Calibration of Aluminum Thickness and Uniformity Measurements

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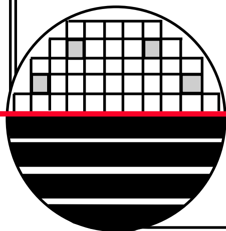

7-13-2014 AluminumCalibration.ppt

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INTRODUCTION

This document contains information on measurement and calibration of sputtered aluminum thickness for the CVC601 tool. After sputtering aluminum the thickness is measured using the CDE Resistivity Mapper (4pt Probe). The thickness is found from the known Resistivity of Aluminum divided by the measured sheet Resistance,

$$Rs=(\pi/\ln2)(V/I).$$

These measurements are Calibrated by comparing to thickness measured using the Tencore P2

CVC 601 Sputter Tool

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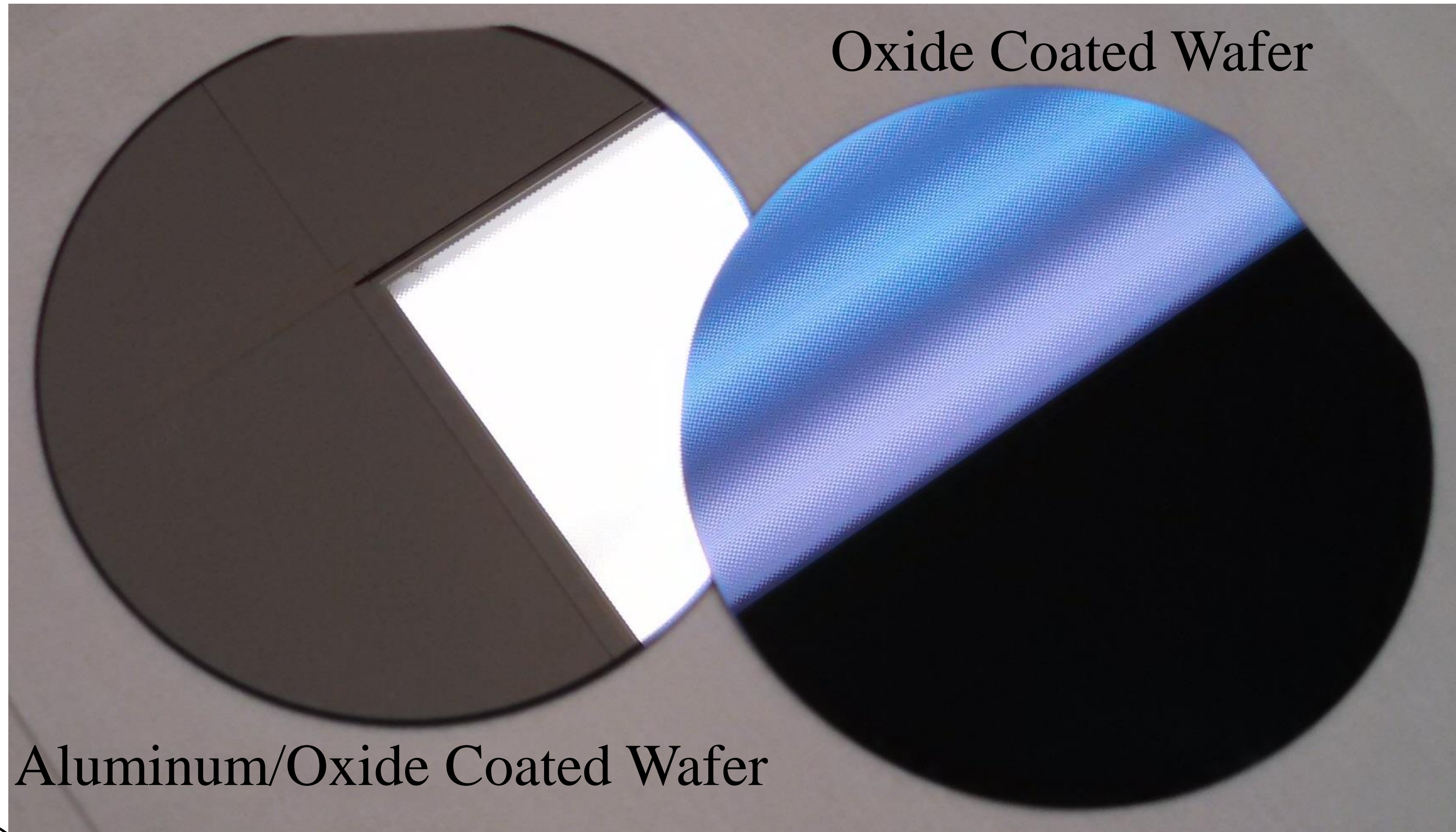
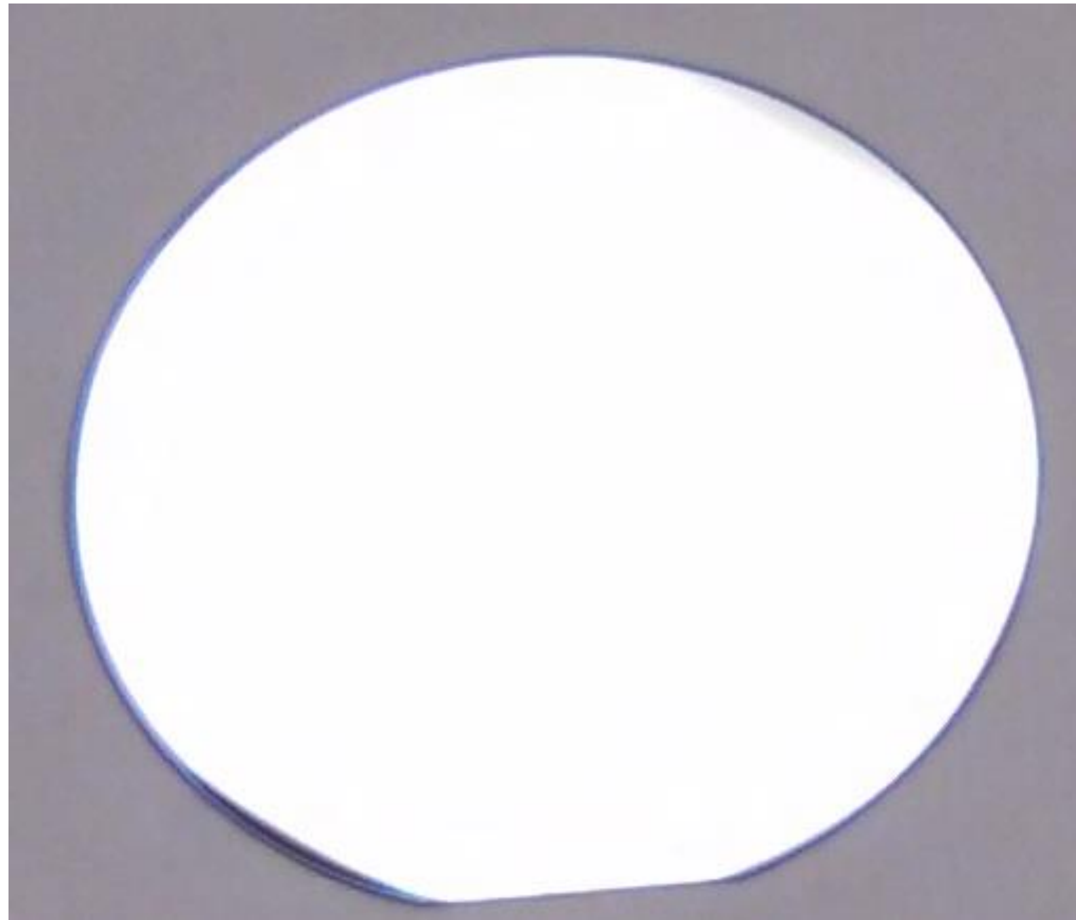
OXIDE COATED STARTING WAFERS



