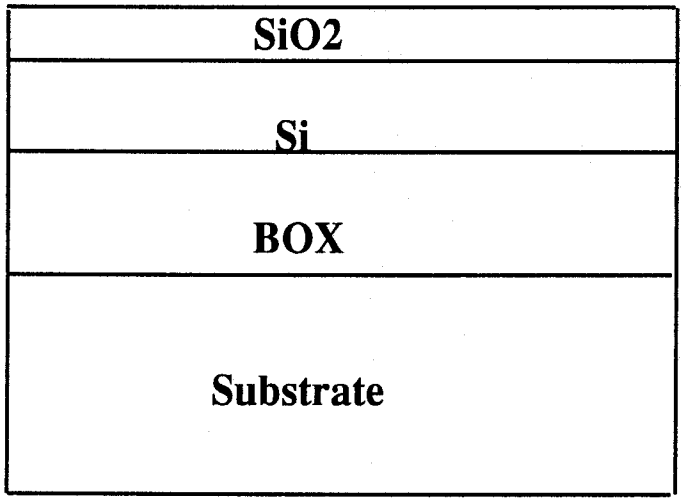
SPECTROSCOPIC ELLIPSOMETRY OF SILICON-ON-INSULATOR MATERIALS

Harold J. Hovel
IBM Corporation
Yorktown Hts, NY

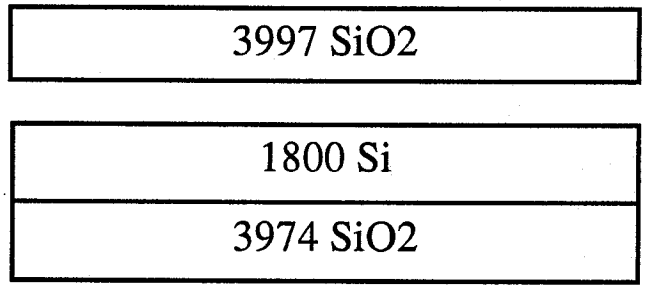
BASIC SOI STRUCTURE



Simple 3 Layer Model

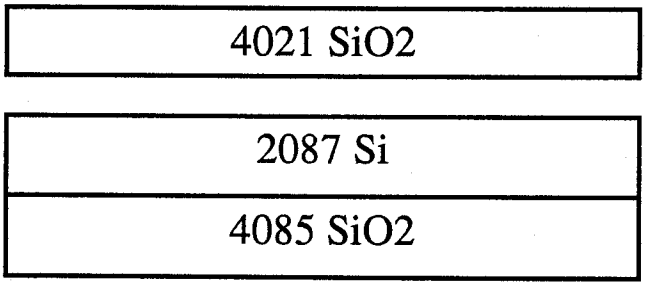
SiO2 / Si / SiO2 / Substrate

BONDED SOI
Thick BOX



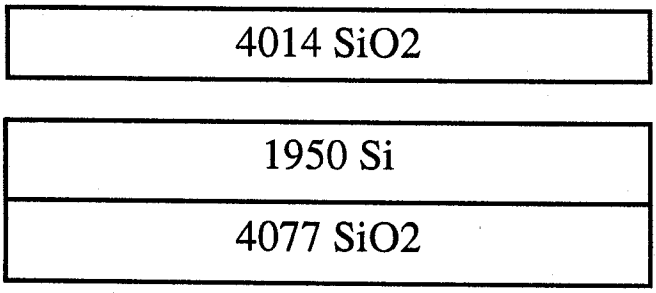
DO127, Si Removed

DO127, Si On.



4282-1826, Si Removed

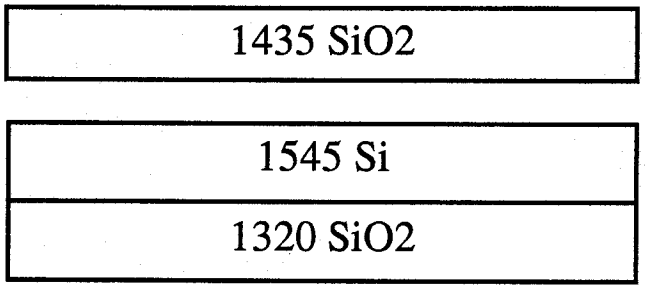
4282-1286, Si On.



U6AZJTG, Si Removed

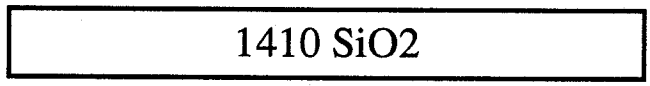
U6AZJTG, Si On.

BONDED SOI
Thin BOX

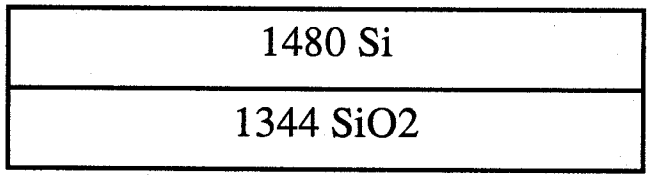


JRD04SY, Si Removed

JRD04SY, Si On.

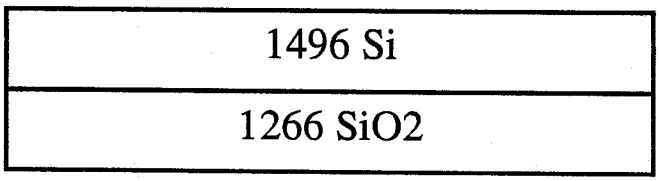


5GU49, Si Removed



5GU49, Si On.

