MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

LAB REPORT

Oxidation(TCAD)

Work objectives

The objective of this laboratory work is to use the *Athena* semiconductor process simulator to study the concept of the thermal oxidation and to investigate how the variation of different factors on thermal oxidation affects the silicon dioxide (SiO_2) thickness.

Amit Sarkar

Date:05-07-2021 **Signature of the Student**

Signature of the Lab Instructor

Date	Topic discussed	Remarks	Signature of supervisor
04/07/2021	EXPERIMENT 1.		
04/07/2021	EXPERIMENT 2		

EXPERIMENT 1: This experiment demonstrates ability to perform oxidation in mixed gas ambients. The gas flows can be specified in relative units for each flow of oxygen, water, hydrogen, and nitrogen by the parameters F.O2, F.H2O, F.H2, and F.N2 on the DIFFUSE statement.Here we vary flow rate of oxygen, tempreture and time and observe the thickness of SiO_2 .

SOFTWARE USED: Silvaco S.EDA tools

THEORY:

Thermal silicon dioxide serves a number of important functions in IC fabrication and performance: the isolation of devices in the circuit or isolation different areas in the same device; the mask to prevent thermal diffusion or ion implantation of dopants into silicon; the pad layer under Si_3N_4 for LOCOS process and the gate oxide in MOS structures. So, thickness of thermal SiO_2 used from 1–2 nm upto 1–2 µm. The formation of SiO_2 on a silicon surface is accomplished through the process called the *thermal oxidation*, whichis a technique that uses high temperatures, usually between 700 to 1300 °C, to promote the growth rate of oxide layers. During the thermal oxidation process, the silicon wafer is exposed to a high purity oxidizing species like oxygen gas (*dry oxidation*) or water vapour (*wet oxidation*). For *thin* oxides with low charge density at interface, the oxides are grown in *dry* oxygen. This is also called the *dry oxidation* explained by the reaction given below:

$$Si + O_2 \rightarrow SiO_2.$$

For *thick* layers of oxides, water vapour is used at high pres- sure for oxidation. The chemical reaction for *wet oxidation* is as follows:

$$Si + 2H_2O \rightarrow SiO_2 + 2H_2.$$

Thermal oxidation is well understood, and can be accurately modelled. Now many of the models have been implemented in thermal oxidation process simulation programs. The first general models dale back to the work of Deal and Grove in the early 1960s.This work resulted in *the linear parabolic model* that is still used today to model the planar oxidation of silicon. The Deal–Grove model is the default model for *wet oxidation*, and for *thick* oxides ingeneral

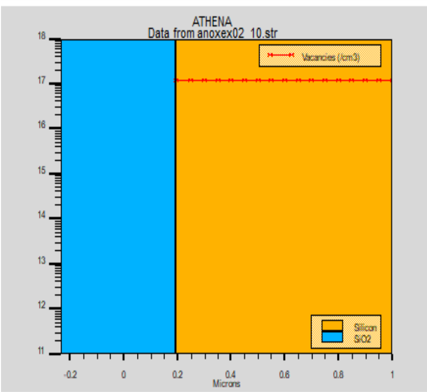
It is not, however, applicable to *thin dry* oxides. A power-law model from Nicollian and Reisman can be used for this regime .

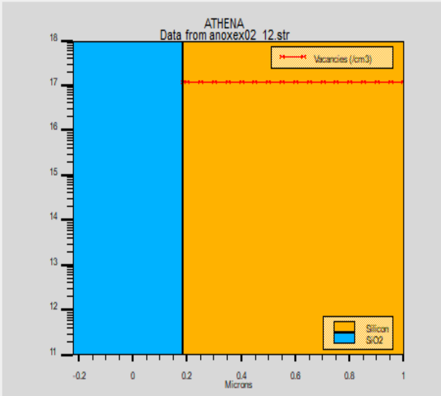
The speed of growth layers in the thermal oxidation processes depends on the *oxidation time, oxidation temperature,* or *oxidation pressure*.

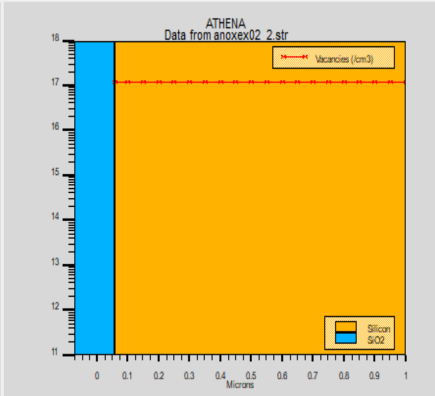
Observation:

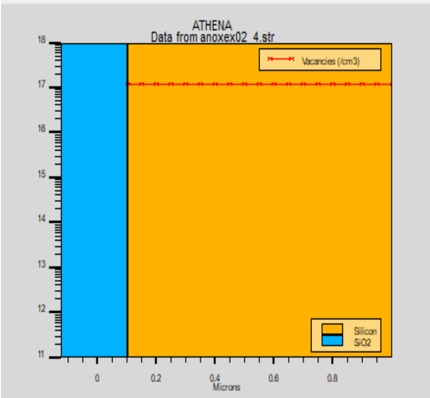
Mixed Ambient Oxidation at different flow rate and constant temp and time

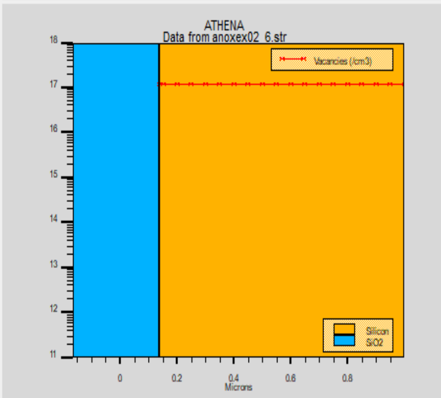
Temp=1000 C and time= 60sec Flow rate varied from 2 to 12

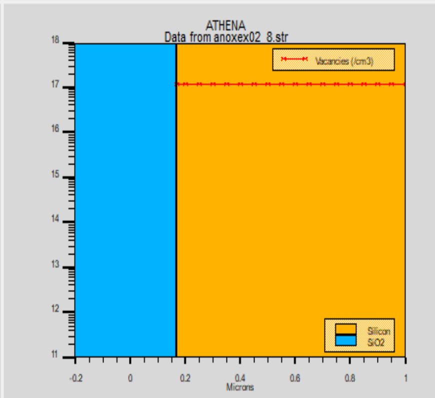












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Mixed Ambient Oxidation at different temp and constant flow rate and time

