AD-A255 606



Contract N00014-91-J-1513

TECHNICAL REPORT NO. 3

Si Atomic Layer Epitaxy using Remote Plasma Assisted Hydrogen Desorption and Disilane as a Precursor

by

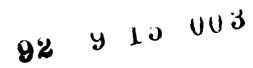
 A. Mahajan, D. Kinosky, R. Qian, S. Thomas, S. Banerjee, and A. Tasch Department of Electrical and Computer Engineering University of Texas at Austin Austin, TX 78712

Digest of the 11th Annual Symposium on Electronic Material Processing and Characterization, June 1–2, 1992, Richardson, Texas

Reproduction in whole or in part is permitted for any purpose of the United States Government

This document had been approved for public release and sale; its distribution is unlimited.





REPORT DOCUMENTATION PAGE					Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of il gathering and maintaining the data needed, a collection of information, including suggestion Davis Highway, Suite 1204, Arlington, VA, 2220	nformati nd comp ns for ret 02-4302.	on is estimated to average 1 hour per leting and reviewing the collection of fucing this burden to Washington Hee and to the Office of Management and	response, including the time for ri information. Send comments rega idquarters Services, Directorate fo isuaget. Paperwork Reduction Pro	eviewing inst ording this bu ir information ject (0704-01	tructions, searching existing data sources, urden estimate or any other aspect of this n Operations and Reports, 1215 Jefferson 88), Washington, DC 20503	
1. AGENCY USE ONLY (Leave bla	nk)	2. REPORT DATE June 4, 1992	3. REPORT TYPE AN Preprint	D DATES	COVERED	
4. TITLE AND SUBTITLE Silicon Atomic Layer Epitaxy using Remote Plasma Assisted Hydrogen Desorption and Disilane as a Precursor					DING NUMBERS No. 14-91-J-1513	
6. AUTHOR(S) A. Mahajan, D. Kinos and A. Tasch	sky,	R. Qian, S. Thomas	s, S. Banerjee,			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Microelectronics Research Center ECE Dept., 433 ENS University of Texas at Austin Austin, TX 78712					ORMING ORGANIZATION DRT NUMBER 3	
9 SPONSORING MONITORING AGENCY NAME(S) AND ADDRESS(ES) Department of the Navy Office of the Chief of Naval Research 800 North Quincy Street, Code 1511:SJH Arlington, Virginia 22217-5000					10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11 SUPPLEMENTARY NOTES				126. DIS	TRIBUTION CODE	
Approved for public			unfimited.			
glow discharge which Deposition(RPCVD) s dihydride and monohyd with He ions from the range of partial pressu min.) without plasma e as to silyl(SiH3) speci maximum growth obtai	silica held system dride (plasm rres(10 xcitat es in ined v he bo	on Atomic Layer Epitaxy(remote from the substrate to minimize surface date ermination. The ALE expense of for 1-3 min. to desorb i 0 ⁻⁷ Torr to 1.67 mTorr), a ion to adsorb Si2H6 on the a self-limiting manner wh was 0.44 monolayers per cy mbardment cycle time is de combardment time.	e in a Remote Plasma nage. The starting sur- criment cycle consisted t followed by dosing th temperatures(250°C-400 bare surface Si atoms co nich results in a hydrog wcle for a 3 minute bom	Enhance face was of bombine surface 0°C) and created by created by created by created by	d Chemical Vapor a combination of arding the substrate e with disilane in a 1 times(20 sec to 3 y the bombardment nated surface. The t cycle. The growth	
14 SUBJECT TERMS Silicon atomic layer epit disilane	аху	He plasma			15. NUMBER OF PAGES 2 16. PRICE CODE	
17 SECURITY CLASSIFICATION OF REPORT		ECURITY CLASSIFICATION	19 SECURITY CLASSIFIE OF ABSTRACT	CATION	20 LIMITATION OF ABSTRACT	
Unclassified	υ	nclassified	Unclassified			

6

ż

Silicon Atomic Layer Epitaxy using Plasma Assisted Hydrogen Desorption and Disilane as a Precursor A.Mahajan, D.Kinosky, R.Qian, J.Irby, S.Thomas, S.Banerjee and A.Tasch Department of Electrical and Computer Engineering, University of Texas at Austin, Austin TX 78712.

1

We have demonstrated silicon Atomic Layer Epitaxy(ALE) using ions from an rf-excited helium plasma glow discharge which held remote from the substrate. The ex situ clean consisted of a modified RCA clean followed by a brief HF(10;1) dip to obtain a stable hydrogen terminated silicon surface which has been discussed elsewhere. The wafers were then loaded into a Remote Plasma Enhanced Chemical Vapor Deposition(RPCVD) system through a load lock chamber as an efficient way to get a clean fast pumped system. The substrate is held remote from the glow discharge in an RPCVD system to minimize surface damage. The starting surface was a combination of dihydride and monohydride termination, as evidenced by a 3x1 Reflection High Energy Diffraction(RHEED) pattern, which was obtained by an in situ H plasma clean which has been described elsewhere. The effectiveness of He and Ar ion bombardment on the surface from a plasma to remove hydrogen from the surface was studied at pressures ranging from 50 mTorr to 400 mTorr, excitation power from 6 to 40W, temperatures from 250°C to 410°C and times from 0.5 to 3 minutes. He ions were found to be more effective for this purpose than Ar ions due to their proximity to H mass than Ar. The RHEED pattern was observed for a change from 3x1 to 2x1 pattern indicating a monohydride coverage or a bare surface. It was found that the most efficient parameters for the ion bombardment were 100 mTorr pressure, 30W plasma power, 400°C temperature, for 1-3 minutes. These parameters were then used in the subsequent ALE experiments. The energy of the bombarding He ions is hypothesized to be in the 40-100 eV range. One ALE experiment cycle consisted of bombarding the substrate with He ions from the plasma for 1-3 min. followed by dosing the surface with disilane in a range of partial pressures $(10^{-7} \text{ Torr to } 1.67 \text{ mTorr})$, temperatures $(250^{\circ}\text{C}-400^{\circ}\text{C})$ and times (20°C) sec to 3 min.) without plasma excitation to presumably adsorb Si2H6 on the bare surface Si atoms created by the bombardment as to silyl(SiH3) species in a self-limiting manner which results in a hydrogen terminated surface. The dosing time and pressures were sufficient to ensure saturation dosing ($\sim 10^{6}$ langmuirs). This cycle is then repeated 100 times to get a sufficiently thick film which can be measured with confidence. The maximum growth obtained was 0.44 monolayers per cycle for a 3 minute bombardment cycle. The growth per cycle decreases as the bombardment cycle time is decreased, indicating that the percentage of hydrogen removed decreases with the bombardment time. The maximum growth per cycle observed agrees with the steric hindrance data for disilane and the results obtained by other investigators (Green et al using photo-thermal UV-assisted ALE). To show that this growth was not thermal or due to ion bombardment alone control wafers were run. Just dosing for 100 cycles without the ion bombardment for 100 minutes showed that there is no or negligible thermal growth (< 5 Å) under the conditions. Ion bombardment without any dosing for 3x100=300 minutes also showed negligible growth (< 5 Å).

DIC QUALITY INSPECTED 3

For

Attilty Code Preis and/or Protal

SPAAL

Li idation

245

Distrieution/

AVALLA

A-1

0.0401064