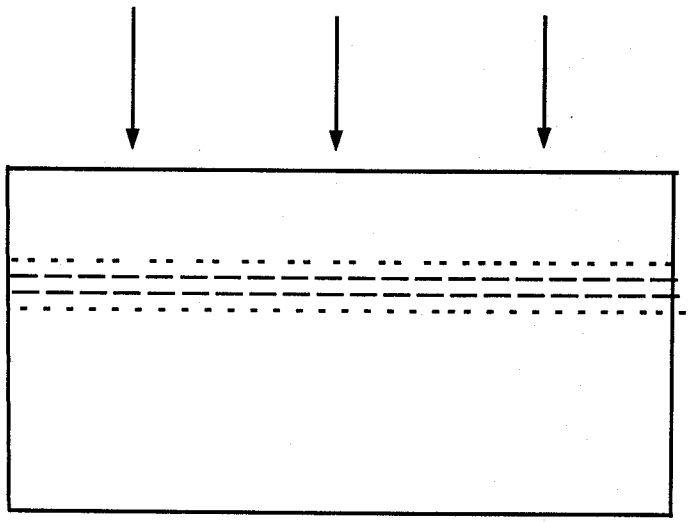
E93, Si Removed



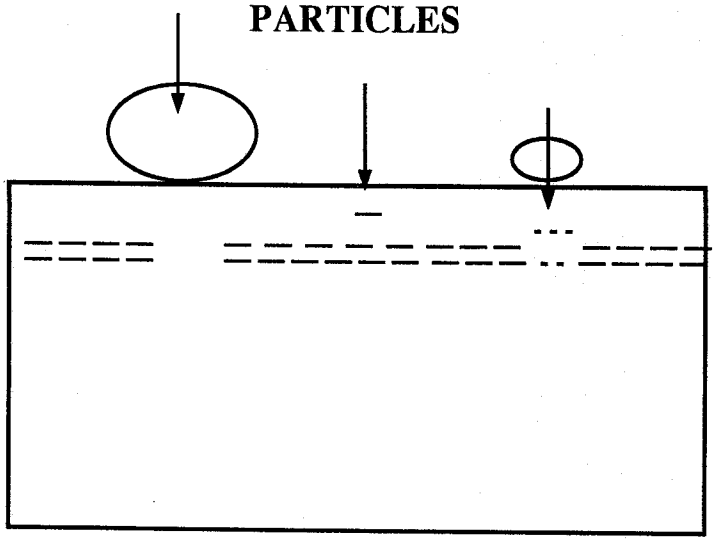
E93, Si On.