time= 60sec  Flow rate= 6 temp varied from 900 C to 1200 C
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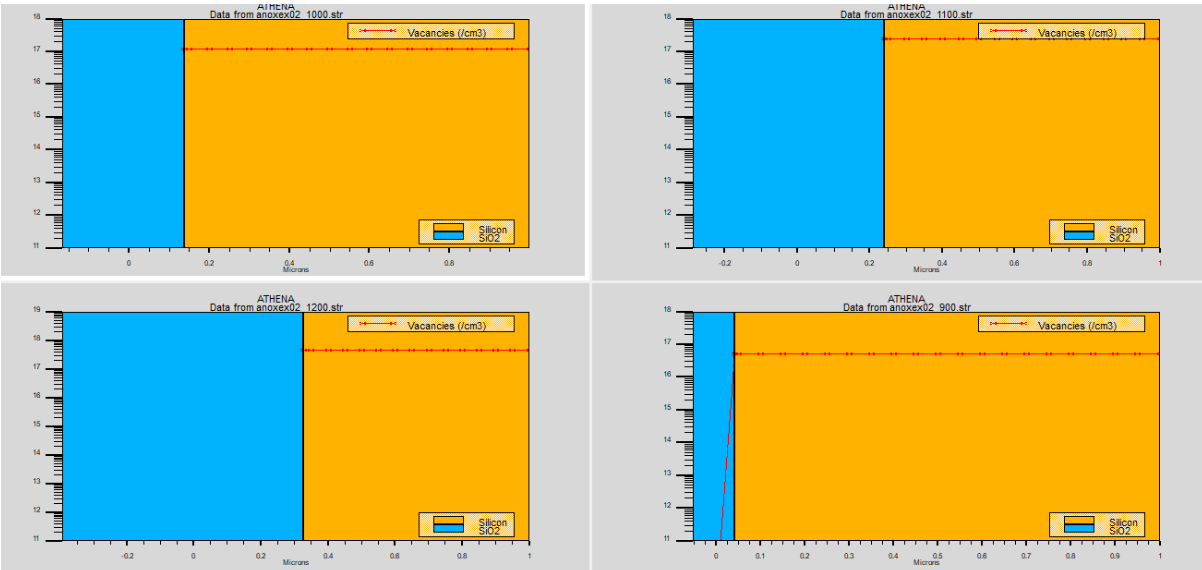
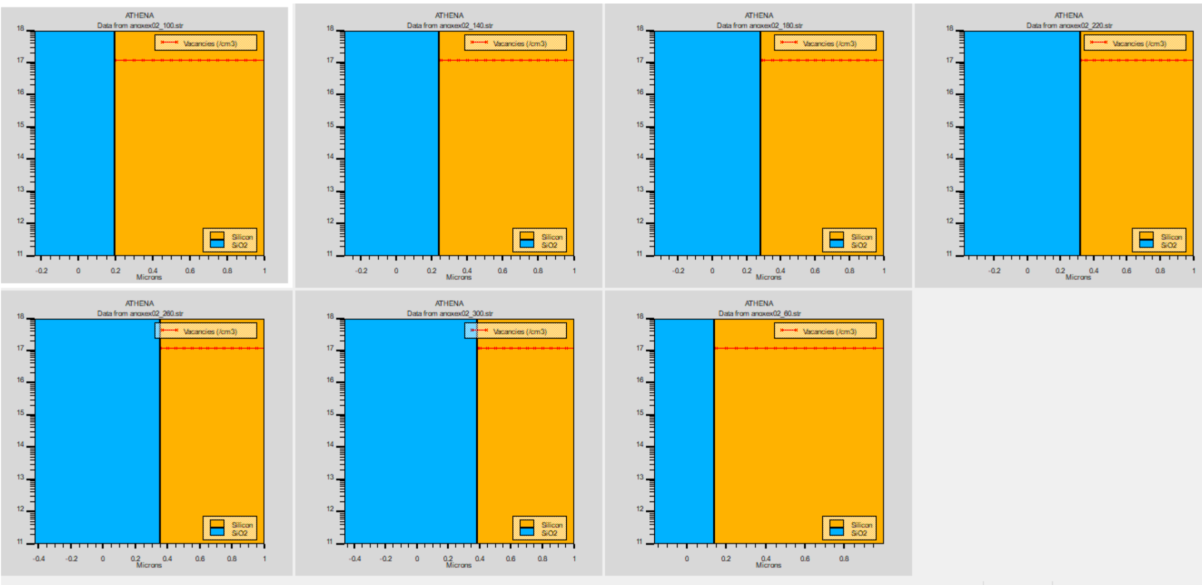


Mixed Ambient Oxidation at different time and constant flow rate and tempreture

Flow rate= 6 tempreture=1000 time varied from 60 to 300 sec



Conclusion: As oxygen flow rate increases SiO_2 thickness increases. As oxygen flow rate decreases SiO_2 thickness decreases. As we increase the tempreture SiO_2 thickness increases. As we increase the time SiO_2 thickness increases.

EXPERIMENT 2: This experiment shows the effect of dopant and variation in energy of implantation and concentration of doping in silicon on oxidation rate.

SOFTWARE USED: Silvaco S.EDA tools

THEORY: The speed of growth layers in the thermal oxidation processes depends on the *oxidation time, oxidation temperature,* or *oxidation pressure*. The *thermal oxidation* is a slow process: 2 h of the dry oxidation at 1000 ˚C produces SiO_2 about 70 nm thick and 2 h of the *wet oxidation* about 600 nm.The linear parabolic model predicts that the oxide growth rate should be directly propor-tional to oxidant pressure.

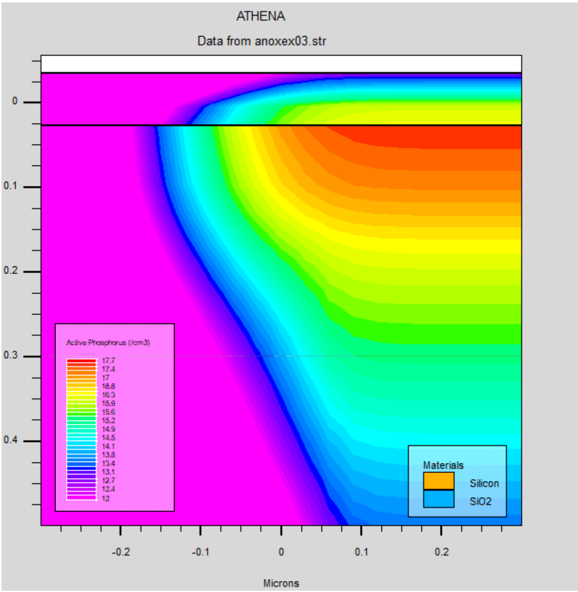
Other factors that affect the thermal oxidation growth rate for SiO_2 include: the *crystallographic orientation* and *doping level* of the silicon wafer; *the percent of hydrochloric acid* (HCl) or *chlorine*(Cl_2). HCl or Cl_2 is often used in the thermal oxidation in order to prevent metallic contamination and to help avoiding defects in the oxidation layer.

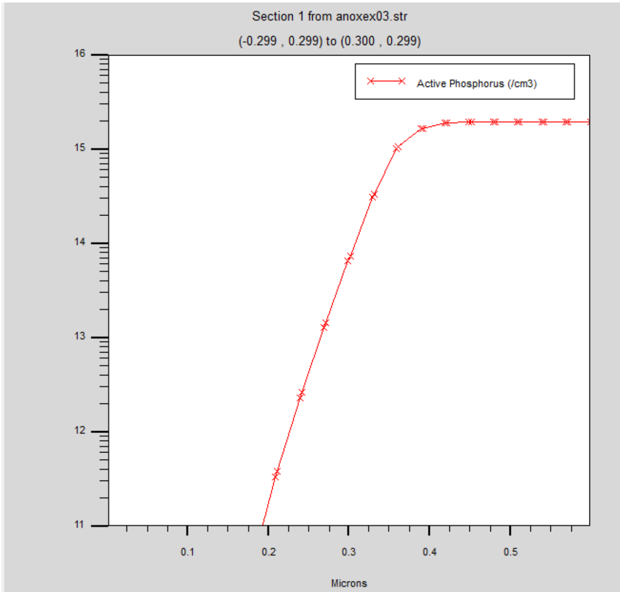
Highly doped substrates oxidize *more rapidly* than do *lightly doped* wafers. The effect is particularly important at lower tempera tures and for thinner oxides: the difference in oxidation rates between heavily doped and lightly doped regions can be three to four times. The difference is more pronounced for n^+ regions than for p^+regions and is more pronounced for low-temperature compared to high-temperature oxidations.

The *crystallographic orientation*: oxidation rates in H_2O are faster on (111) surfaces than on (100) surfaces. The (110) rate be- comes fastest for very thin oxides grown at very low pressures in dry O_2 and at very high pressures and low temperatures in H_2O.

Shaped silicon structures oxidize differently than simple flat surfaces.

OBSERVATION:



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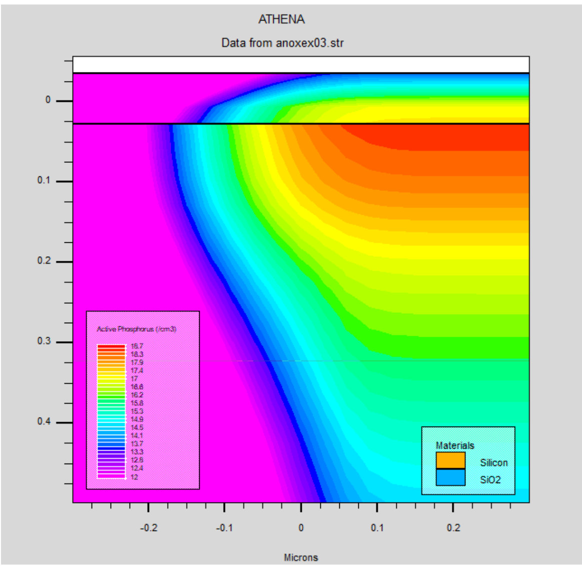

