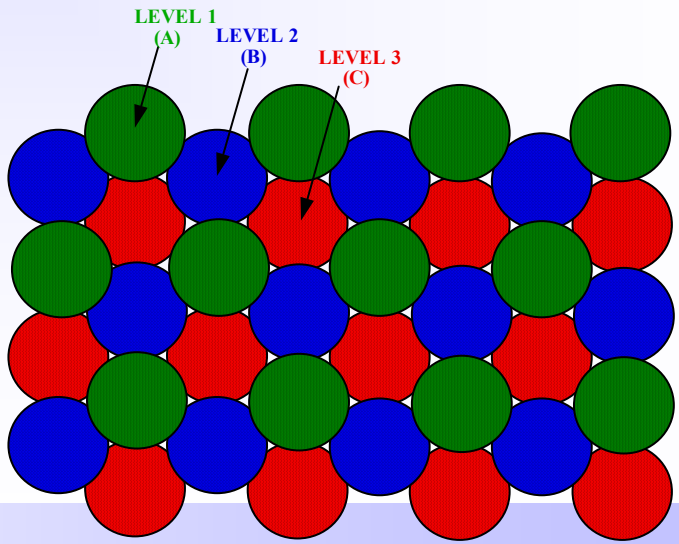
- Printed Antenna Substrates (E.R. Brown-LL)
- Spatial Filtering
- Beam Shaping
- Frequency-Selective Reflectors
- Ultra-Wideband Applications