SIMOX

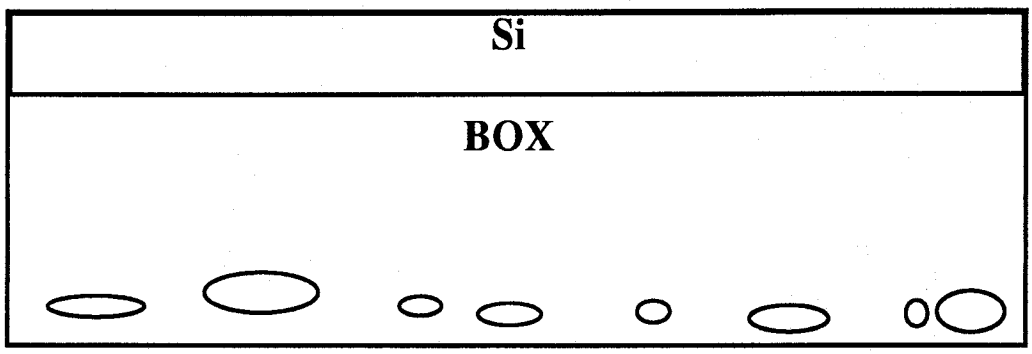
Oxygen Implant



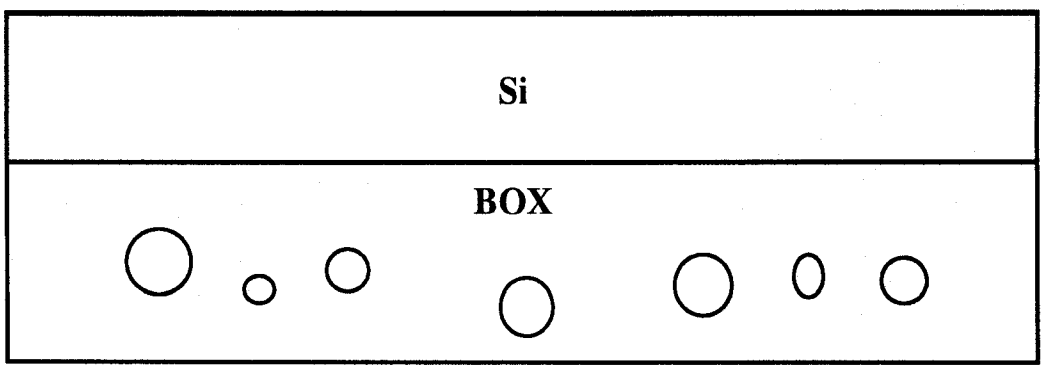
PARTICLES



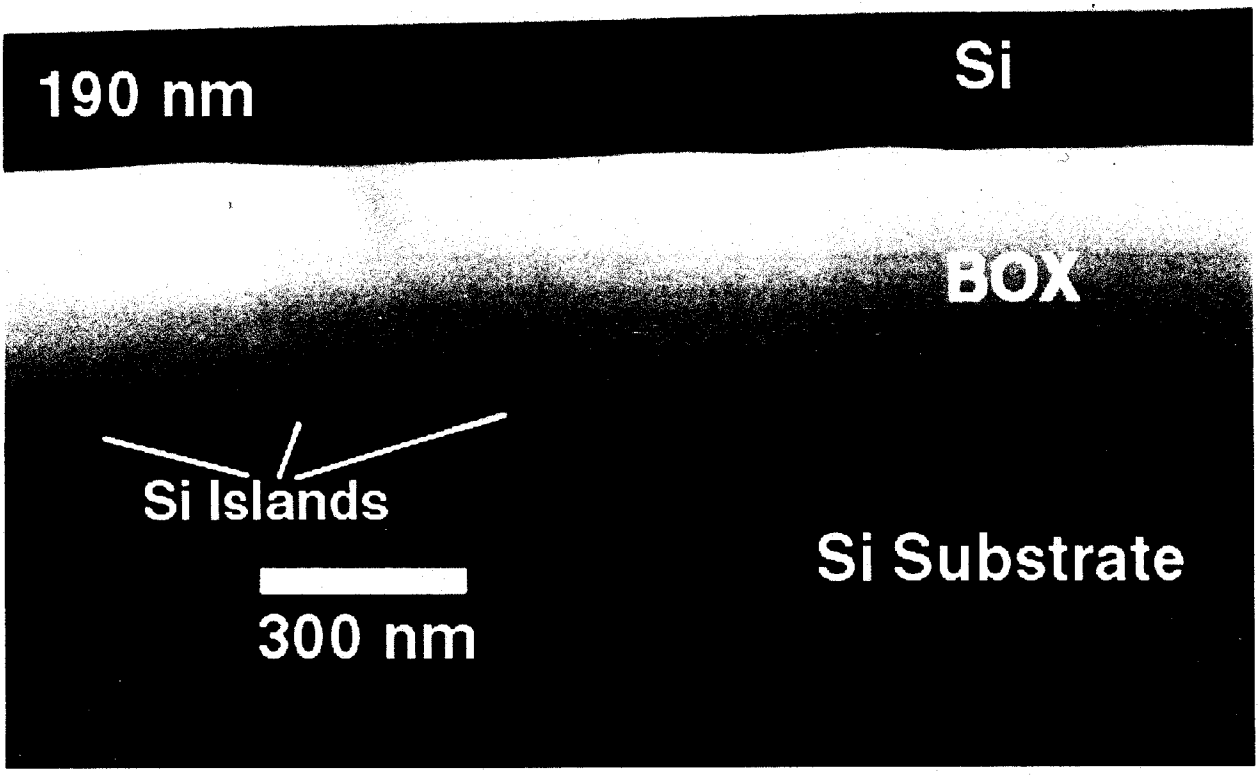
SIMOX



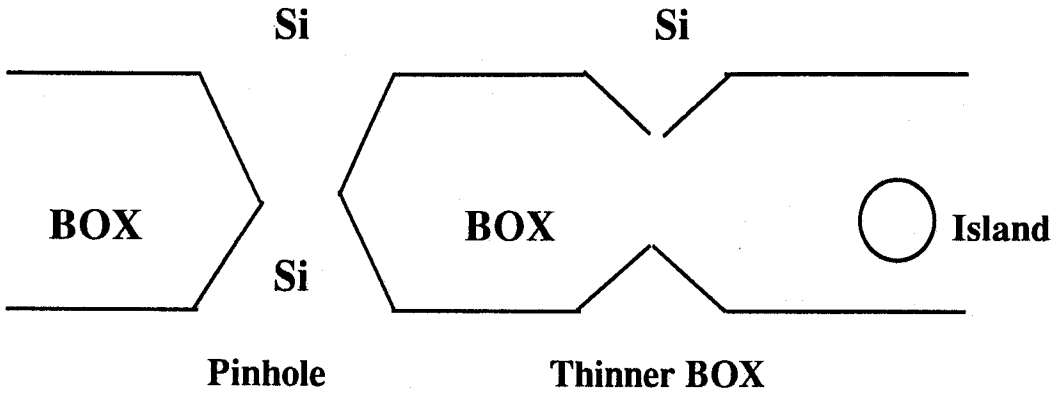
Si Islands In BOX
Standard Dose