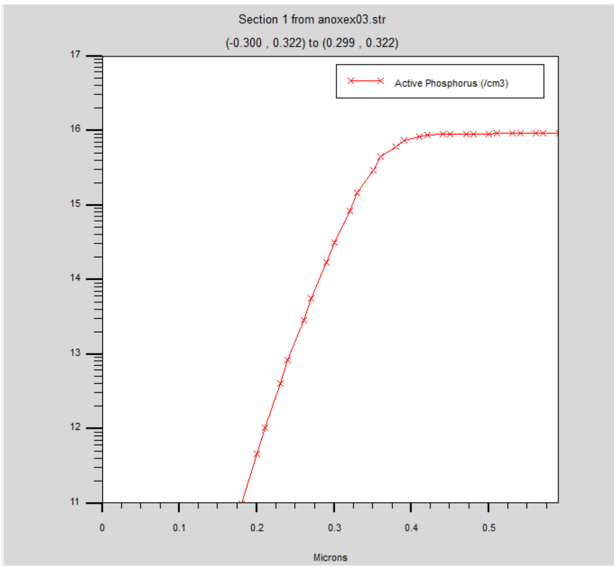


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toxhigh=635.293 angstroms (0.0635293 um)  X.val=0.25
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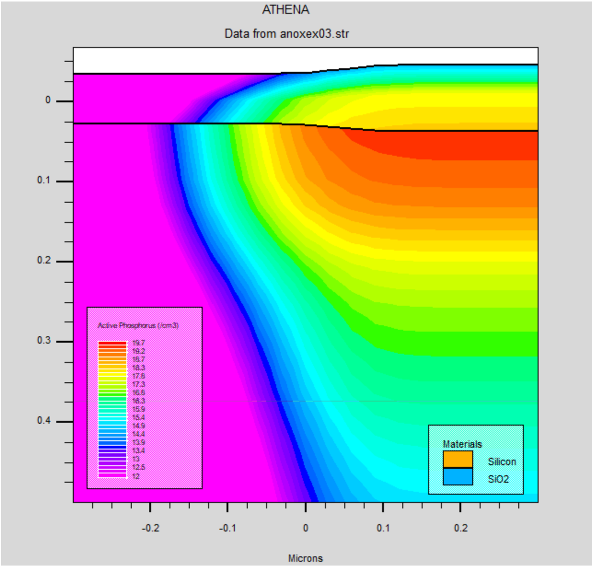
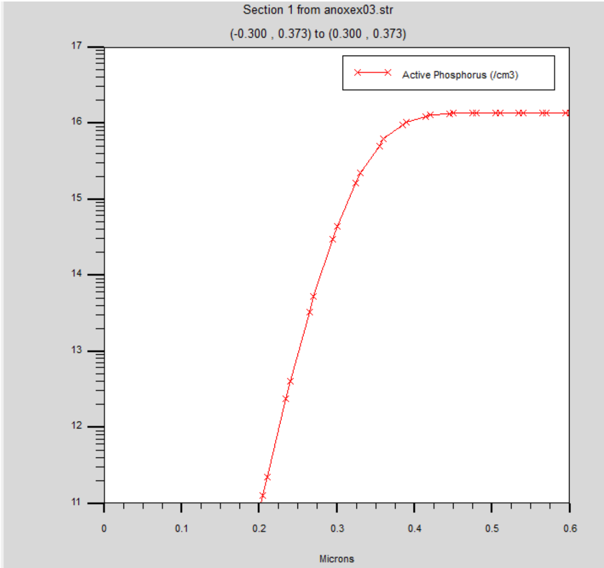
Main Campus: Haringhata, Nadia, PIN:741249



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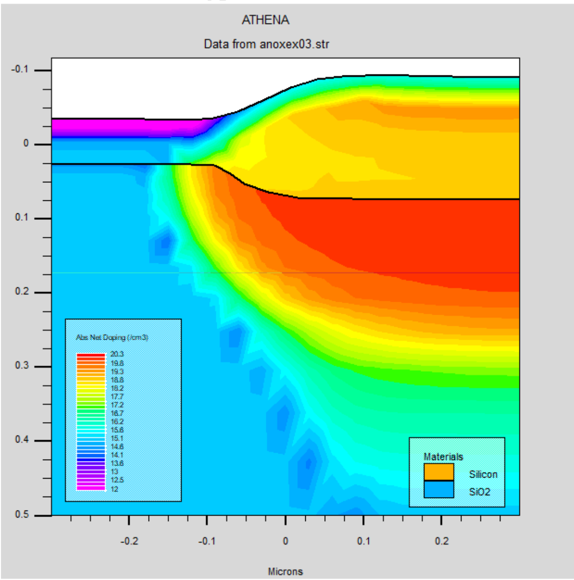

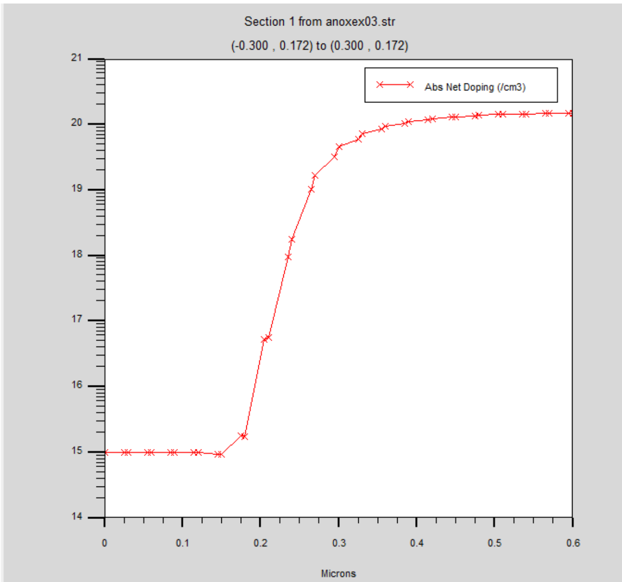


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toxhigh=1658.87 angstroms (0.165887 um)  X.val=0.25
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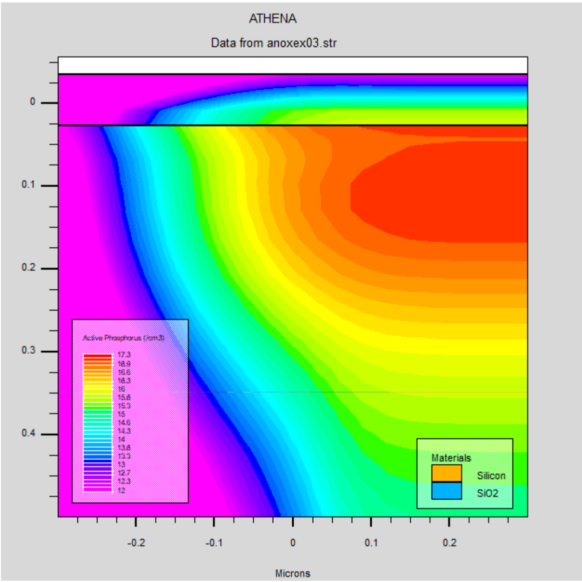

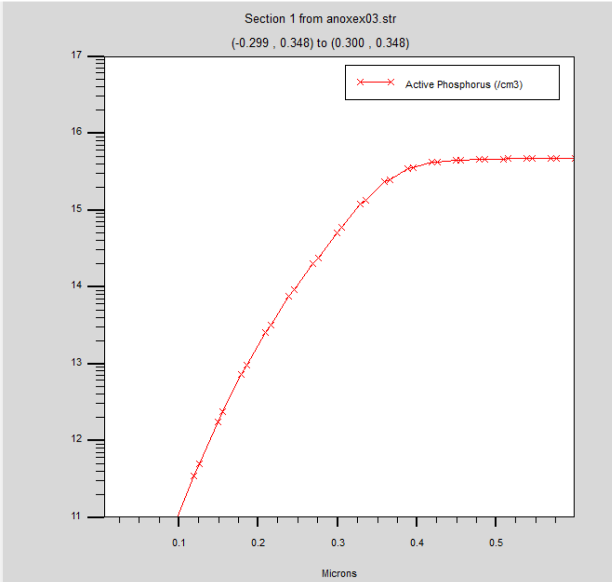


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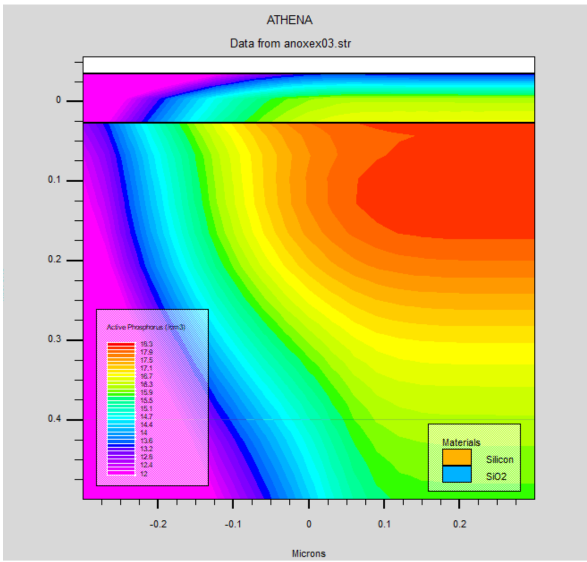