INTRODUCTION

Face-Centered-Cubic Structure

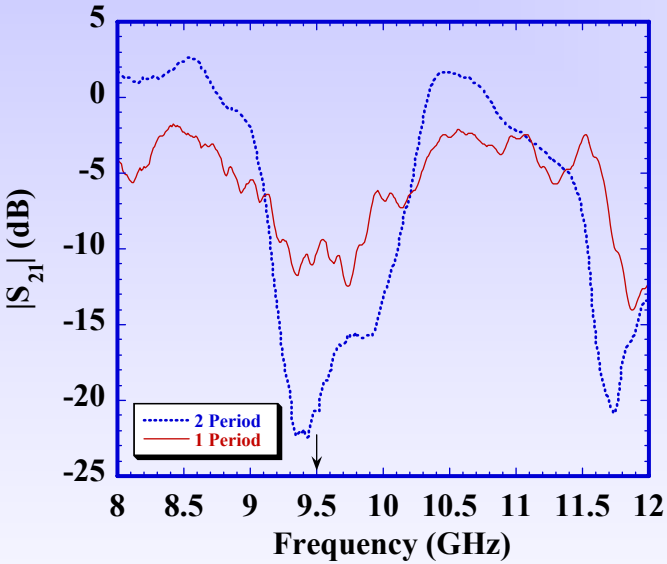


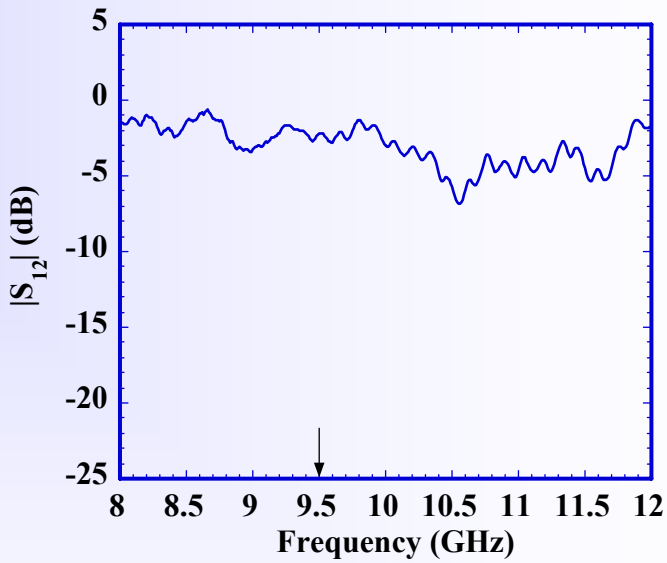


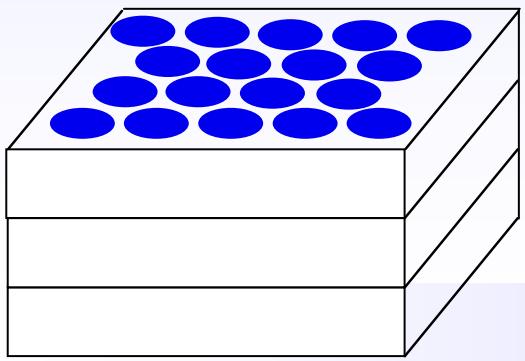


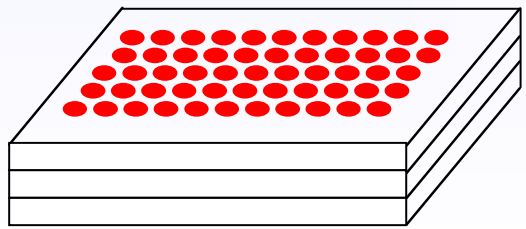
HPM EXPERIMENTS