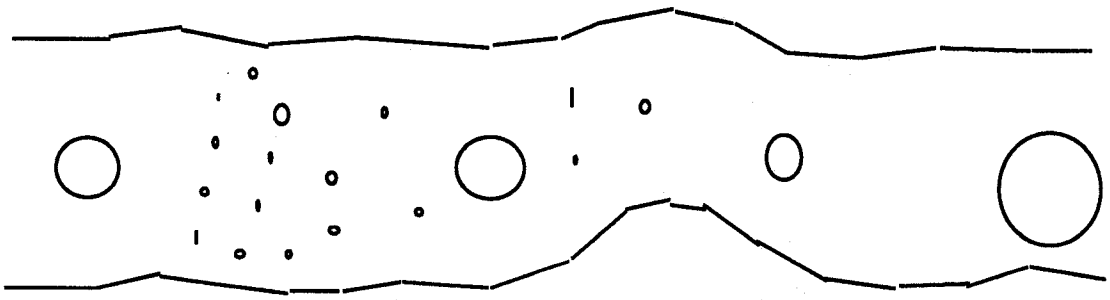


Si Islands in BOX
Low Dose


190 nm
Si
BOX
Si Islands
Si Substrate
300 nm


1 micron
A. Domenicucci

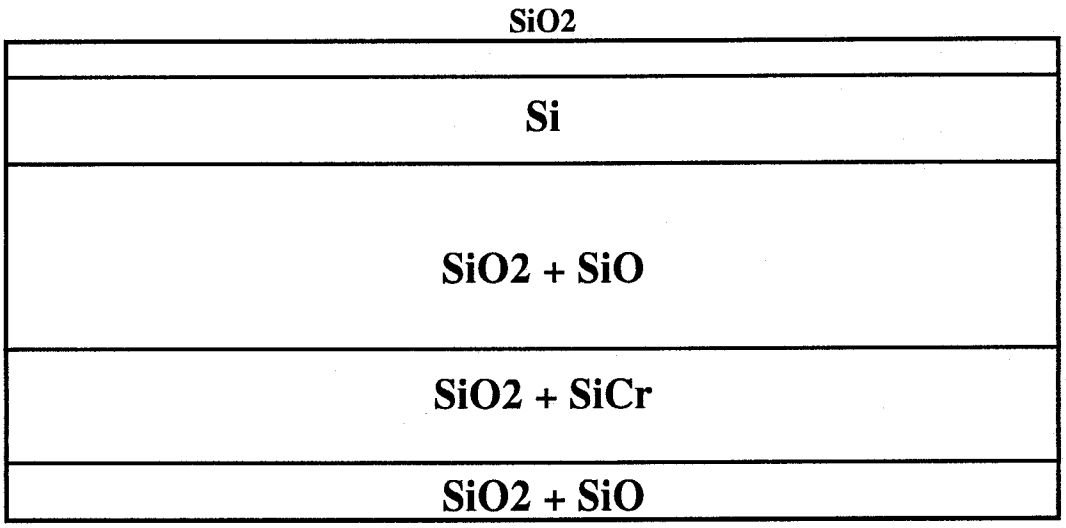




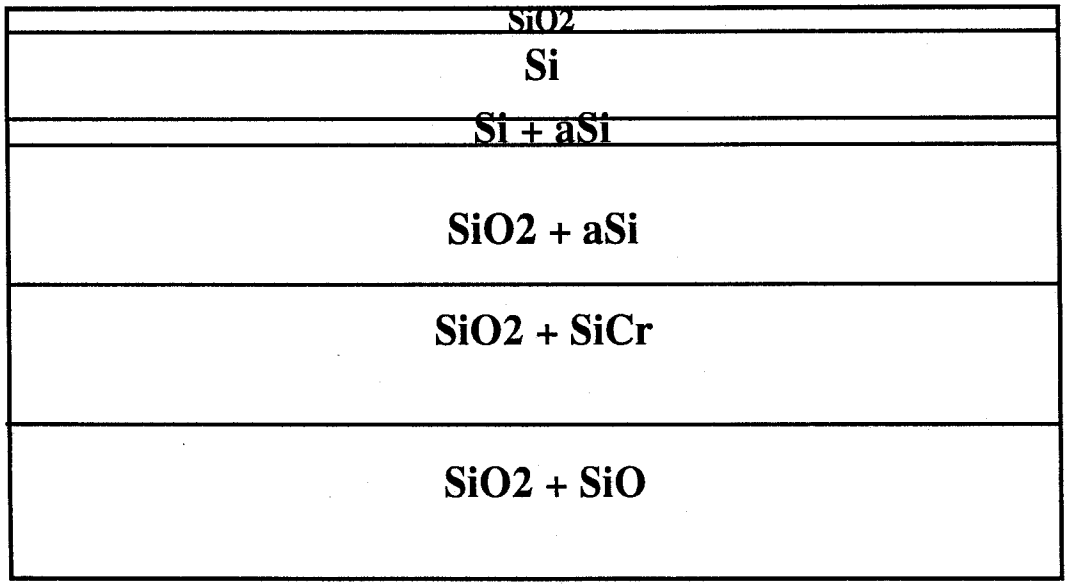
SIMOX BOX Abberations.