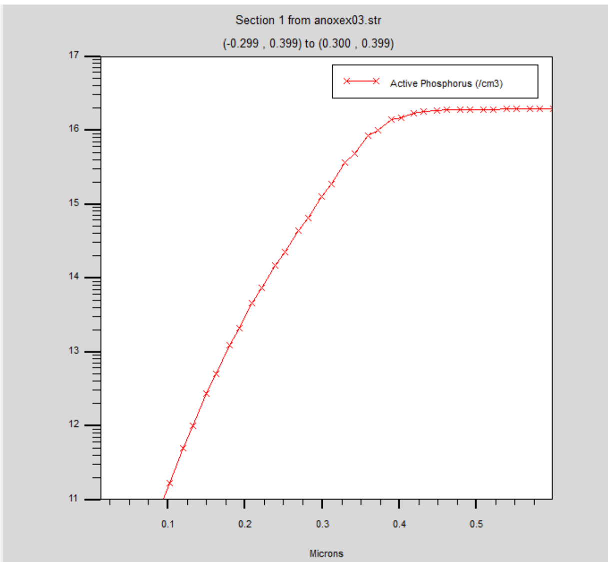


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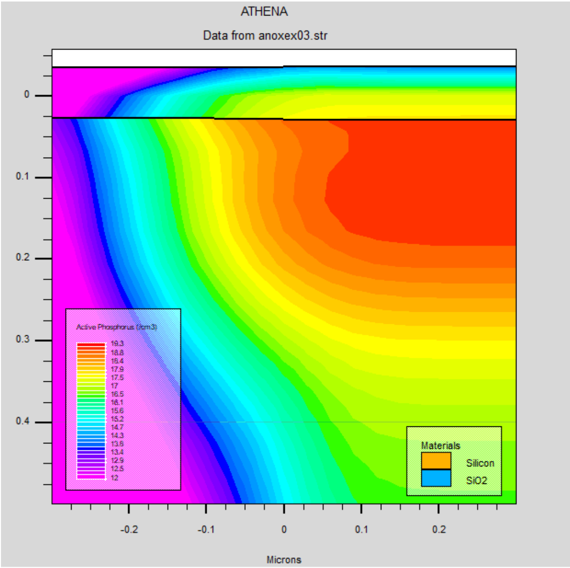

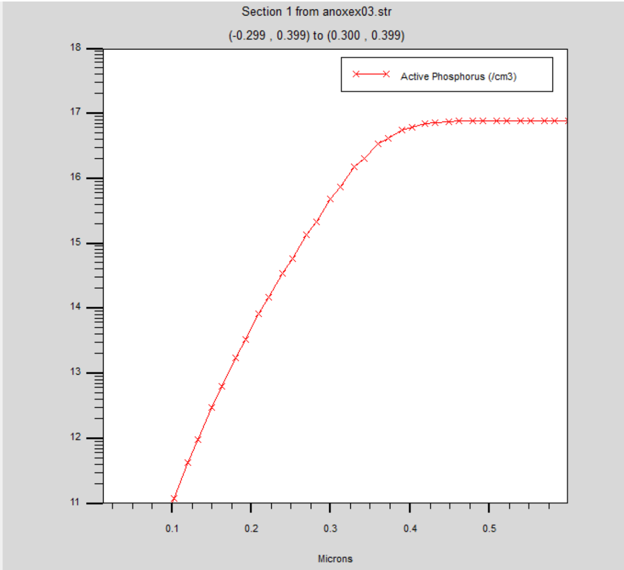


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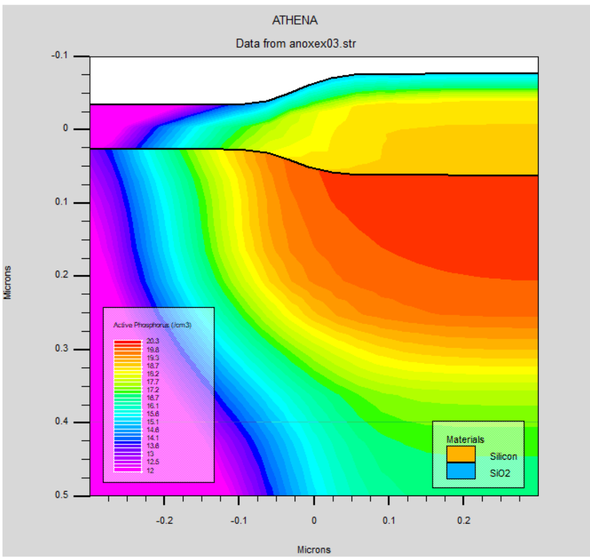