Crystal Responses



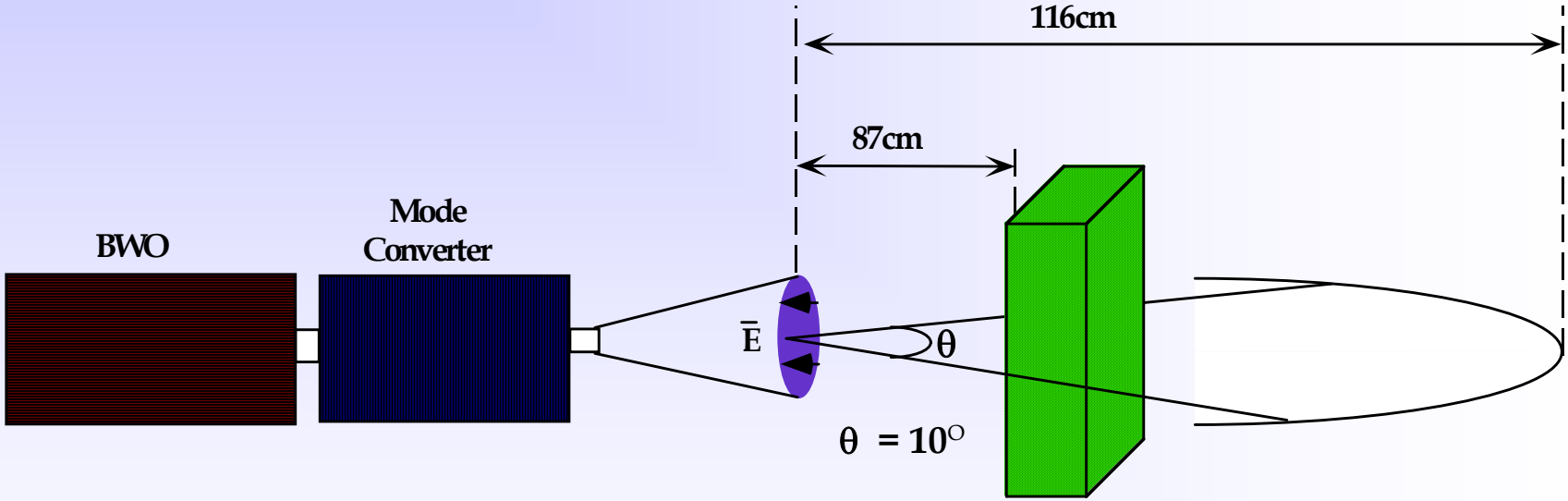






HPM EXPERIMENTS

Experimental Set-Up

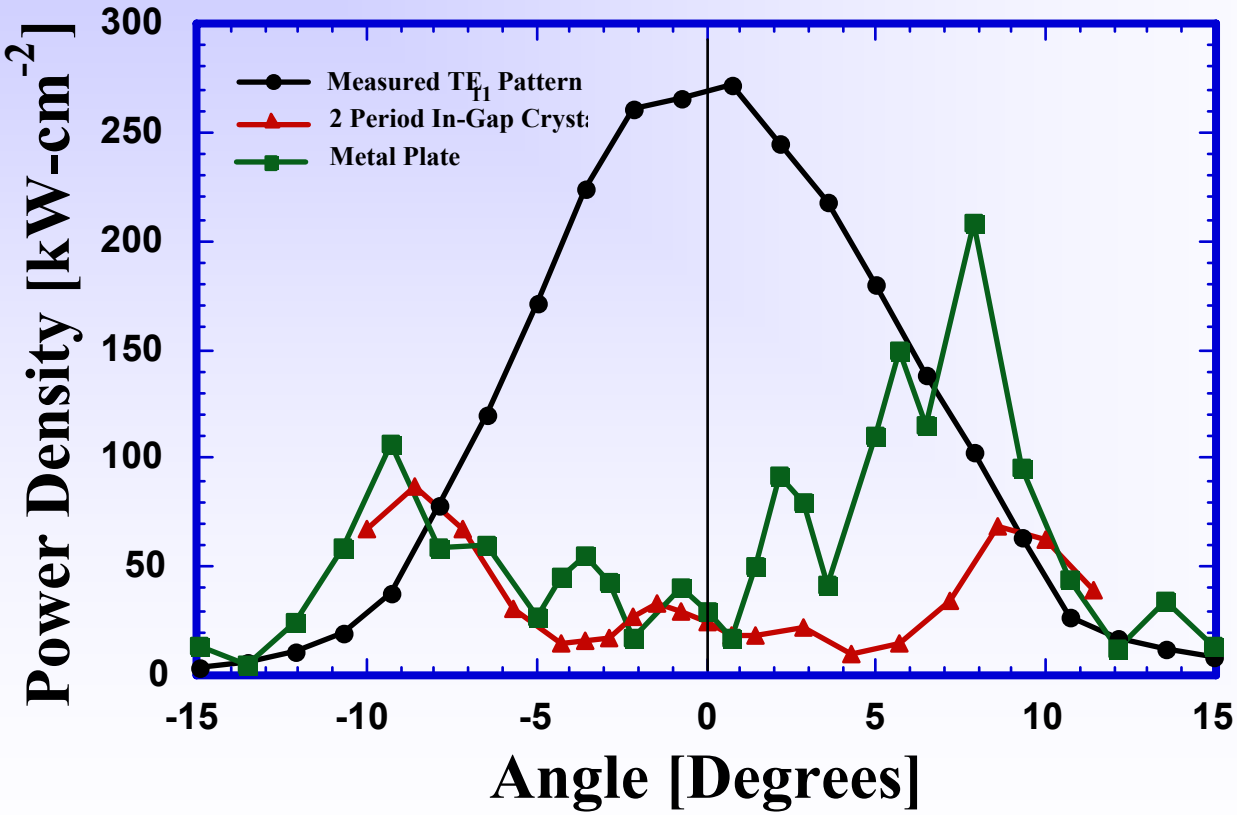


Beam Parameters

Beam Current	Power Density	RF Frequency	Power
4.0 kA	270 kW-cm^{-2}	9.6 GHz	400 MW