Pinholes
Thinner Regions
Rough Interfaces
Amorphous Si Clusters - Si Richness

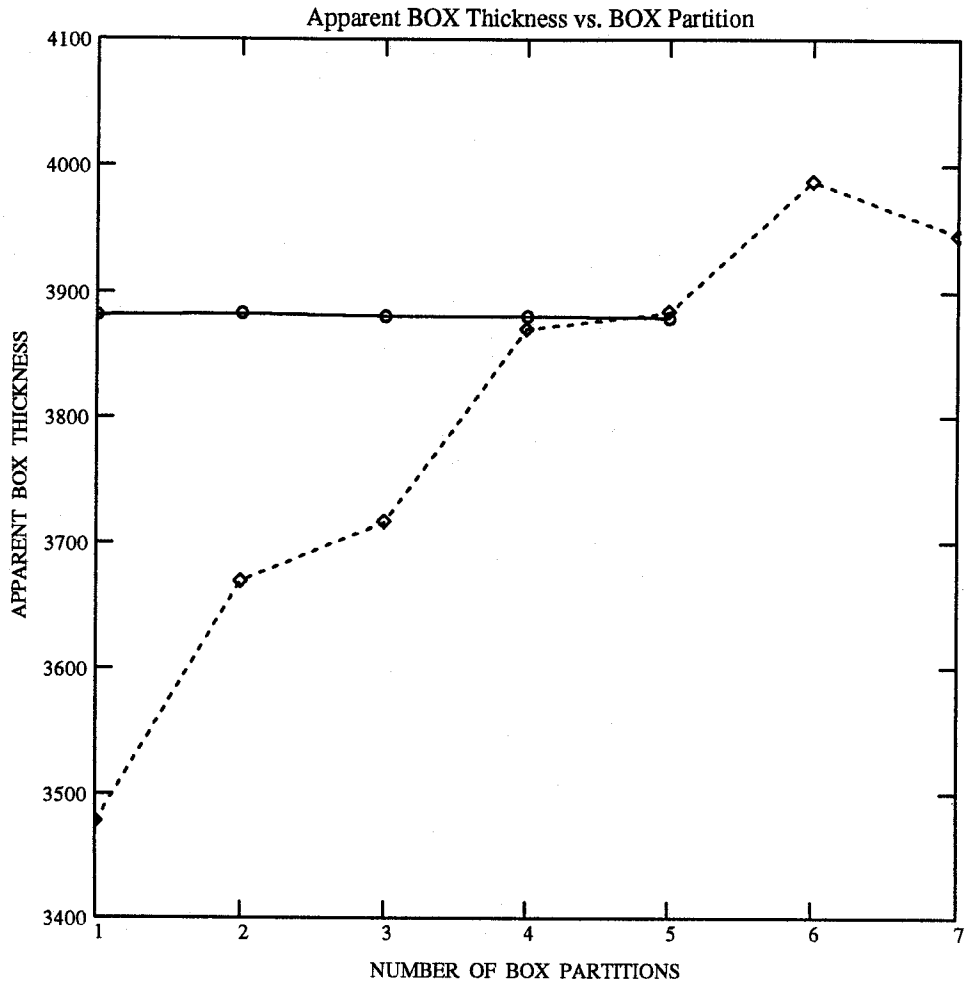
SIMOX MODELS



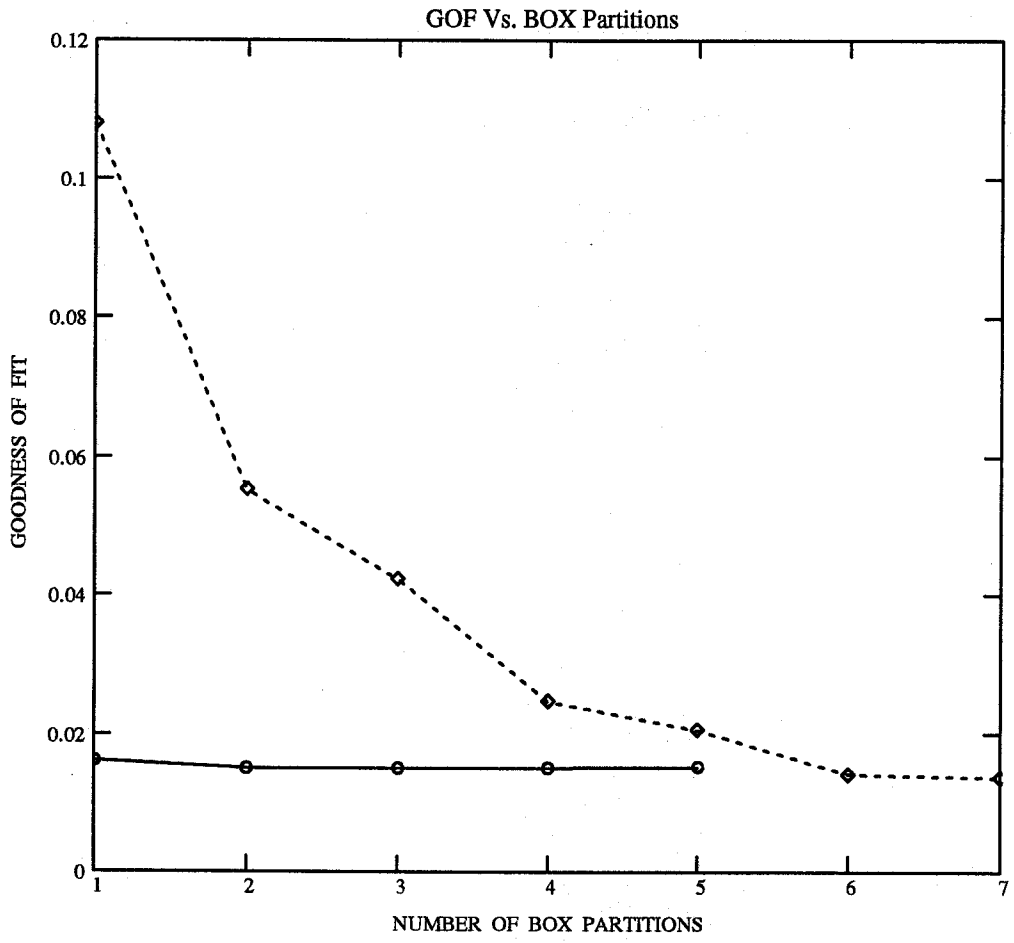
Standard Dose SIMOX



Low Dose SIMOX



BOX Thicknesses from Regressions After Partitioning the BOX into the Number of Layers Shown on the X Axis. Bonded SOI (solid line) and SIMOX (dotted line).



Goodness of Fit from Regressions After Partitioning the BOX into the Number of Layers Shown on the X Axis. Bonded SOI (solid line) and SIMOX (dotted line).

Standard Dose SIMOX: BOX ONLY

3656 SiO2 + .11 SiO

1 Layer. σ = .108

3621 SiO2 + .045 aSi
212 SiO2 + .58 cSi

2 Layer. σ = .054