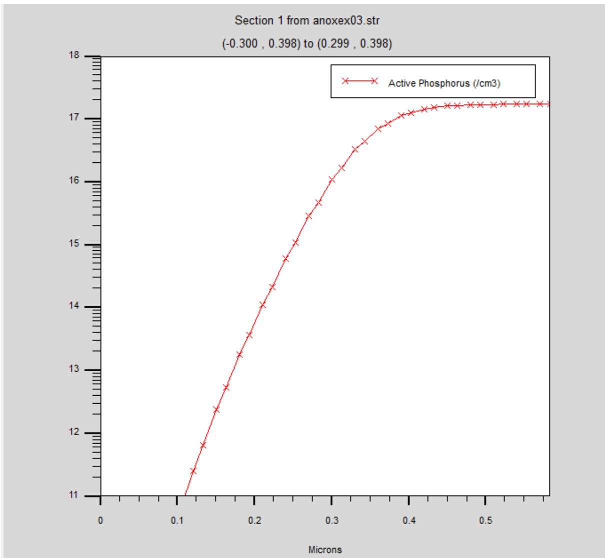


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3e15 energy=100
```

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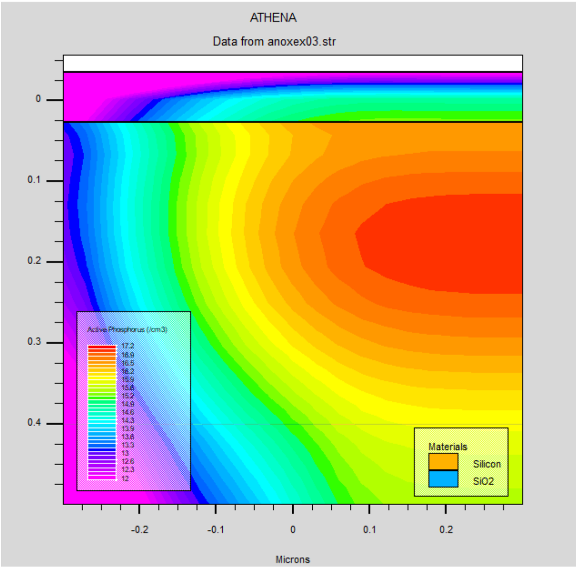

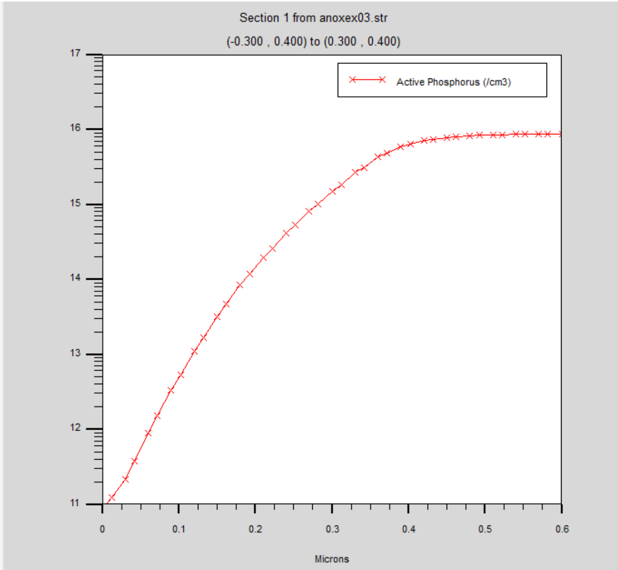


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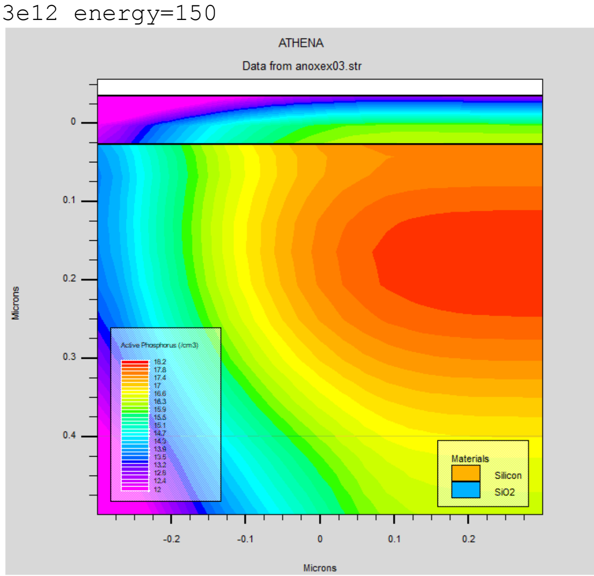

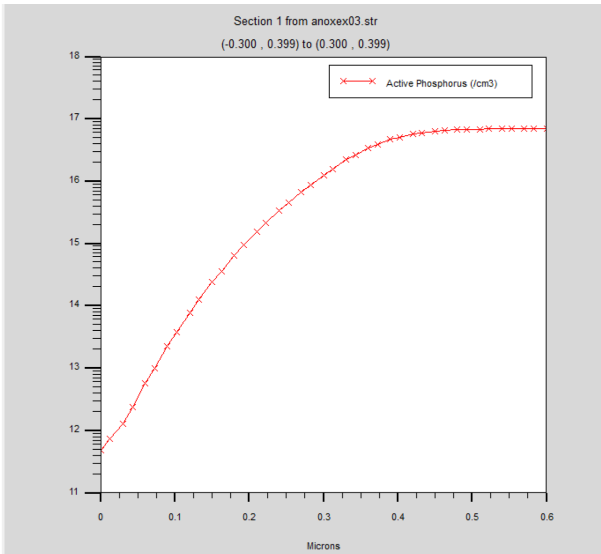


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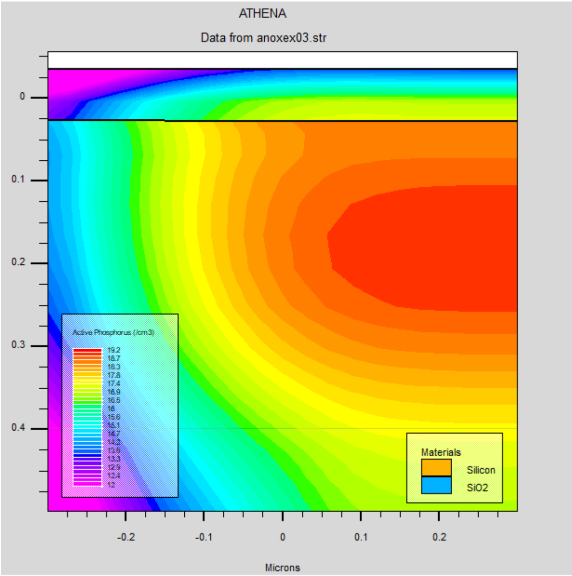

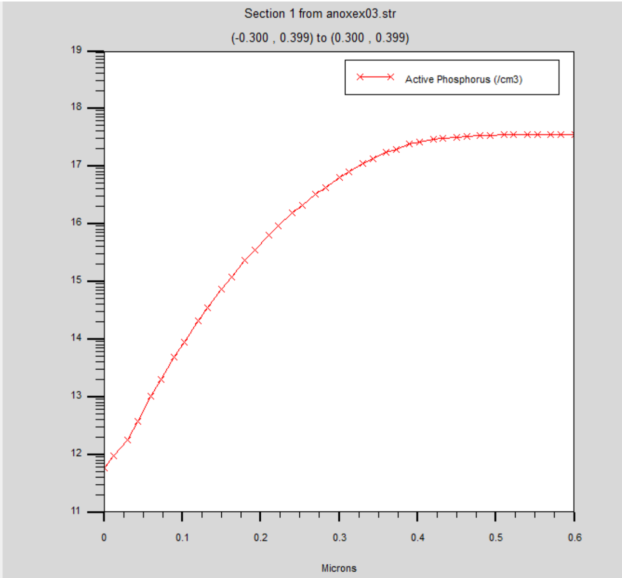

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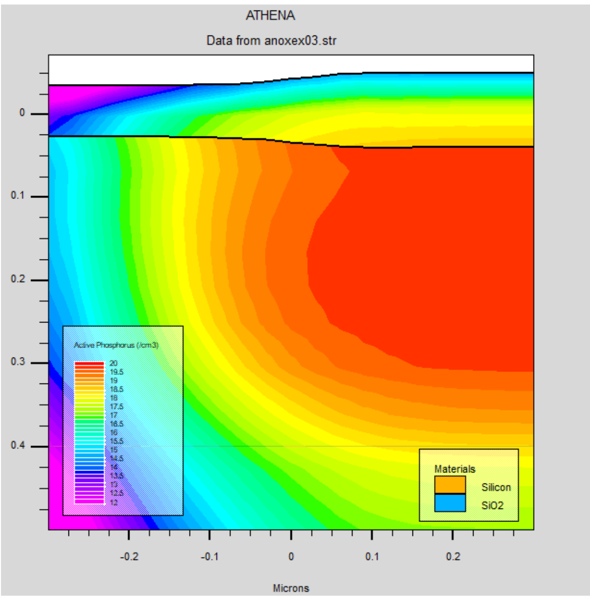

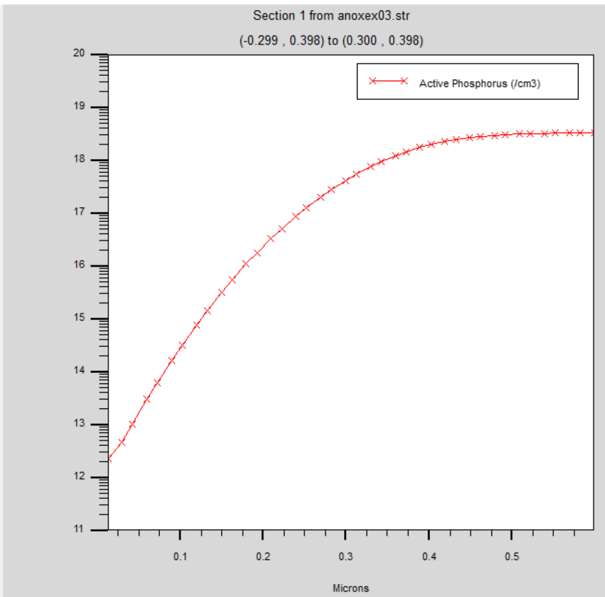

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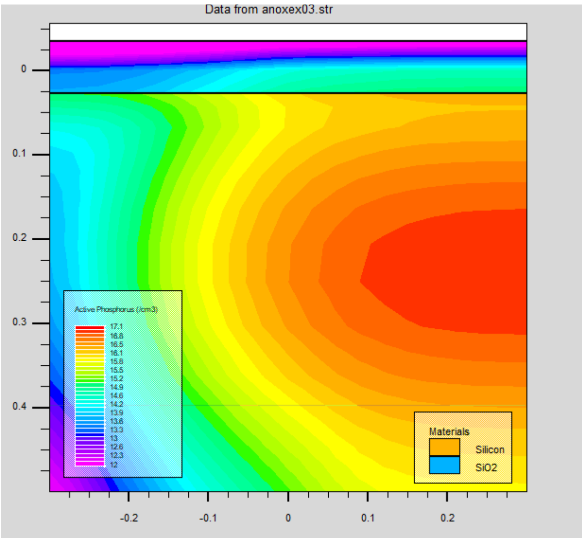