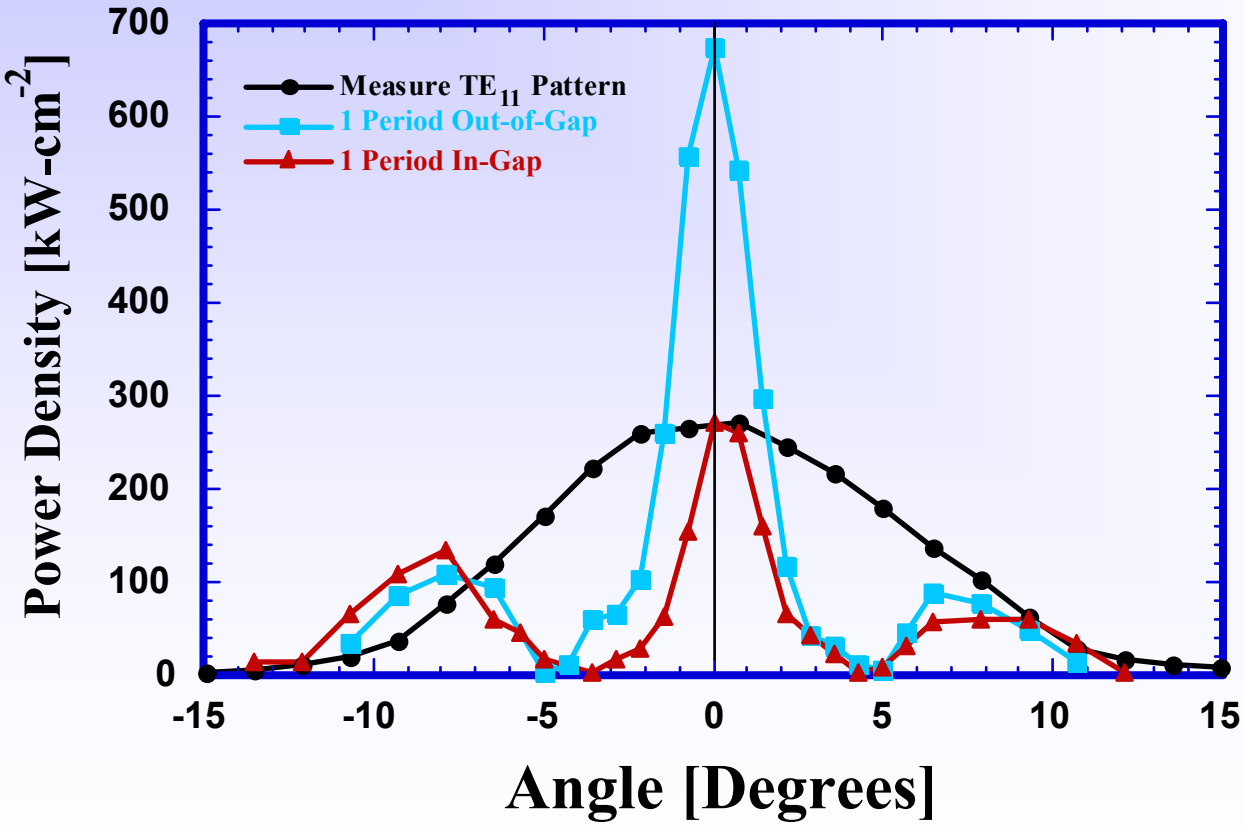
HPM EXPERIMENTS

Spatial Filtering



HPM EXPERIMENTS

Beam Shaping



HPM EXPERIMENTS

Summary

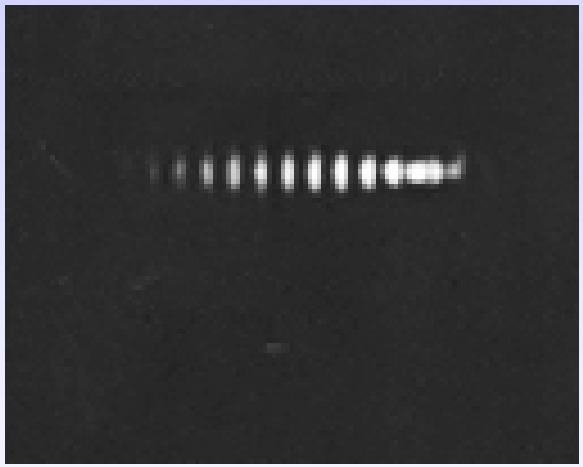
Diffracted and Transmitted Power From -5° to 5°

Direct Transmission (Reference)	**173MW (0 dB)**
Metal Plate (Reflector)	**42MW (-6 dB)**
In-Gap PC (2 Periods)	**28 MW (-8 dB)**
Out-of-Gap PC (1 Period)	**60 MW (-4.6 dB)**