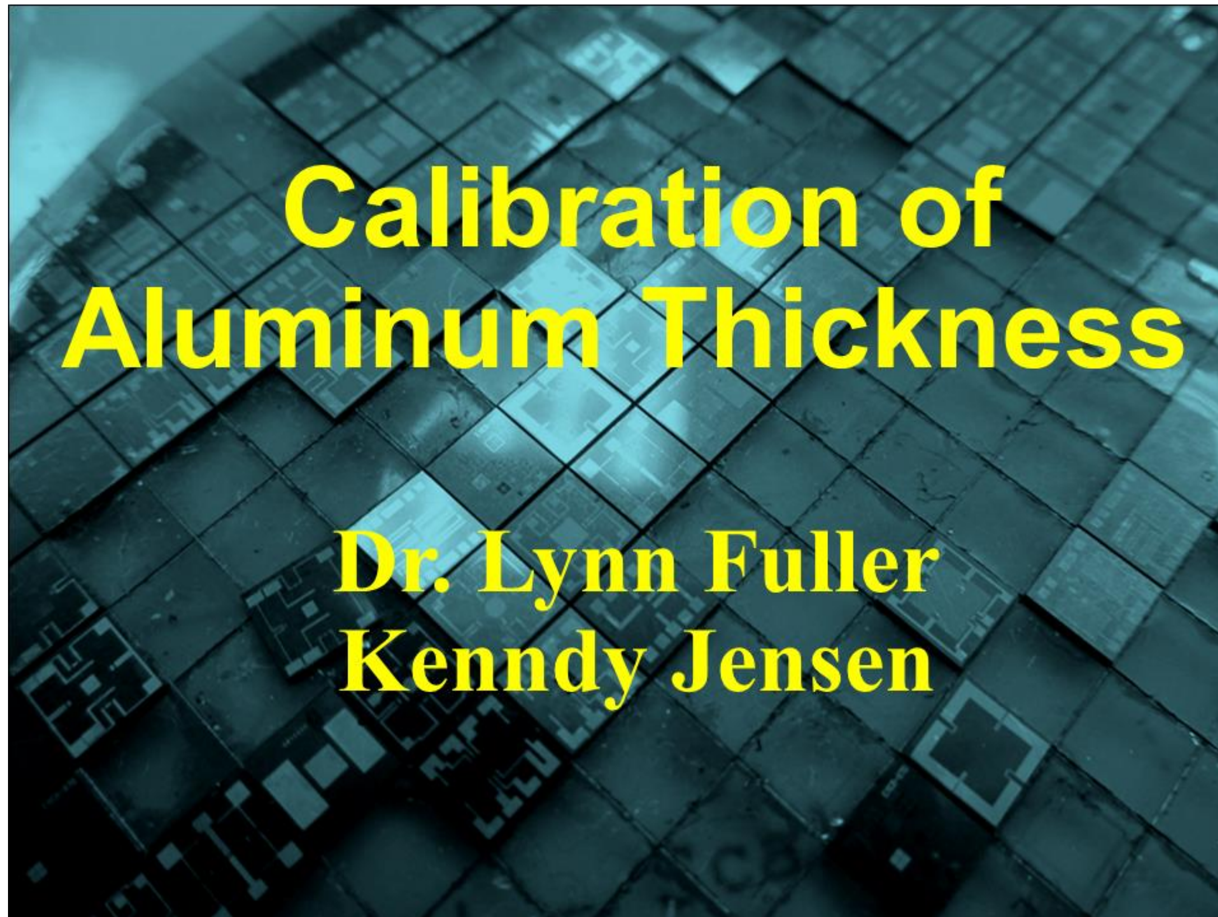
ALUMINUM COATED WAFER

Sputter Recipe
2000 Watts
5 mTorr
40 sccm Argon
20 minutes

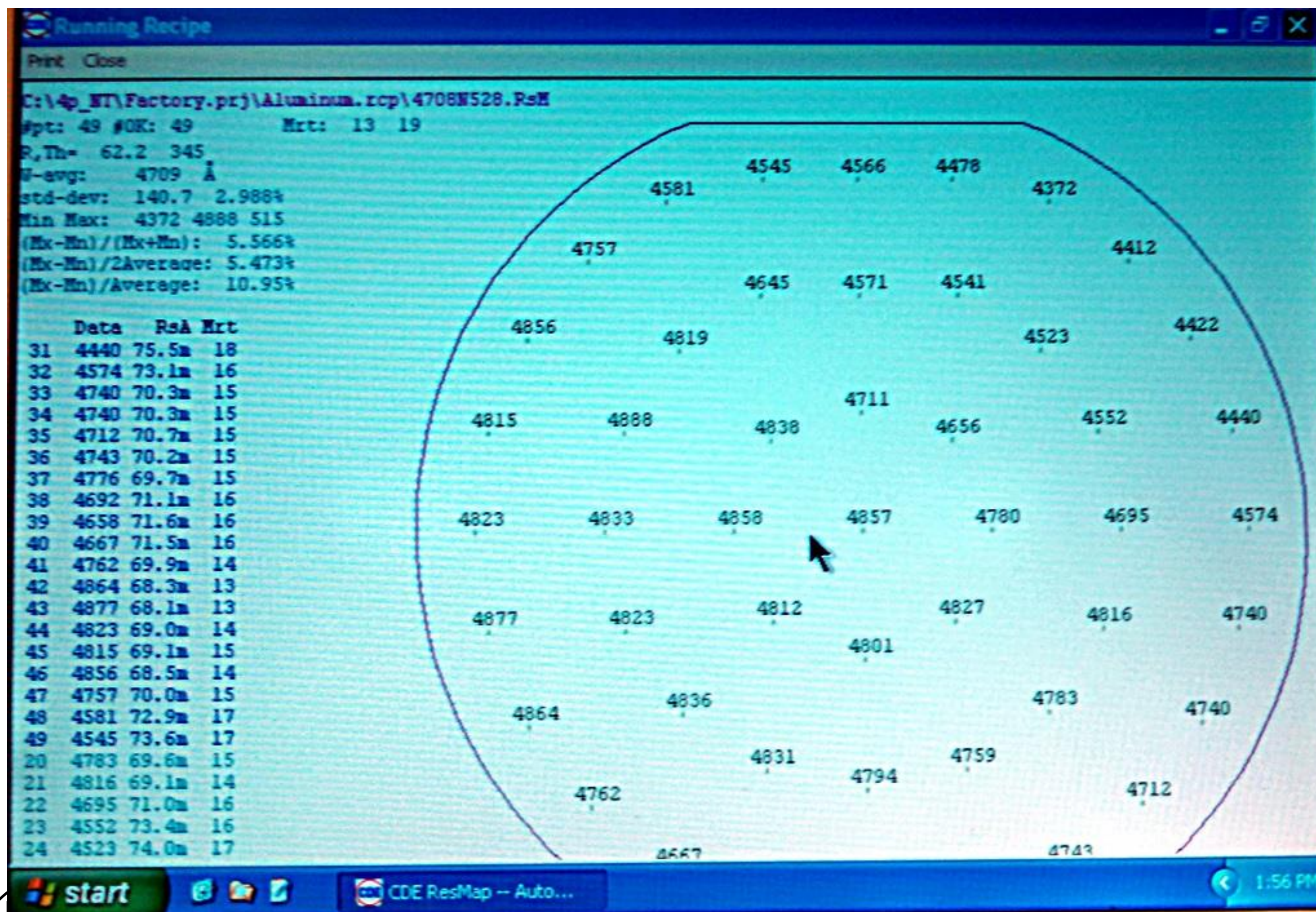
Wafer Orientation is with the wafer flat out during sputtering and flat to the back left on the CDE resistivity mapper and to the front on the Tencore P2.



