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19. ABSTRACT (Continue on reverse if necessary and identify by block number) This research comprises a study of the origins of mechanical, optical and electronic properties of thermally grown thin SiO ₂ films on Si substrates as related to the film growth mechanisms and of the cleaning of Si and InP surfaces.					
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Accomplishments During Contract

Under ONR sponsorship, we have discovered that the initial Si oxidation kinetics is dependent on the orientation of the Si substrate and the number density of Si atoms. Also there is a change in order for thicker films, i.e., a crossover effect. We have discovered an ordering of decreasing intrinsic film stress and decreasing SiO₂ film density, with increasing oxidation temperature for post crossover SiO₂ films. Furthermore, the literature reports other parallel trends in the electronic behavior of the Si-SiO₂ interface (fixed charge, Q_f , and interface trapped charge, Q_{it} with oxidation temperature. Many of the oxidation kinetics and electronics effects have been vaguely ascribed to pre-oxidation Si surface treatments. The scientific strategy for the research effort was to elucidate the apparent interrelationships between the observed oxidation kinetics effects and the SiO₂ physical and interfacial electronic properties. In addition to the above discoveries which were partly based on previous ONR support of our research, several entirely new and both scientifically and technologically important discoveries were made in the contract period:

1. Correlation of film stress with density and Youngs modulus as measured using both a laser beam reflection technique in the present research and IR techniques in collaboration with Lucovsky's group at NC State university (also funded by ONR). The agreement and consistency of the two techniques lends considerable credence to our previous stress measurements.
2. In-situ ellipsometric measurement of both HF and NH₄OH effects on the Si surface. A bare Si surface is found after NH₄OH treatment in contrast with a film on Si after HF treatment. These differences may now help to explain the longtime mystery of different Si surface properties after these accepted cleaning steps and with the development of the in-situ techniques for this kind of research the details of the liquid phase cleaning process on Si is elucidated in detail.
3. In-situ ellipsometric measurements of cleaning of InP surfaces. Different optical properties for the InP surface have been measured as a result of different literature cleaning procedures. Procedures that yield reproducible optical properties have been identified. These results pave the way for further passivation studies on the InP surface.

Technical Reports

<u>ONR Report #</u>	<u>Report Title</u>
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- 11 The Influence of Silicon Surface Cleaning Procedures on Silicon Oxidation
- 12 The Effect of Surface Orientation on Silicon Oxidation Kinetics
- 13 Redistribution of Arsenic in Silicon during High Pressure Thermal Oxidation
- 14 Thermionic Emission Model for the Initial Regime of Silicon Oxidation
- 15 Thermal Oxidation of Silicon: New Experimental Results & Models
- 16 Models for the Oxidation of Silicon
- 17 An In-Situ Study of Aqueous HF Treatment of Silicon by Contact Angle Measurement and Ellipsometry
- 18 SiO₂ Film Stress Distribution during Thermal Oxidation of Si
- 19 Thermal Oxide Growth on Silicon: Intrinsic Stress & Silicon Cleaning Effects
- 20 Silicon Oxidation Studies: A Review of Recent Studies on Thin Film Silicon Dioxide Formation
- 21 An-situ Ellipsometric Study of Aqueous NH₄OH Treatment of Silicon

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