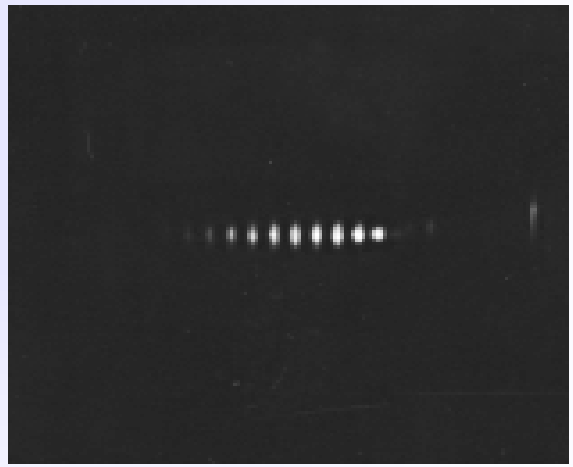
HPM EXPERIMENTS

Frequency-Selective Reflector

Metal



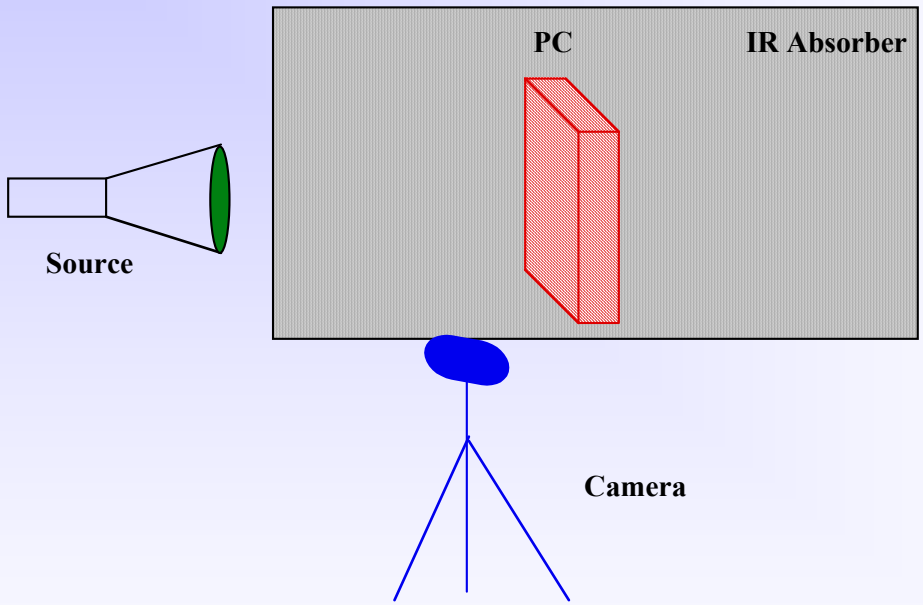
PC



Beam Current	Power Density	RF frequency	Power
5.1 kA	325 kW-cm^{-2}	9.7 GHz	450 MW

IR EXPERIMENTS

Experimental Set-up



Source:

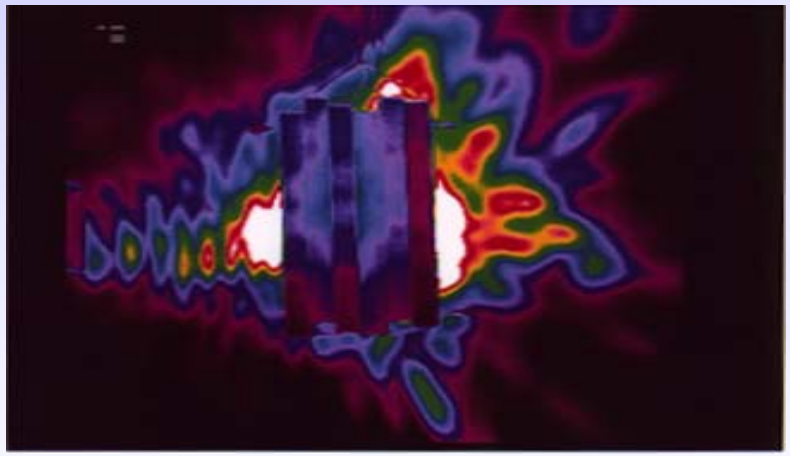
- HP 83623A Sweep Generator:0.01-20 GHz
- Logimetrics TWT Amplifier:8-18GHz
- 200W Output Power

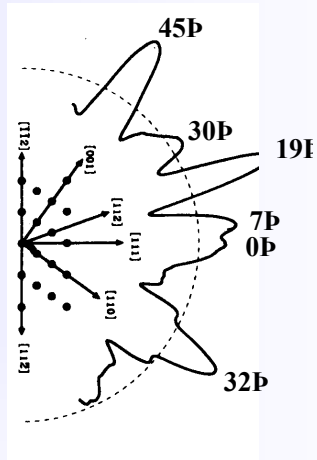
Camera:

- Amber Engineering 4256 IR Camera
- Liquid Nitrogen Cooled
- 256x256 InSb FPA
- 3-5μm Range
- 30 Hz Frame Rate