BOX = 3832

3630 SiO2 + .042 aSi
197 SiO2 + .57 cSi
54 SiO2 - .61 SiO

3 Layer. σ = .0399
BOX = 3881

3353SiO2 + .013 aSi
484 SiO2 + .132 aSi
59 SiO2 + .92 cSi
114 SiO2

4 Layer. σ = .021
BOX = 4010

3117 SiO2 + .01 aSi
568 SiO2 + .068 aSi
189 SiO2 + .27 cSi
19 SiO2 + 1 cSi
127 SiO2 - .04 SiO

5 Layer. σ = .019
BOX = 4020

Comparison of Models for BOX Determination.
IBM 149; M503P5Y

Standard Dose SIMOX: Full SOI.

1812 Si
3433 SiO2 + .17 SiO

σ = .027
BOX = 3433

1807 Si
3537 SiO2 + .085 SiO
287 SiO2 + .59 aSi

σ = .019
BOX = 3823

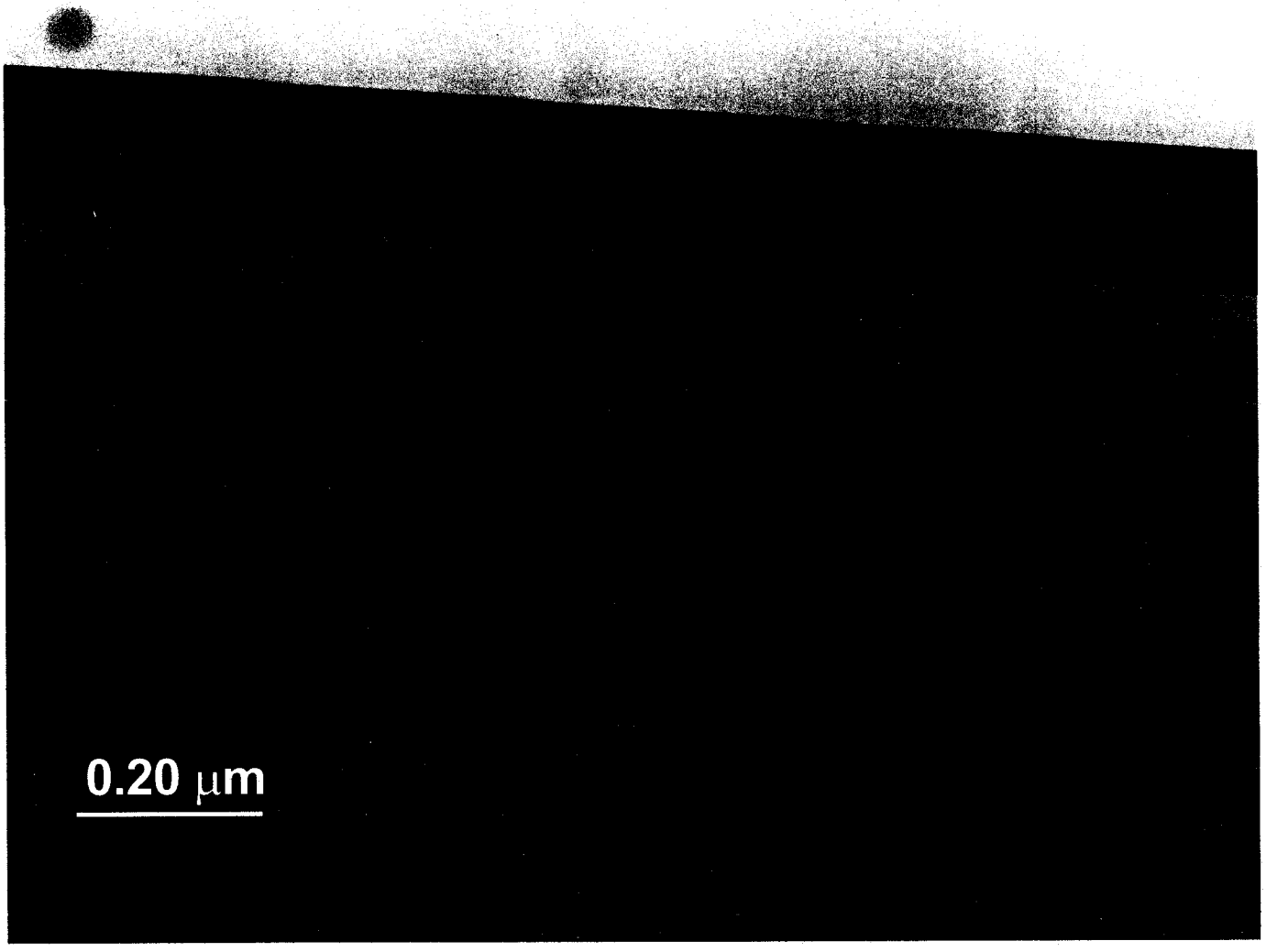
1818 Si
3730 SiO2 - .037 aSi
392 SiO2 + .33 cSi
114 SiO2 - .44 SiO