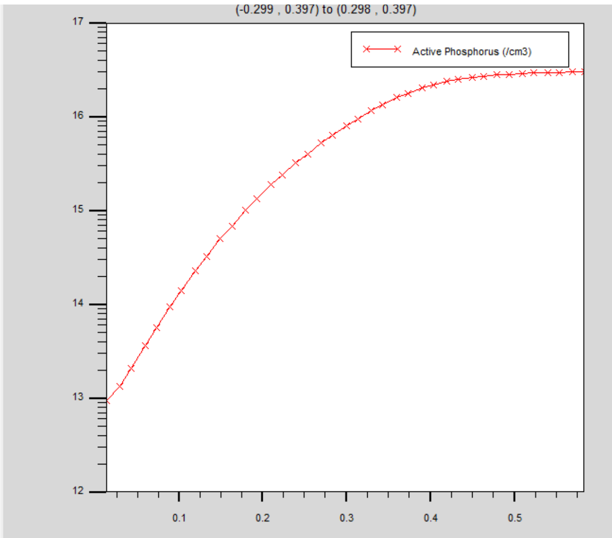


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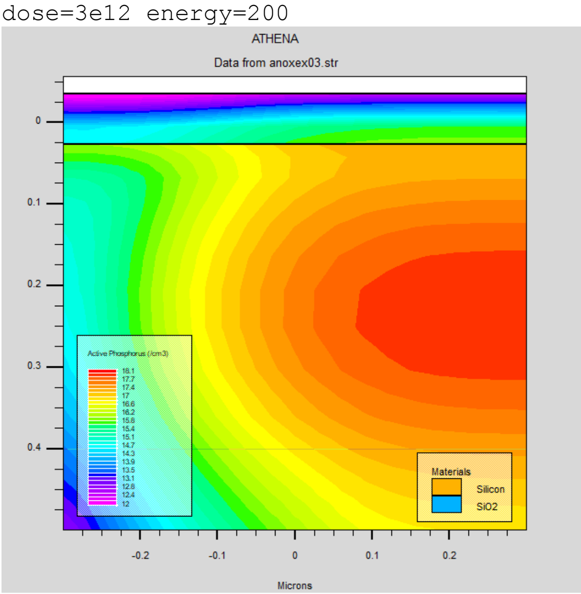

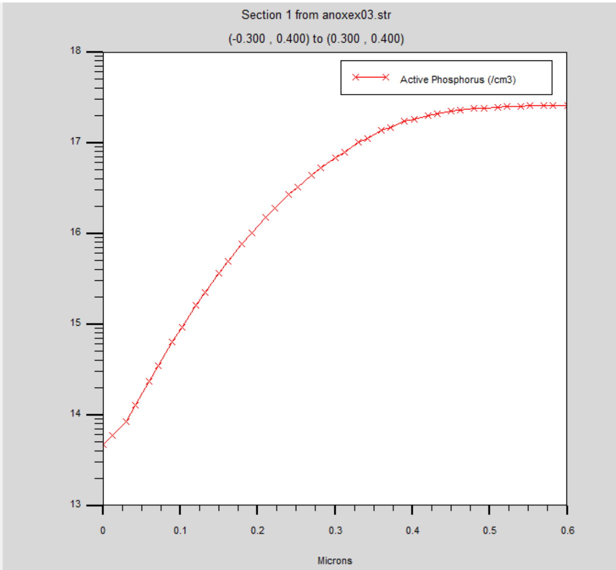


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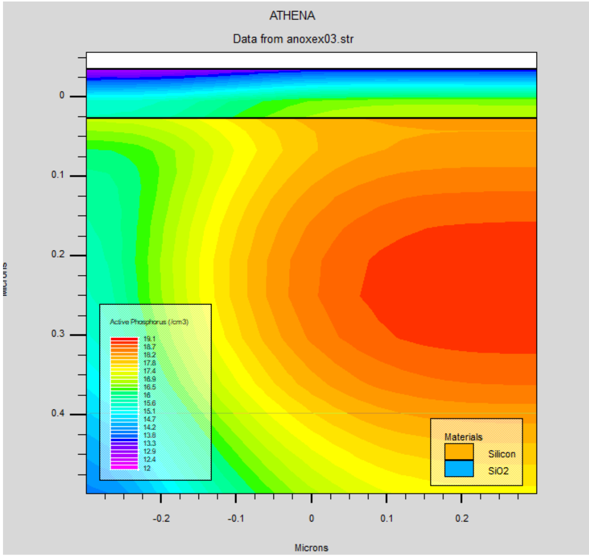

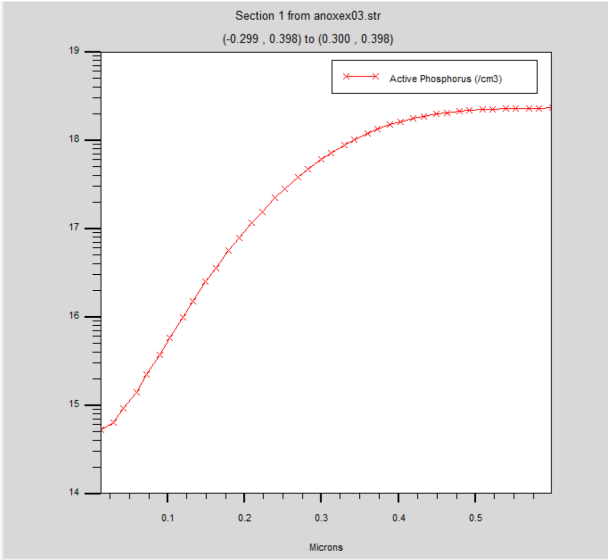

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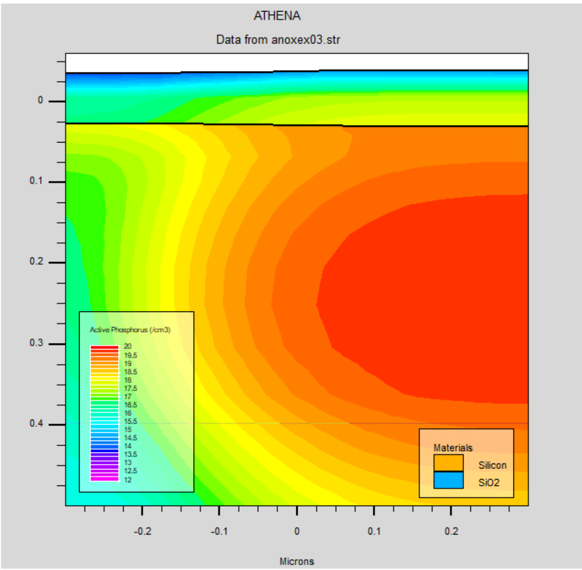

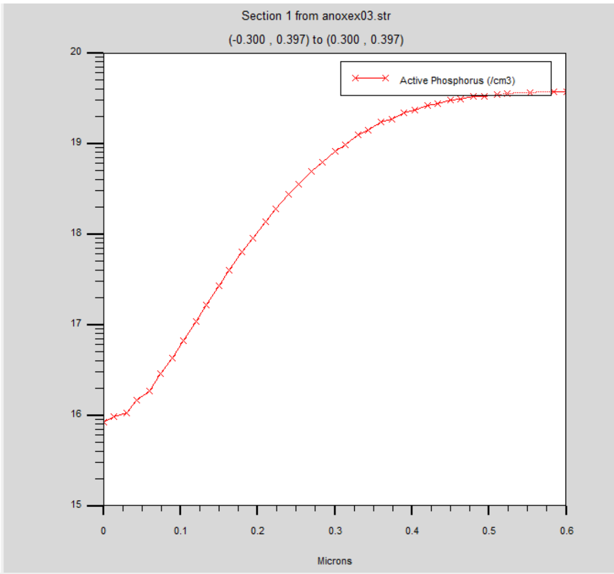

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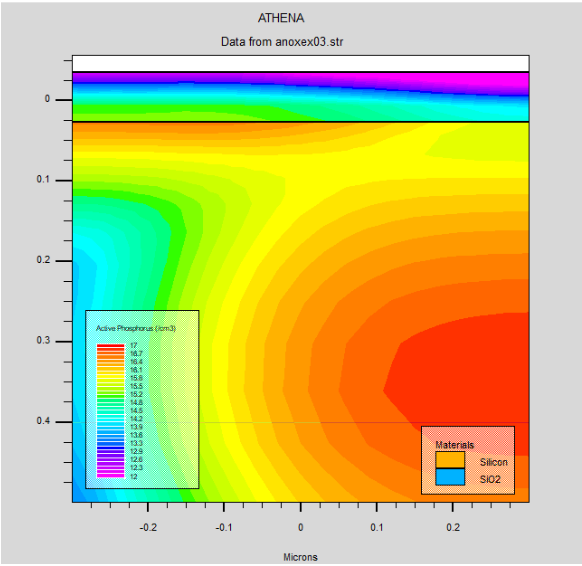

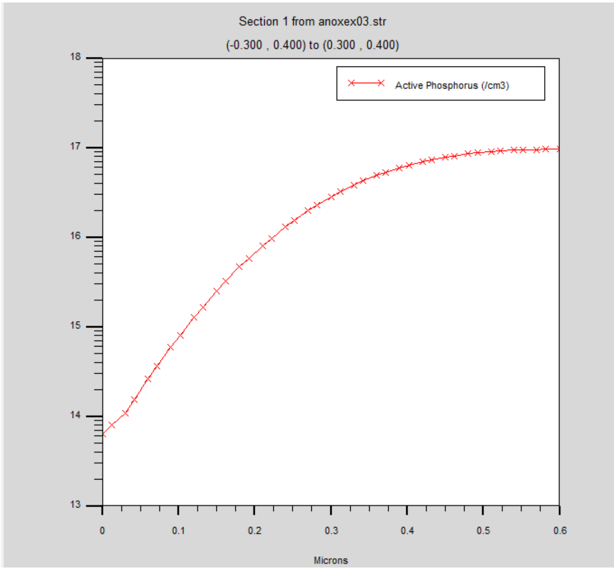


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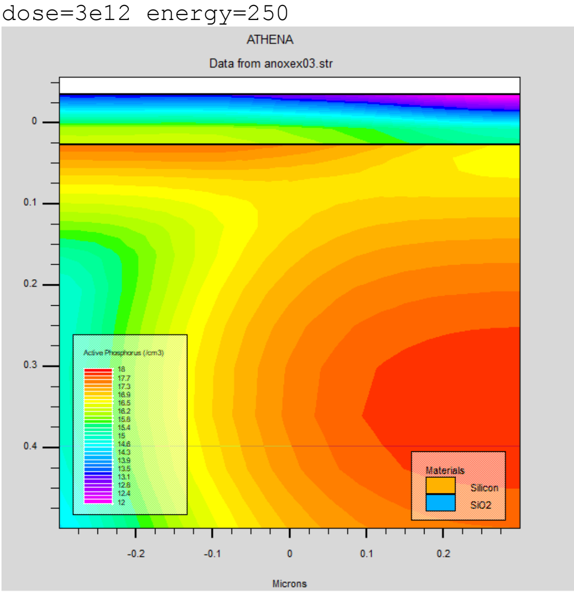

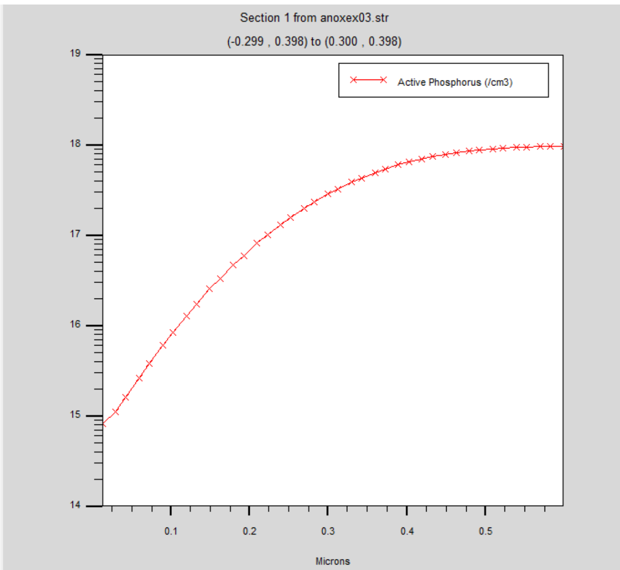