IR EXPERIMENTS

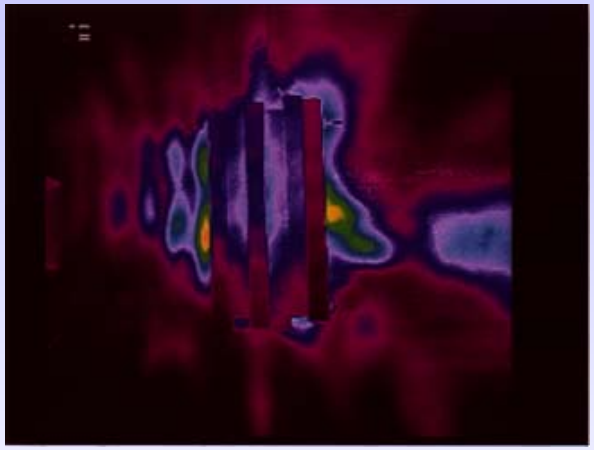
“X-Ray Diffraction”



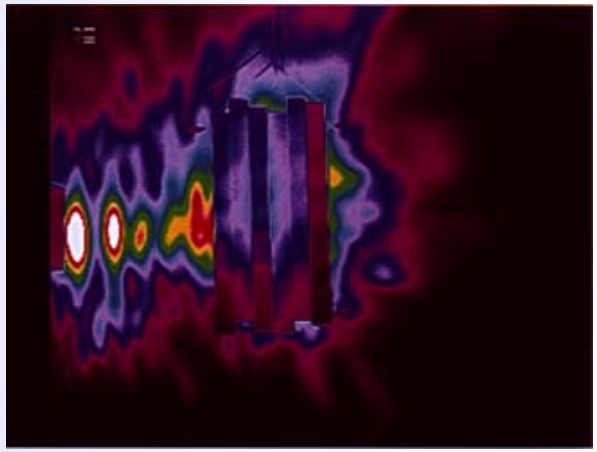


IR EXPERIMENTS

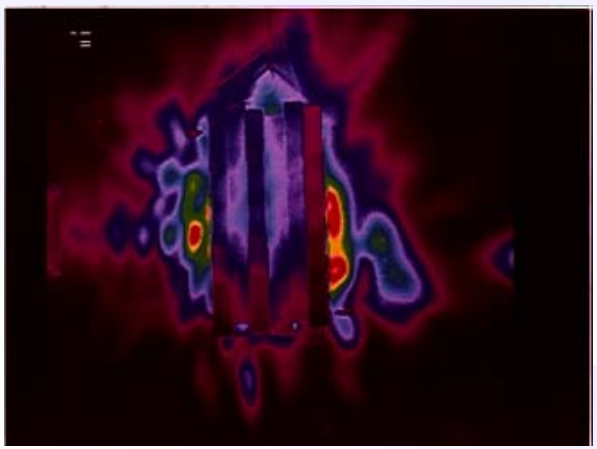
8.5 GHz Excitation

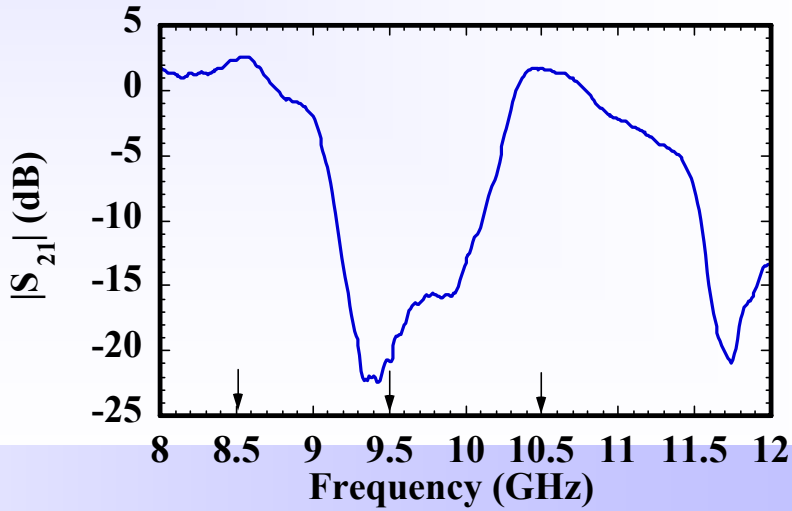


9.5 GHz Excitation



10.5 GHz Excitation





CONCLUSIONS

For HPM:

- **Spatial Filtering**
- **Beam Shaping**
- **Higher Power Densities**
- **Frequency-Selective Reflector**

For IR:

- **Determination of Energy Distribution**
- **Analogies to X-Ray Diffraction**

Applications

UWB Photonic Crystal