AUTOMATED CAPACITANCE-VOLTAGE MEASUREMENT

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ABSTRACT

An IBM personal computer was used as an automatic data aquisition system for obtaining capacitance voltage (CV) measurements. An HP4145 paramater analyzer was used as an analog to digital converter and the resulting digitized CV data was analyzed on the VAX mainframe.

INTRODUCTION

Capacitance - voltage measurements are one of the most useful methods of determining information about the metal / oxide / silicon system. Because of the ease of performing and evaluating these measurements the CV plot is commonly used in industry to monitor process flow. Parameters such as oxide capacitance, flat-band voltage, threshold voltage, substrate doping, mobile ion concentration, minority carrier lifetime, surface states, etc. can be extracted from these plots. The purpose of this project was to create an interface that would allow capacitance-voltage (CV) measurement plots to be easily and accurately transferred to the VAX mainframe computer for analysis and comparison to theoretical CV curves.

In order to store this data the analog signals, resultant capacitance and applied voltage, from the high or low frequency CV measurement systems had to be converted to digital signals. Using the Hewlett Packard HP4145 paramater analyzer as and analog to digital converter this digital information was then transferred to the IBM personal computer via the IE488 bus between the HP4145 and the PC. This digitized CV data file could then be transferred to the VAX mainframe using a communications software package called KERMIT. This entire process outlined above (including setting-up and running the HP4145 as well as transferring the digitized CV file to the VAX) would be run entirely by remote control using the IBM personal computer.

Once transferred to the VAX, this CV data file could be easily accessed by many people and analyzed using a program on the VAX called CVPLOT. This CVPLOT is an in-house program that would allow the experimental CV data file to be superimposed on the same graph as the theoretical CV plot. This theoretical CV plot is constructed using the exact charge analysis theory for the MOS capacitor. This program can also include the effects of several nonidealities (such as metal work function difference, fixed

charge, mobile charge, surface states, etc.) in calculating the theoretical CV curve. An in-depth explanation of this theory is given in Reference 1.

EXPERIMENTAL

In order to easily record a CV measurement (by remote control using the IBM PC) a software routine was written in basic programming language that would communicate with the HP4145 using the IE488 bus. This program would automatically set-up the HP4145 paramater analyzer, begin recording with the HP4145 and obtain the results from the HP4145 directly from the IBM PC. A listing of this program is shown in the appendix.

To record a CV measurement one must make the following connections:

1) Connect the IE488 bus between the HP4145 and the IBM PC.
2) Connect the voltage corresponding to the capacitance to the VM2 jack on the HP4145.
3) Connect the voltage applied to the gate to the VM1 jack on the HP4145.
4) Connect the ground jack on the HP4145 to ground.
5) Connect the RS232 line (from the VAX) to the IBM PC.

The CV data program can be loaded into the PC by booting up a DOS 3.1 disk, typing basic, typing load"CVDATA and then typing run. The program will then prompt the user for the correct responses.

A normal procedure for recording a CV plot would be to choose option one in the main menu (which would set-up the HP4145 for the measurement). At this time one could make any changes in the HP4145 pages by simply hitting the LOCAL key in the upper right-hand corner of the HP4145 and making the desired changes. The cursor should be returned to the last page where it initially was located when done. To begin recording data the space bar should be pressed on the IBM PC. The resulting graph will be displayed on the HP4145 screen. Again, the HP4145 can be operated normally at this time (to obtain a plot or analyze the data) by hitting the LOCAL key. By choosing option 2 on the main menu screen (on the PC) one can load the data into the IBM PC and can save the data file by choosing option 3 and supplying the appropriate file name.

This data file can then be transferred to a VAX account by using a software routine called KERMIT. Directions for this process are shown in the appendix.

Data can then be analyzed using the CVPLOT program on the VAX. This program can be run by typing RUN CVPLOT and supplying the requested information. Using this program the CV data file can be plotted on the same graph as the theoretical CV curve which can include several non-idealities if desired.

RESULTS/DISCUSSION

The above process was used to plot the CV graphs shown below. The dotted line represents the actual results and the solid line represents the theoretical curve. Note that both the theoretical and actual results are normalized and the actual curve can be obtained by multiplying the normalized curve by the appropriate Cox value (shown above the curves). Note also that the threshold voltage is extracted for the low frequency curves.

Once set-up this entire process only takes a matter of minutes to complete and can be used for many other types of data aquisition needs. Further work that could be done to improve this system would be integrating the program on the IBM PC with the Kermit communications software so that the CV data files could be automatically sent to the VAX using the same program. There is also a lot of modifications that could be made to the CVPLOT program on the VAX that would allow several non-idealities to be automatically calculated by comparing the actual and theoretical CV curves.

