ANALYSIS OF ELLIPSOMETER MEASUREMENTS

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ABSTRACT

A procedure for making Δ vs ψ plots to analyze ellipsometer readings was generated. This replaced the look-up tables. The refractive index and thickness were generated using the McCrackin Ellipsometer program.[1] This program was debugged.

INTRODUCTION

Ellipsometry is the measurement of the effect of reflection due to a dielectric medium on the state of polarization of light.[2]

In the ellipsometer, monochromatic light passes through a polarizer and a wave plate. It is then reflected from the surface under investigation, and passes through a polarizing prism called an analyzer and to a detector (Figure 1). The polarizer and analyzer form the plane of incidence which is perpendicular to the sample surface. The wave plate is set at a fixed azimuth and the polarizer and analyzer rotated until the light is extinguished as determined by the detector. The azimuths of the polarizer, fast axis of the wave plate, and analyzer, (P, Q, and A respectively), measured from the plane of incidence are recorded. From these readings delta (Δ) and psi (ψ), the ellipsometer parameters, are calculated. The optical constants of the surface or the thickness and refractive index of films on a substrate are calculated from Δ and ψ.

A Fortran program written by Frank McCrackin for the National Bureau of Standards[1] is currently operable to calculate film thickness and index of refraction. Measurement data must be linked in the form of a data file for program execution. The data file is composed of a set of instructions which causes the computer to change experimental parameters (Table 1) or, based on various models of one or more films, perform calculations (Table 2).

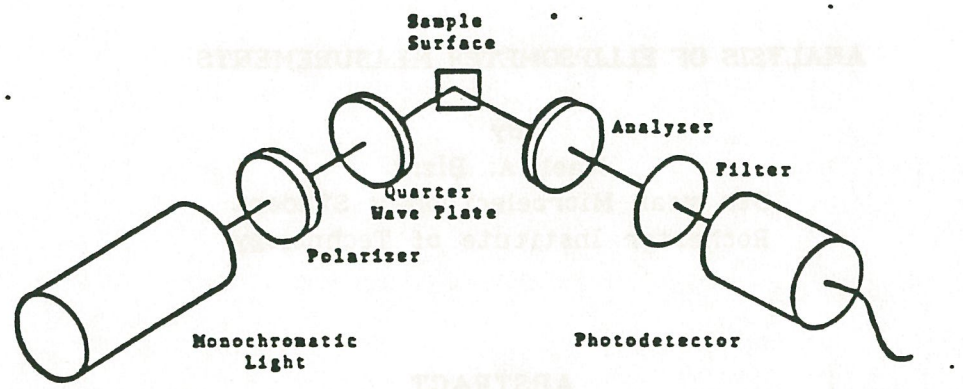

Figure 1. Basic Ellipsometer Schematic.

Instruction	Parameter	Default
AI	Angle of incidence	70 degrees
NF	Refractive index of film	1
NM	Refractive index of medium	1
NS	Refractive index of substrate	1
WL	Vacuum wavelength of light	5461
WP	Wave plate constants	1,90 degrees
AT	Angle of tilt	0

Table 1 : McCrackin's program default parameters

Instruction	Computation
CAT	Angle of tilt of reflecting surface
CD	Thickness of film
CND	Refractive index and thickness of film
CNDC	Refractive index and thickness of film with combination of values
CNDE	Refractive index and thickness of film with confidence limits
CNK	Complex refractive index of film of given thickness
CNS	Refractive index of substrate
CTABLE	Table of Δ and ψ and reflection coefficients
PAGE	New page of output
RESET	New page of output with new reset to parameter
STOP	End program

Table 2 : McCrackin's program commands

The goal is to generate curves by using the Fortran program for various ranges of thickness and indices of refraction. These curves may be used for quick determination of t_{ox} and n_f for measured values of Δ and Ψ, instead of the old look up table, where prior knowledge of index of refraction is required.

EXPERIMENT

The RIT's AME-500 ellipsometer, using a Na light with a wavelength of 5461 Angstrom, was compared to a standard Gartner 117 ellipsometer, at SUNY Buffalo, which uses a HeNe laser with a wavelength of 6328 Angstrom. Sample wafers with oxide thickness of 500 and 1200 Angstrom are used as the comparative tools. The values of Δ and Ψ were obtain for the two ellipsometers.

By using the McCrackin program instruction CTABLE, a table a value for t_{ox} and n_f was generated for a given range of Δ and Ψ. This table was then incorporated into a spreadsheet were it was sorted by thickness and by refractive index. From these data, plots of Δ vs Ψ were obtain using a graph generator DIS8.

RESULTS

After comparing both ellipsometers, it was found that the RIT ellipsometer need calibration to give us an accurate reading. The sample wafer could be measured before using the ellipsometer to make sure that it is calibrated.

The McCrackin Ellipsometer program is currently operable on the VAX. All but the CNK instruction run properly.