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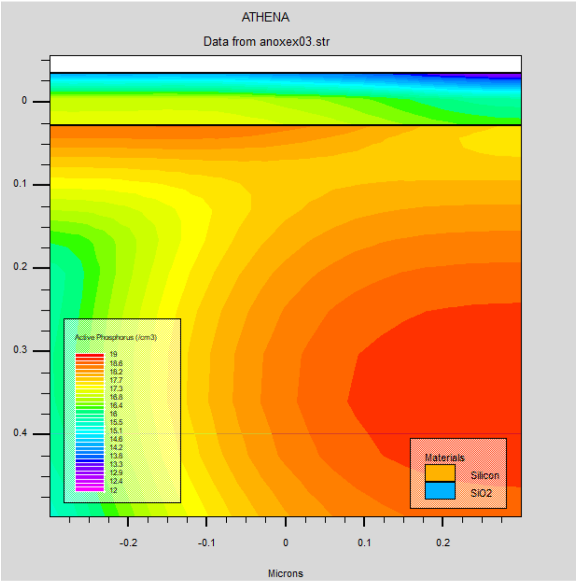

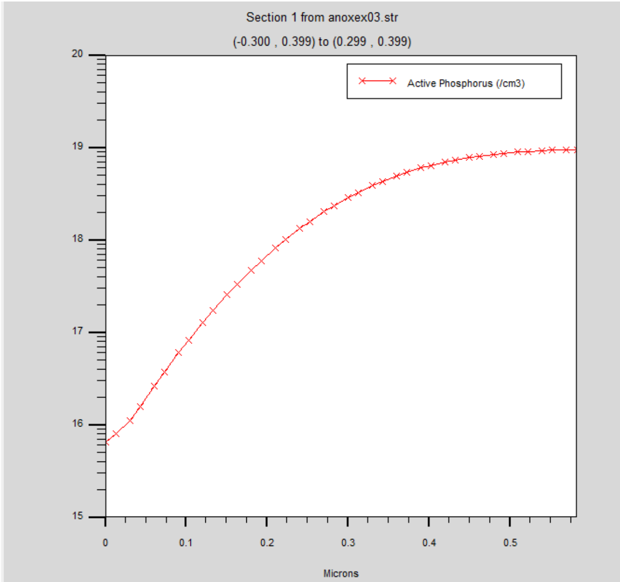


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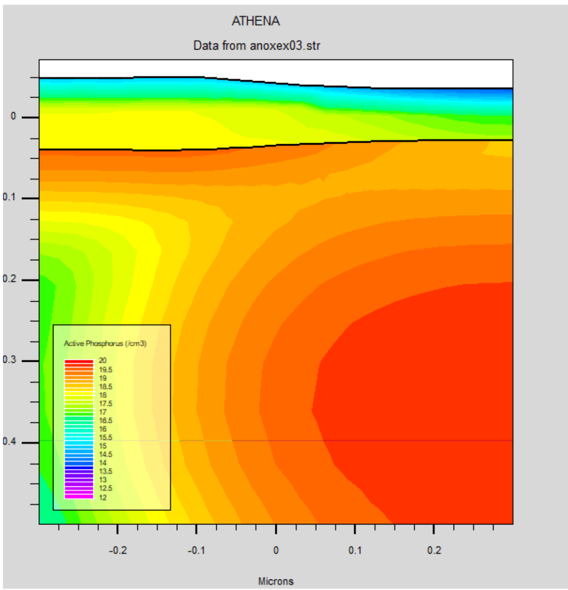

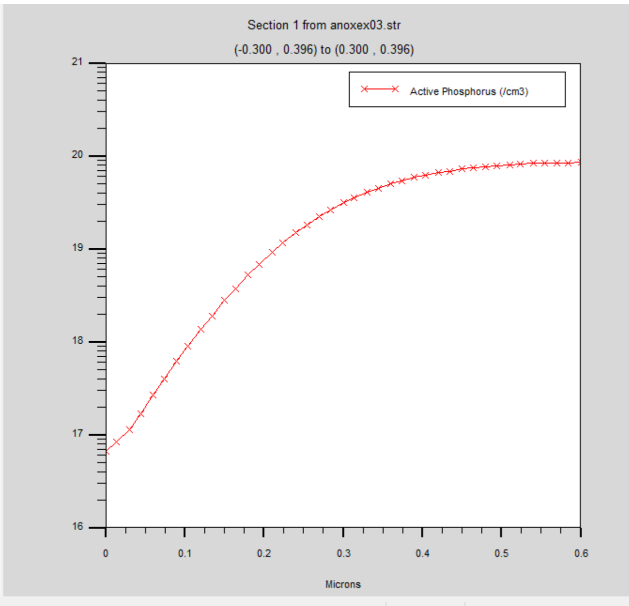


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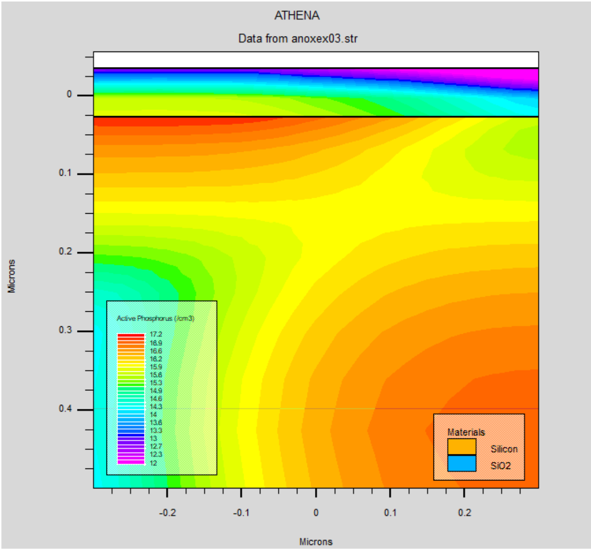
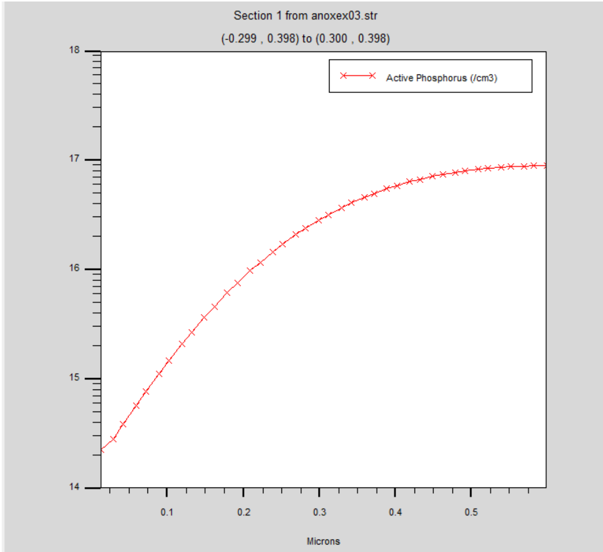
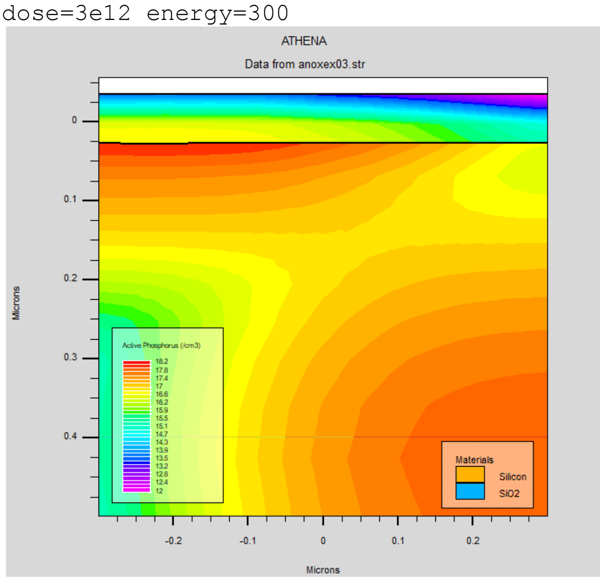
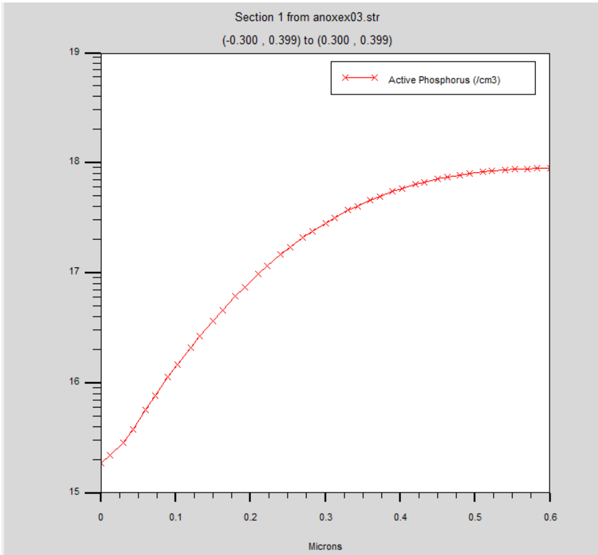




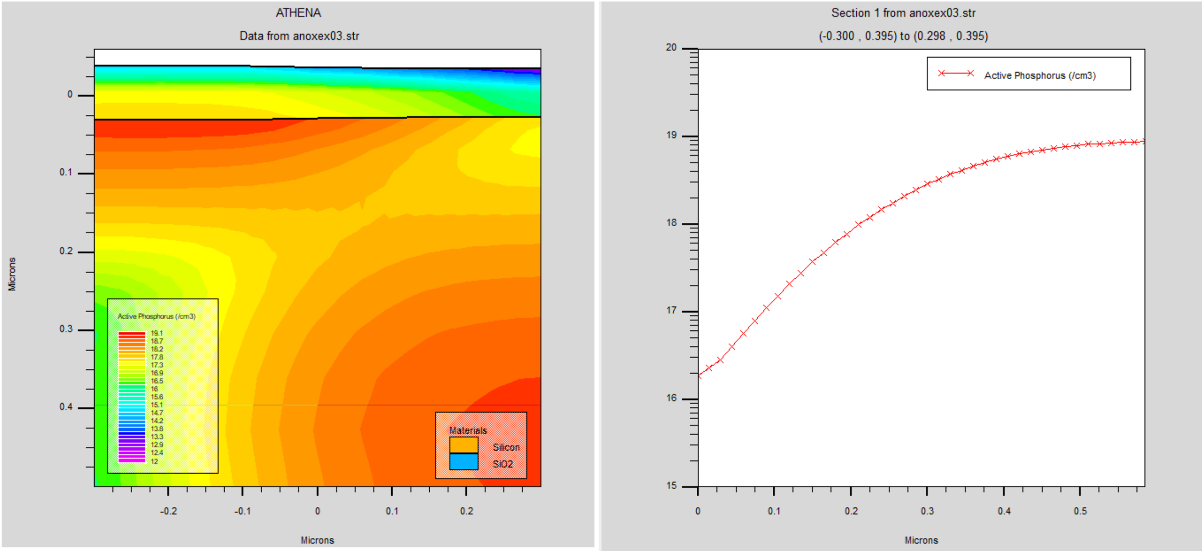
toxlow=624.151 angstroms (0.0624151 um) X.val=-0.25
toxhigh=623.683 angstroms (0.0623683 um) X.val=0.25
dose=3e12 energy=300





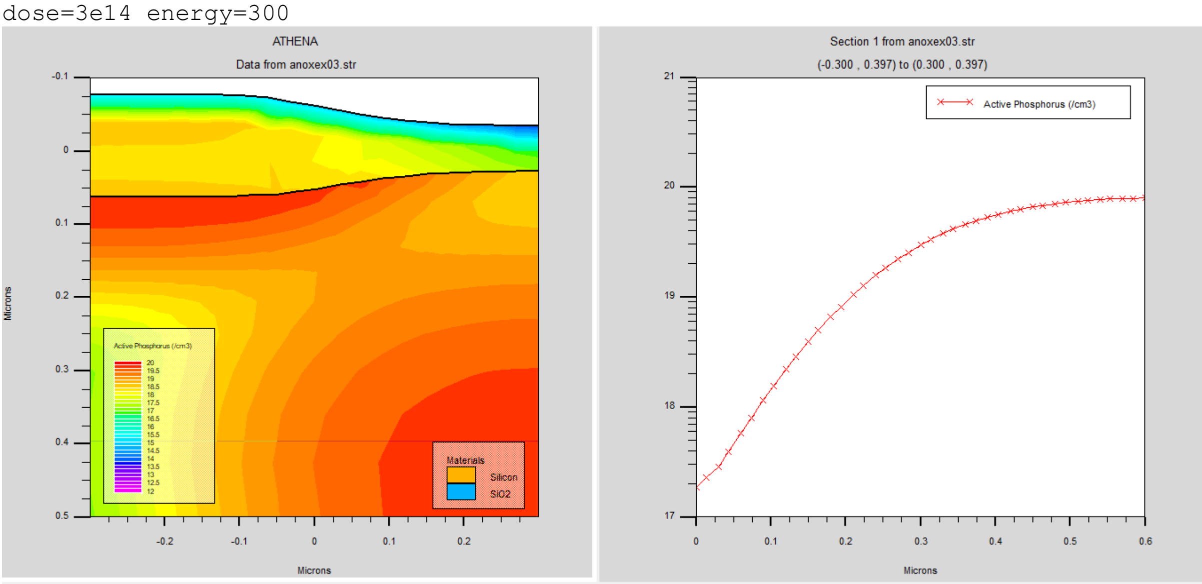
toxlow=629.275 angstroms (0.0629275 um) X.val=-0.25

toxhigh=624.419 angstroms (0.0624419 um) X.val=0.25
dose=3e13 energy=300




```
toxlow=694.998 angstroms (0.0694998 um)  X.val=-0.25
toxhigh=624.054 angstroms (0.0624054 um)  X.val=0.25

dose=3e14 energy=300
```




```
toxlow=1402.41 angstroms (0.140241 um)  X.val=-0.25
toxhigh=630.795 angstroms (0.0630795 um)  X.val=0.25
dose=3e15 energy=300
```

CONCLUSION: When doping concentration increases thickness of oxide increases . At energy of 50KeV,100KeV,150KeV oxide thickness of doped region is more than undoped region. At energy 200 KeV,250KeV,300KeV thickness in doped region decreases whereas the thickness of oxide layer in undoped region increases

Amit Sarkar

DATE:05-07-2021 **SIGNATURE OF STUDENT**