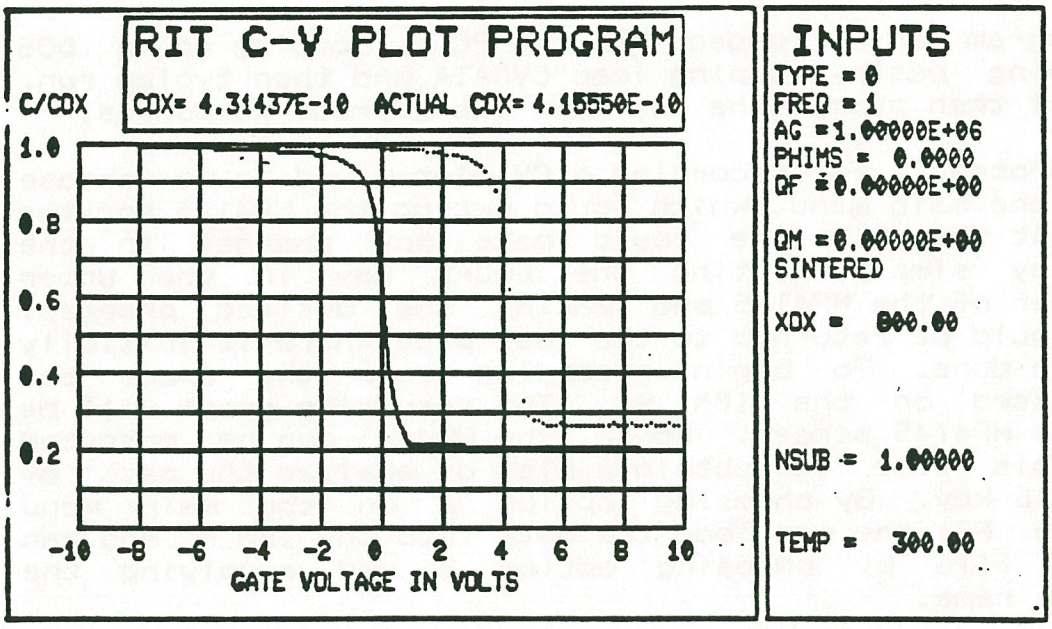

FIGURE 1: ACTUAL AND THEORETICAL HIGH FREQUENCY CV PLOT

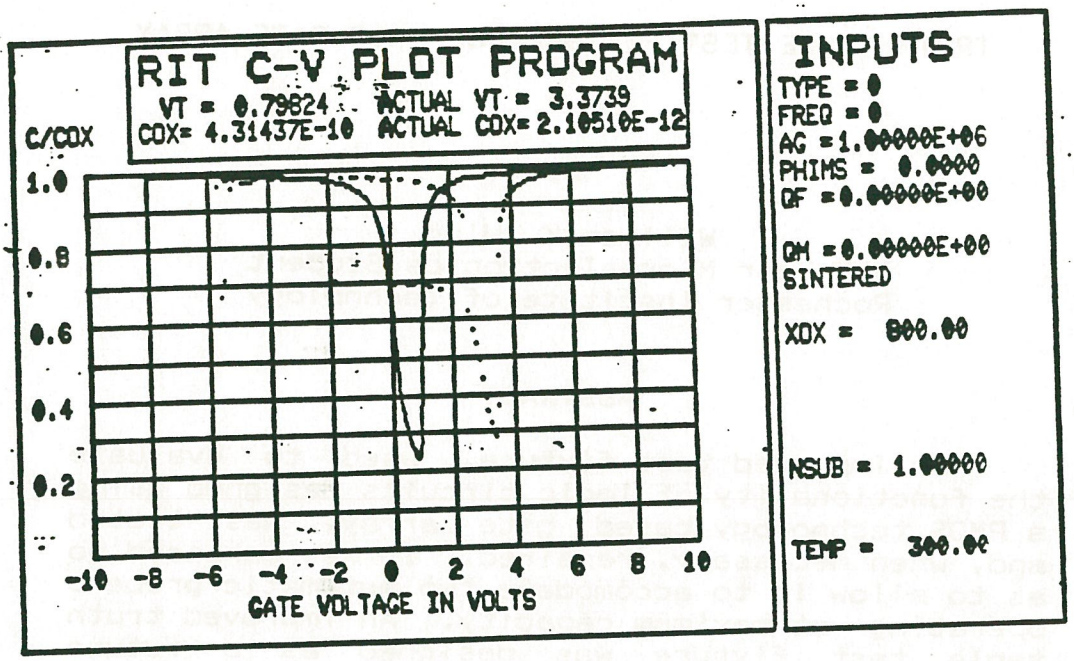

FIGURE 2: ACTUAL AND THEORETICAL LOW FREQUENCY CV PLOT

CONCLUSION

This entire process described above is fully operational at this time and can easily be modified for many other types of data aquisition needs. This represents a large improvement in the aquisition and analyses of CV curves at RIT.

ACKNOWLEDGMENTS

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REFERENCES

[1] Modular Series on Solid State Devices Volume IV by Robert F. Pierret