SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION unclassified	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION / AVAILABILITY OF REPORT approved for public release; distribution unlimited
AD-A221 240	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION UNC Chemistry Department 6b OFFICE SYMBOL (If applicable)	7a NAME OF MONITORING ORGANIZATION Office of Naval Research (Code N00014)
6c. ADDRESS (City, State, and ZIP Code) CB #3290, Venable Hall The University of North Carolina Chapel Hill, NC 27599-3290	7b ADDRESS (City, State, and ZIP Code) Chemistry Program 800 N. Quincy Street Arlington, Virginia 22217
8a. NAME OF FUNDING / SPONSORING ORGANIZATION Office of Naval Research 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER Contract #N00014-86-K-0305
8c. ADDRESS (City, State, and ZIP Code) Chemistry Program 800 N. Quincy Street, Arlington, VA 22217	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)
SILICON OXIDATION STUDIES: ORIGINS OF THE PROPERTIES OF THERMALLY PREPARED SiO_2 FILMS

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13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final	FROM May 1986 TO May 1988	April 25, 1990	

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	

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.

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT	21 ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL Dr. David L. Nelson	22b TELEPHONE (Include Area Code) (202) 696-4410
	22c OFFICE SYMBOL

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

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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 SiO_2 film density, with increasing oxidation temperature for post crossover SiO_2 films. Furthermore, the literature reports other parallel trends in the electronic behavior of the Si-SiO_2 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 SiO_2 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 NH_4OH effects on the Si surface. A bare Si surface is found after NH_4OH 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

ONR Report #	Report Title

Two Step Oxidation Processes in Silicon

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	SiO_2 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 NH_4OH Treatment of Silicon

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