SEMICONDUCTOR SURFACE CHARACTERIZATION USING TRANSVERSE ACOUSTOELECTRIC V. TROY RENSSELAER POLYTECHNIC INST TROY NY DEPT OF ELECTRICAL COMPUT... B DAVARI ET AL. OCT 82 UNCLASSIFIED AFSR-TR-83-0646 AFSR-77-3426
ANNUAL TECHNICAL REPORT FOR THE GRANT NO. AFSR-77-3426

For the Period

August 1981 - October 1982

Rensselaer Polytechnic Institute
Troy, New York 12181

by

Pankaj K. Das

Electrical, Computer, and Systems Engineering Department
An alternative to Capacitance-Voltage (C-V) measurement is experimentally demonstrated. This technique measures the Transverse Acoustoelectric Voltage (TAV) as a function of applied D.C. voltage across the semiconductor. The technique is nondestructive and is applied to uniformly doped Si samples. Surface properties such as the flat band voltage, oxide charge and the zero bias surface condition are determined.
P.S. An annual interim report is being accepted as the Final report
for AFOSR-77-3426. The technical effort is being continued for one
year under AFOSR-82-0281. The Final report for this continuation
will contain more overall detail and should be considered as the
final report for the entire technical effort.
ABSTRACT

A surface acoustic wave (SAW) device has been developed under AFOSR Grant No. 77-3426 for use in the nondestructive determination of the electronic properties of semiconductors. The properties that can be determined by this technique include the bulk and surface conductivity, the location in the energy gap of traps, surface states, and interface states, trap emission and absorption times and storage times in the depletion layer. This characterization of the semiconductor could be performed at progressive stages of device fabrication thereby improving yield by identifying faulty processing steps. Preliminary investigations have been conducted on silicon, ion-implanted silicon, gallium arsenide, indium arsenide, gallium phosphide and cadmium sulfide. These are well documented by 20 papers and 14 meeting presentations as listed in the report. The technique uses surface acoustic waves on a piezoelectric substrate. The electric field associated with the SAW interacts with free carriers of a semiconductor placed near the piezoelectric surface. The interaction generates detectable currents in the semiconductor and attenuates the SAW. By observing these effects while varying external parameters such as temperature, applied acoustic power, SAW frequency, semiconductor surface irradiation and bias voltage, the desired information is obtained.

This report discusses the progress made in the last year.
1. INTRODUCTION

The research being carried out under this grant is directed toward the development of a technique for nondestructive determination of electrical properties of semiconductors using surface acoustic waves.

Recent developments in the field of semiconductor devices demand highly reliable material processing techniques. This, in turn, requires increased sophistication in monitoring the properties of the semiconductor during processing. For example, the diminishing size and increasing packing density necessary for silicon VLSI circuits places great importance on detection of impurities and defects in order to maintain high yield. As a second example, consider the high speed GaAs devices which are approaching the production stage. The high electron mobility in GaAs offers a significant improvement in operational speed for digital signal processing with anticipated clock rates of 10 GHz or more. Since GaAs is a direct gap semiconductor, laser diodes can be fabricated on it opening the way to single chip integration of signal processing and light source for optical transmission systems. But before these devices can be reliably produced with high yield, several material and processing obstacles must be overcome. Some of these problems may not be best solved by the conventional techniques employed for silicon.

It is projected that the use of the surface acoustic wave (SAW) technique can provide the energy location, concentration, capture and emission rates, and spatial distribution of energy levels within the bandgap of various semiconductors. Investigations have been performed on silicon, gallium arsenide, gallium phosphide, indium arsenide and cadmium sulfide. Because of the importance of GaAs, special emphasis is being given to anodically oxidized GaAs. The SAW technique can also be effective in
characterizing ion implanted semiconductors. Measurements can be performed
which will detect the presence of the ion implanted layer near the semicon-
ductor surface and its effective dose, lifetime, and conductivity. The
effectiveness of annealing also can be monitored nondestructively.

Semiconductor testing using surface acoustic waves has the unique
advantage of being contactless; there is no need to form a junction or apply
a metal to the surface. It is possible to test the same sample after each
processing step without disturbing the electrical or physical properties of
the sample.

Significant progress has been made in the development of this non-
destructive semiconductor evaluation technique using SAW in the last few
years. In the last reporting year significant results have been obtained
in the general area of contactless C-V measurements using SAW-semiconductor
interaction. This is discussed in papers nos. 18 and 19 listed in the next
section. As the papers 18, 19 and 20 are not yet published, they are
included in this report.

LIST OF PUBLICATIONS RESULTING FROM THIS AFSOR GRANT

1. P. Das, R. T. Webster, H. Estrada-Vazquez and W. C. Wang, "Contactless
   Semiconductor Surface Characterization Using Surface Acoustic Waves",

2. R. T. Webster, H. Estrada-Vazquez, P. Das and R. Bharat, "Study of the
   Surface Properties of Thermally Oxidized Silicon Using Surface Acoustic

3. P. Das, H. Estrada-Vazquez and R. Webster, "Transverse Acoustoelectric
   Voltage (TAV) Spectroscopy of High Resistivity GaAs", J. Appl. Phys.,

4. R. Bharat, P. Das, R. T. Webster and H. Estrada-Vazquez, "Contactless
   Measurement of Carrier Generation Rate in Semiconductors", Proceedings
   of the Topical Conference on Characterization Techniques for Semicon-


*Previously listed as to be published

**New papers in the last reporting period.

LIST OF PRESENTATIONS IN MEETING RESULTING FROM THIS AFSOR GRANT