Figure 2 shows the Δ vs Ψ plots generate for thickness range of 400 to 800 Angstrom, and index of refraction between 1.3 and 1.6.

CONCLUSION

Plots of different ranges were plotted for quick determination of t_{ox} and n_f. The ellipsometer program could also be used to give accurate result when the ellipsometer is well calibrated.

N_F

PSI VS DELTA

WL-5461, AI-70, NF-1.3-1.6, CTABLE-400-800

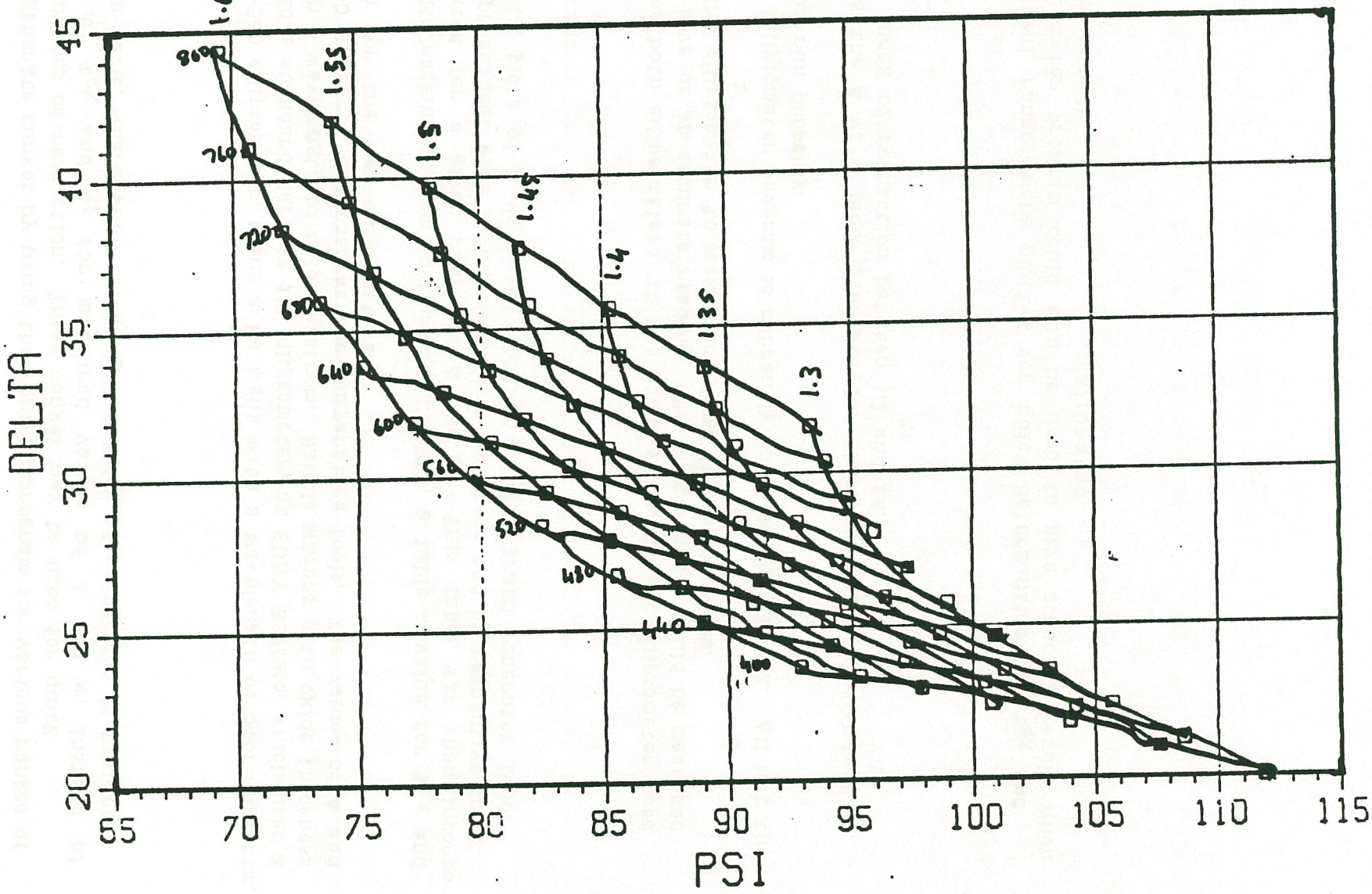

Figure 2
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REFERENCES

1) Frank L. McCrackin - A Fortran Program for Analysis of Ellipsometer Measurements - National Bureau of Standards # 479 - 1969.

2) R. J. Archer - Manual on Ellipsometry - Gaertner Scientific Corporation - 1968.

3) Alice R. Farver - Determination of Film Thickness and Refraction Index from Ellipsometer Measurements - RIT - Class of 1986.

4) Technical Memorandum - Review of Ellipsometry - Rochester Institute of Technology - Microelectronics Engineering Department - Unpublished paper.

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