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Multiphoton photoelectric emission from Lithium niobate was investigated. At the wavelengths of interest, 1060 nm and 530 nm, thermionic emission occurs at energy density of about 1 J/cm ² .		

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Final Report

Investigation of Photoacoustorefractive Effect in LiNbO_3 SAW Devices.

1. Introduction

Real time processing advanced radar system data has placed extensive requirements on the analog information processing technologies that are now utilized. Applications have developed that require real time processing with large dynamic range together with large bandwidth. A relatively new and exciting approach to carry such processing out is based on acoustooptic technology. Surface Acoustic Wave (SAW) technology has been combined with integrated optics (IO) technology to obtain real-time correlation, convolution, and Fourier transform devices. The present status of this technology has shown that additional investigation of some of the materials properties is needed to advance the device capabilities.

One particular area of interaction utilizes the imprints of high frequency rf signatures in a Surface Acoustic Wave (SAW) device when a high intensity laser pulse interacts with the SAW created by the rf signal. An acoustophotorefractive effect occurs, wherein areas of a lithium niobate (LiNbO_3) crystal are irradiated by intense laser illumination and develop semi-permanent index of refraction changes (δn). The effect has been used to implement a memory correlator. Both short duration, high intensity green (532 nm) laser light and near IR (1060-nm) laser light have been utilized to create such an effect.

One possible cause proposed for the changes in the refractive index is photoemission of electrons.¹ The fields set up by the Surface Acoustic Wave would modulate the emission. The influence of spontaneous polarization on the photoelectric effect has previously been reported.²

Both the (single photon) photo-emission threshold and photoemissive yield were found to be quite different for the two ends of a single-domain

LiNbO₃ crystal. The purpose of this work was then to study the multiphoton emission of electrons from LiNbO₃ both in order to obtain information about the photoemissive yield as a function of photon energy and any influence of the spontaneous polarization.

2. Experimental Methods and Results.

The experimental work performed consisted of: 1. Design and assembly of a vacuum chamber with access window for a laser beam to enter and electrical feedthroughs for photoelectron detection. 2. Experiments using the vacuum chamber and a tuneable pulsed dye laser to study photoemission. 3. A Q-switched Nd:BEL laser was constructed to be used as a 1 μm source for photoemission.

Actual LiNbO₃ samples that had been used in the SAW device experiments at Harry Diamond Laboratories, were used in our investigation. In the HDL experiments a Q-switched Nd:YAG laser with output of $\sim 0.5\text{J}$ and 5 ns pulse duration was used to radiate about 1 cm^2 area. The output of our dye laser is about 100 μJ in 10 ns. Thus to obtain a similar power density (100 MW/cm^2) we focussed the beam down to approximately 100 μm beam diameter. The power density was adjusted by changing the focussing of the beam.

With 2.5 eV photons we found a signal threshold near 100 MW/cm^2 and a very strong intensity dependence above 100 MW/cm^2 . This is characteristic of thermionic emission and indeed we found that both positive and negative charges were emitted. Attempts to increase the detection sensitivity were not successful. It was found that the microchannel plate collector we used, with a gain of $\sim 10^4$, had too high capacitance to resolve the 1 ns to 10 ns pulse. An attempt to use just a collector plate and subsequent amplifier

also failed to due to insufficient gain-bandwidth product. In order to proceed it was decided that an electron multiplier tube with a gain of $\sim 10^8$ should be used. However, insufficient funds prevented purchase of this.

Since the original experiments at H.D.L. had been performed with a Nd:YAG laser at $1.06 \mu\text{m}$, we had planned to also study the photoemission at this wavelength. A Nd:BEL laser is constructed for this purpose. A flowing dye passive Q-switch was used. The operating characteristics of this laser are: wavelength $\lambda = 1.07 \mu\text{m}$, output energy $E = 50 \text{ mJ}$, pulse duration $T_p \leq 50 \text{ ns}$, pulse repetition rate P.P.R. $= 0.5 \text{ sec}^{-1}$.

3. Conclusion.

This research program yielded no new results regarding multiphoton photoelectric emission from lithium niobate. However, at the energy and power levels originally used at Harry Diamond Laboratories, the threshold for thermionic emission might have been exceeded. The very similar results that they have observed at the two wavelengths, $\lambda = 1060 \mu\text{m}$ and $\lambda = 530 \text{ nm}$, would be more in accordance with photon energy independent thermionic emission than photoelectric emission.

4. References

1. John N. Lee et al, Ferroelectrics, 1980, 27, pp. 139-142.
2. A. A. Akhayan et al, Sov. Phys. Solid State 20 (5), May 1978, p.912.