CDE RESISTIVITY MAPPER MOVIE

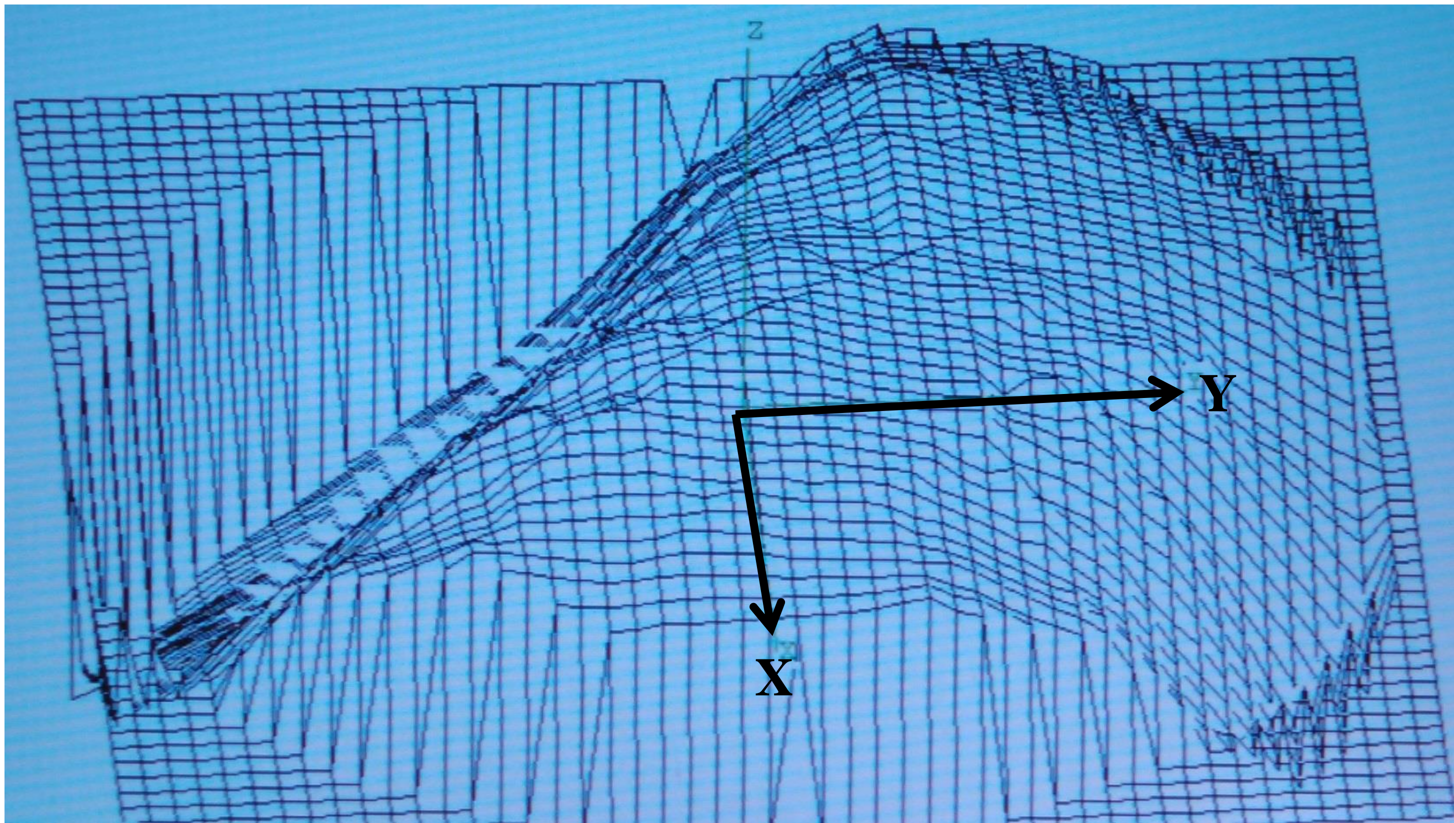


CDE RESISTIVITY MAPPER DATA



Average **4709Å**
Measure 49 points
Min 4372Å
Max 4888Å
Min-Max/Ave **11%**

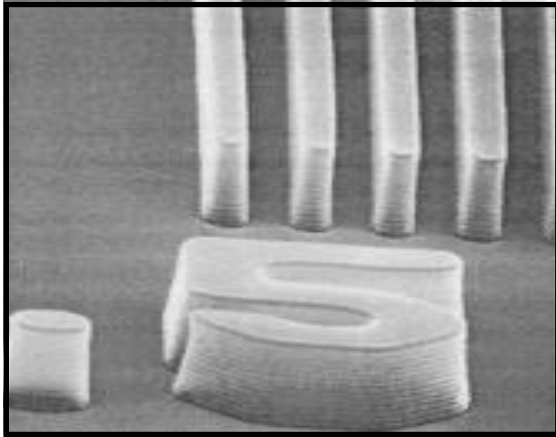
3D PLOT OF ALUMINUM THICKNESS



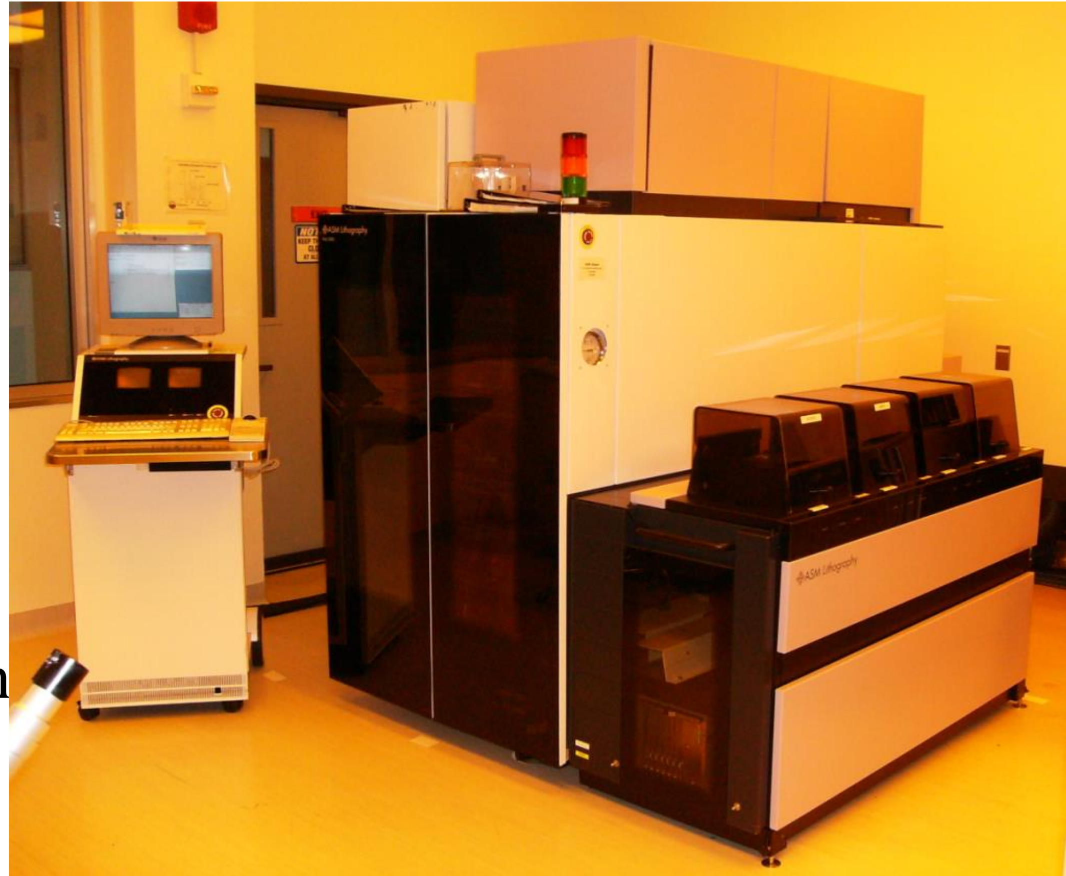
Wafer Flat

Note: the aluminum thickness falls off on side opposite the wafer flat.

ASML 5500/200



NA = 0.48 to 0.60 variable
σ= 0.35 to 0.85 variable
With Variable Kohler, or
Variable Annular illumination
Resolution = K1 λ/NA
= ~ 0.35μm
for NA=0.6, σ =0.85
Depth of Focus = k_2 $\lambda/(NA)^2$
= > 1.0 μm for NA = 0.6