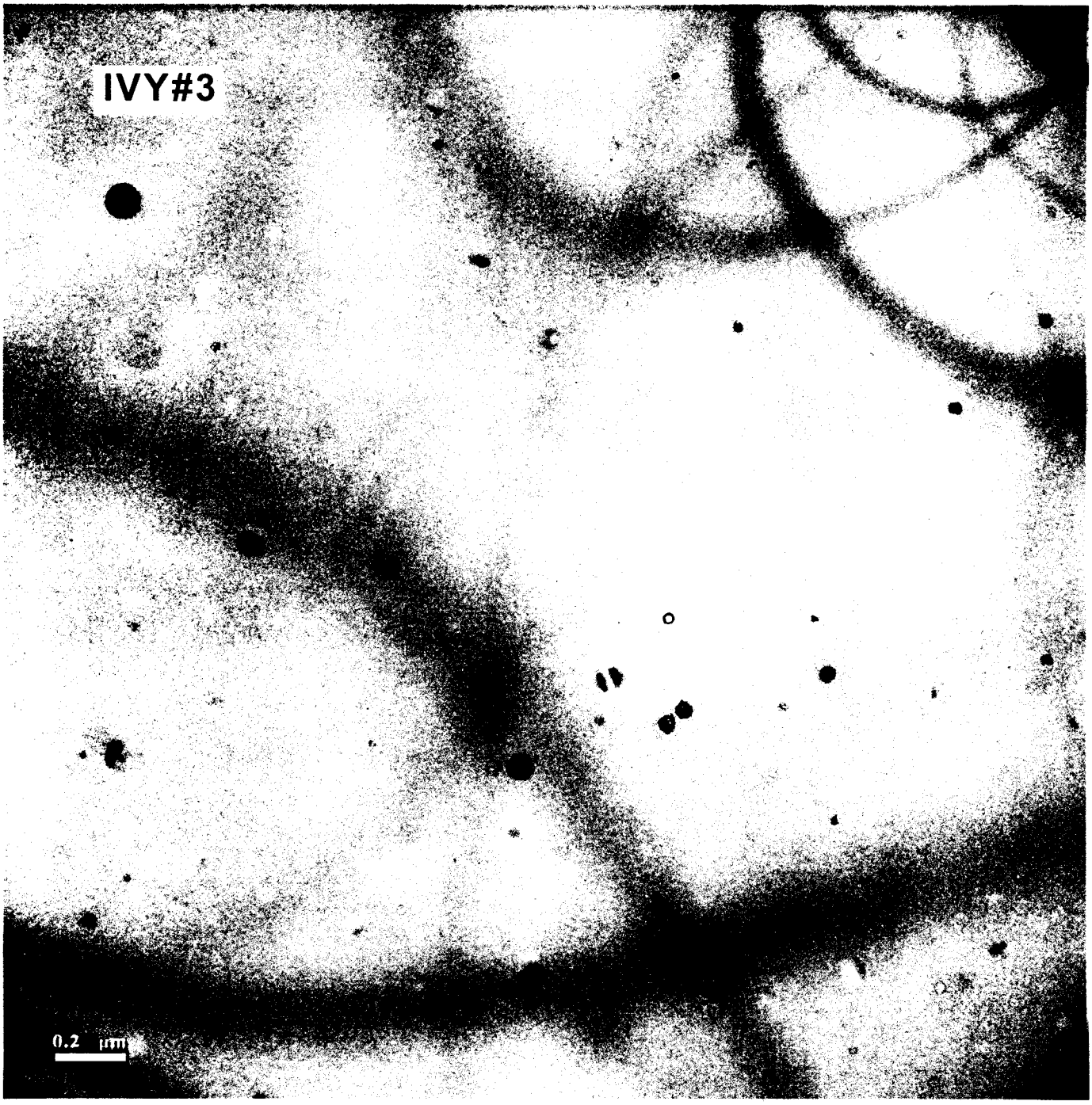
σ = .013
BOX = 4236

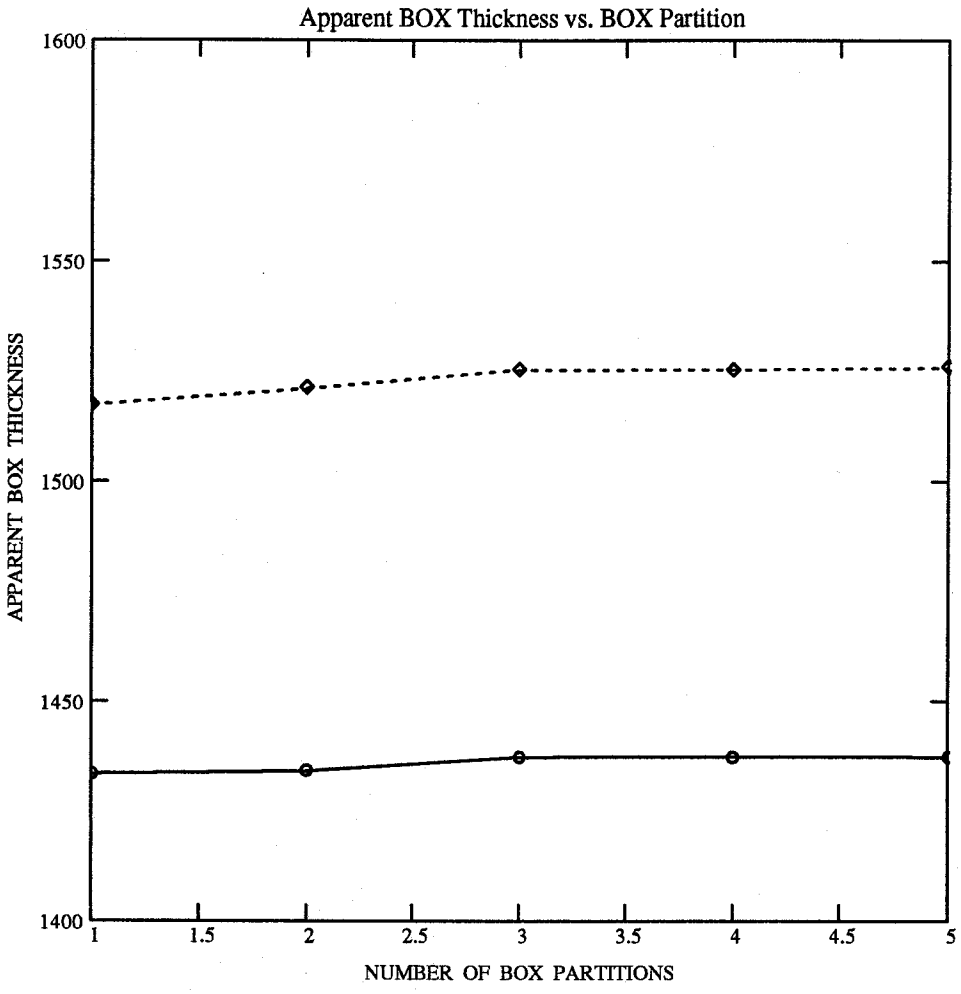
1818 Si
3532 SiO2 + .01 aSi
308 SiO2 + .31 cSi
68 SiO2 + .47 cSi
98 SiO2 - .48 SiO

σ = .01935
BOX = 4006

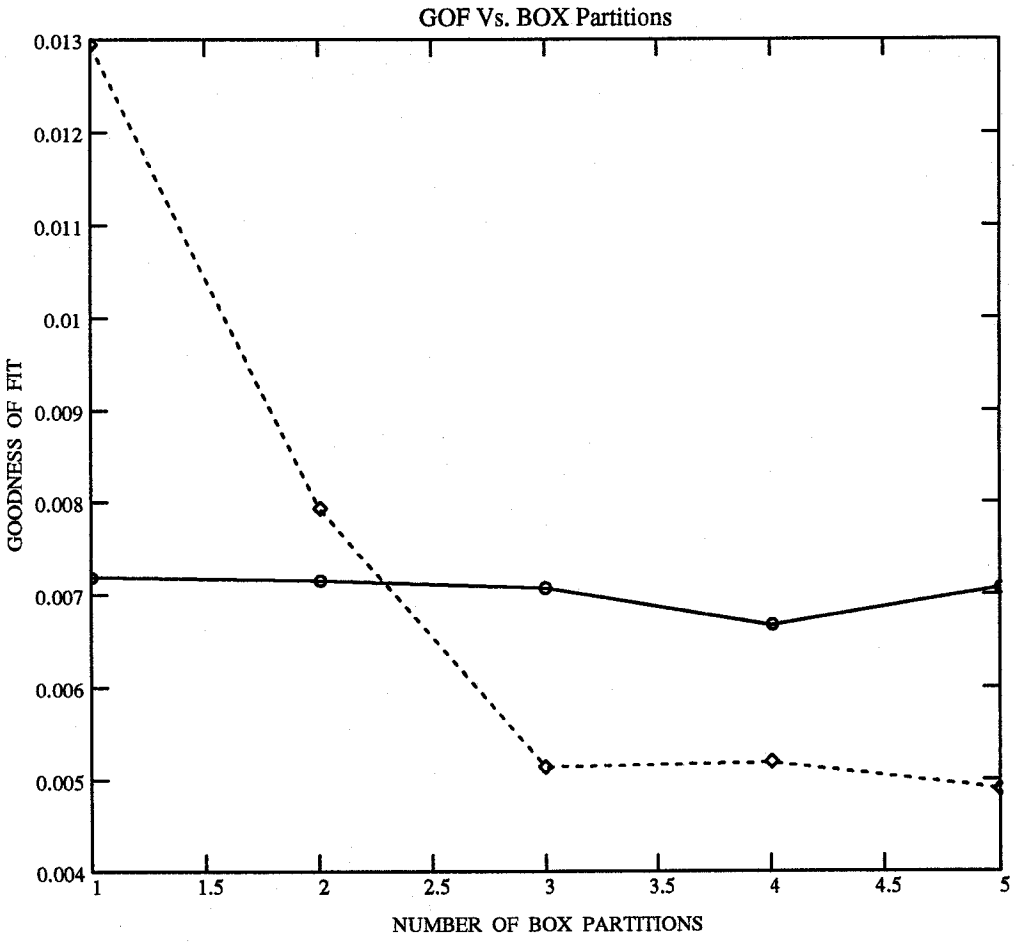
Comparison of Models for Si and BOX Determination.
IBM 149; M503P5Y


0.20 μm


IVY#3
0.2 μm



BOX Thicknesses from Regressions After Partitioning the BOX into the Number of Layers Shown on the X Axis. Bonded SOI (solid line) and SIMOX (dotted line).



