Polar Optical Phonons in AlN/GaN superlattice structures.

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Infrared reflection spectra of bulk semiconductors and superlattices can be predicted mathematically with optical phonon frequencies as some of the input variables. This method will be used to determine the polar longitudinal optical phonons and their corresponding energies that are present in AlN/GaN superlattices. Theoretical results will be compared to reflection experiments taken at a 75° incidence angle. Different AlN/GaN superlattice combinations will be studied to see if any pattern of phonon energies may arise. This outcome may prove useful in engineering phonons at specific frequencies. Furthermore, new phonons exist that are not at the energy levels present in bulk AlN and GaN. Phonon dispersion curve "folding" might prove useful to predict these new phonons. It will be determined whether this "folding" is a useful explanation for these new phonons, and if not, a new hypothesis will be made.

I. INTRODUCTION

Phonons which are atomic vibrational waves greatly affect electron mobility due to scattering. These waves displace atoms in semiconductor crystals which in turn alter the electronic potential and causes electron scattering. Additionally, In compound semiconductors, like AlN and GaN, the bond is ionic. A phonon in this case alters the dipole between the atoms and creates an electric field. This electric field due to these polar optical phonon causes very strong scatting and is typically the dominating scattering mechanism in compound semiconductors[1]. Despite the negative effects of slowing down electrons, phonons can also be useful to semiconductors such as in heat dissipation.

GaN and AlN compounds have been proven useful in wide bandgap microelectronics and optoelectronics. Study of phonon properties in Bulk GaN and AlN has been extensive. However, phonon properties of AlN/GaN superlattices are not well understood.

With the help of infrared spectroscopy experiential results, Optical phonon frequencies in AlN/GaN superlattices can be determined. This present work has identified some new phonons that are present in these superlattices, yet not present in bulk AlN and GaN. This study will determine whether these phonons are due to "folding" of phonon dispersion relations[2]. However, so far, study seems to be leading to the fact that the phonons observed are not due to "folding." One hypothesis is that these optical phonons are caused by the defects at the interfaces of the alternating superlattice periods.

II. EXPERIMENTAL METHOD

The AlN/GaN superlattices in this work have been fabricated on a thin (30-70nm) GaN buffer layer which was deposited on a sapphire substrate. Each superlattice is made of 300 periods. A period consist of one GaN layer and one AlN layer. Different superlattices have been studies which vary is layer thickness and thickness ratio. The layers are between 1 and 4 monolayers thick.

Room temperature infrared spectroscopy measurements were taken at oblique incidence of 75°.

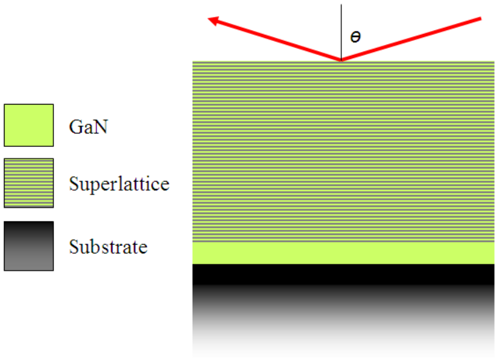

FIG. 1: Cross-sectional view of sample showing material layers and the angle of incident.

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[1] M. Lundsrom, *Fundamentals of Carrier Transport* (Cambridge, 2000).
[2] P. Y. Yu and M. Cardona, *Fundamentals of Semiconductors: Physics and Materials Properties* (Springer, 2001).