Goodness of Fit from Regressions After Partitioning the BOX into the Number of Layers Shown on the X Axis. Bonded SOI (solid line) and SIMOX (dotted line).

Low Dose SIMOX: BOX ONLY.

1517 SiO2 + .017 cSi

1 Layer. σ = .0129
BOX = 1517

771 SiO2 + .016 aSi
750 SiO2 + .013 cSi

2 Layers. σ = .0079
BOX = 1521

613 SiO2 + .0066 aSi
30 SiO2 + .217 cSi
882 SiO2 + .011 SiO

3 Layers. σ = .00513
BOX = 1525

613 SiO2 + .0068 aSi
5 SiO2 + .0006 cSi
30 SiO2 + .21 cSi
877 SiO2 + .011 SiO

4 Layers. σ = .00518
BOX = 1525

615 SiO2 + .0084 aSi
4 SiO2 - .87 aSi
56 SiO2 + .098 cSi
5 SiO2 + .34 cSi
845 SiO2 + .012 SiO

5 Layers. σ = .00489
BOX = 1526

Comparison of Models for Si and BOX Determination.
Low Dose ,5E17, MR13QIY

LOW DOSE SIMOX: Full SOI. (BOX = 1526 Angs.)

12 SiO2
1540 Si
1438 SiO2

1 Layer BOX .
BOX = 1438
σ = .0151

9 SiO2
1562 Si
1005 SiO2 + .017 aSi
353 SiO2 + .17 cSi

2 Layer BOX.
BOX = 1357
Si = 1562
σ = .0105

9 SiO2
1561 Si
1040 SiO2 + .014 aSi
310 SiO2 + .19 cSi
7 SiO2 + .24 SiO

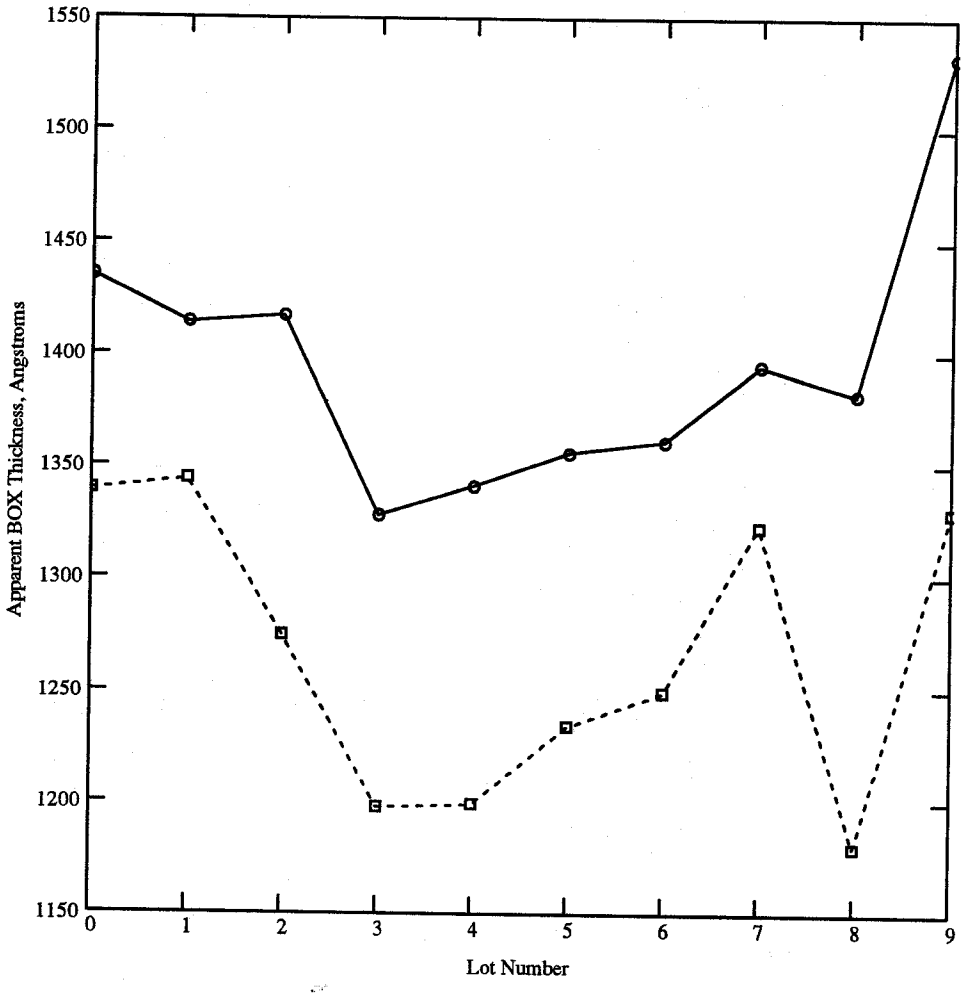
3 Layer BOX.
BOX = 1357
Si = 1561
σ = .0106

9 SiO2
1562 Si
1000 SiO2 + .014 aSi
16 SiO2 + .14 cSi
310 SiO2 + .18 cSi
35 SiO2 + .13 SiO

4 Layer BOX.
BOX = 1361
Si = 1562
σ = .0105

Comparison of Models for Low Dose SIMOX. MR13QIY

Difference Between Buried Oxide Measured with the Si Layer Intact or Removed.



SUMMARY

1. **Bonded SOI: No BOX Partitioning is Needed.**

2. **For SIMOX, accurate BOX measurements require partitioning the BOX into 3 sections (thin BOX material) or 4 sections (thick BOX material).**

3. **The need for BOX partitioning is a result of non-uniformities, especially Si islands, in the SIMOX buried oxide.**

4. **For thick BOX structures, bonded and SIMOX, the error in measuring the BOX thickness with the Si intact is small.**

5. **For thin BOX structures, bonded and SIMOX, there is considerable error in measuring the BOX with the Si layer in place.**