i-Line Stepper λ = 365 nm
22 x 27 mm Field Size

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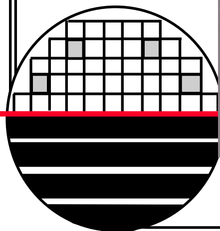
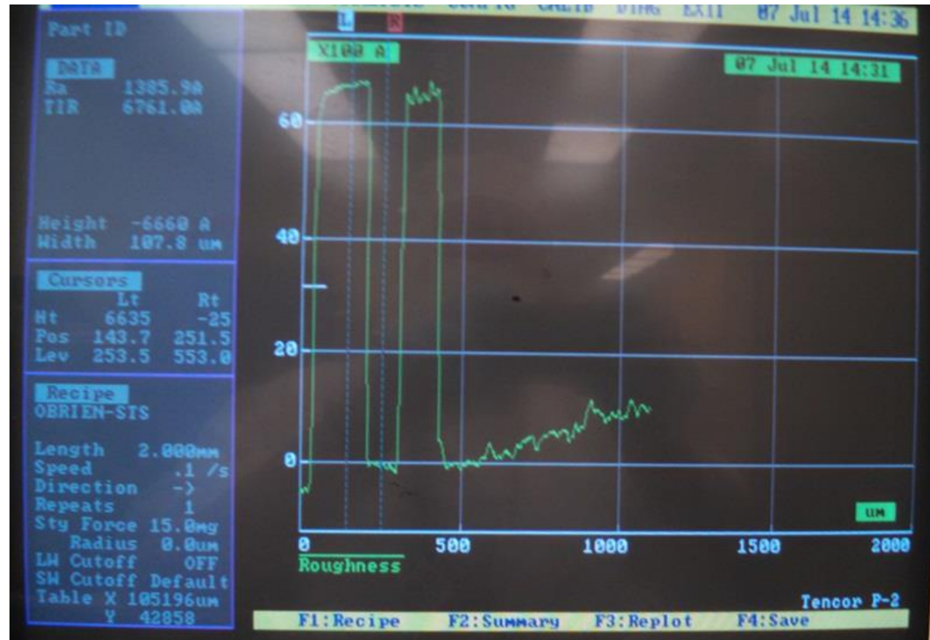
ETCHED ALUMINUM PATTERN

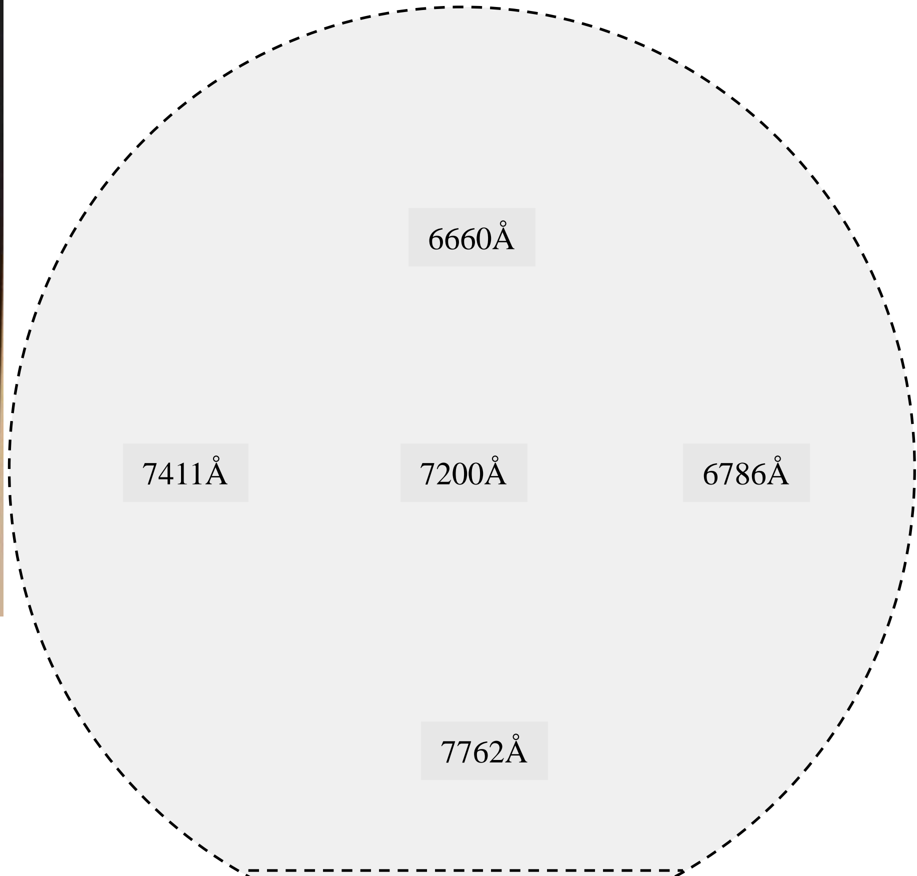


TENCORE P2

Picture of Tencore P2

TENCORE P2 MEASUREMENTS

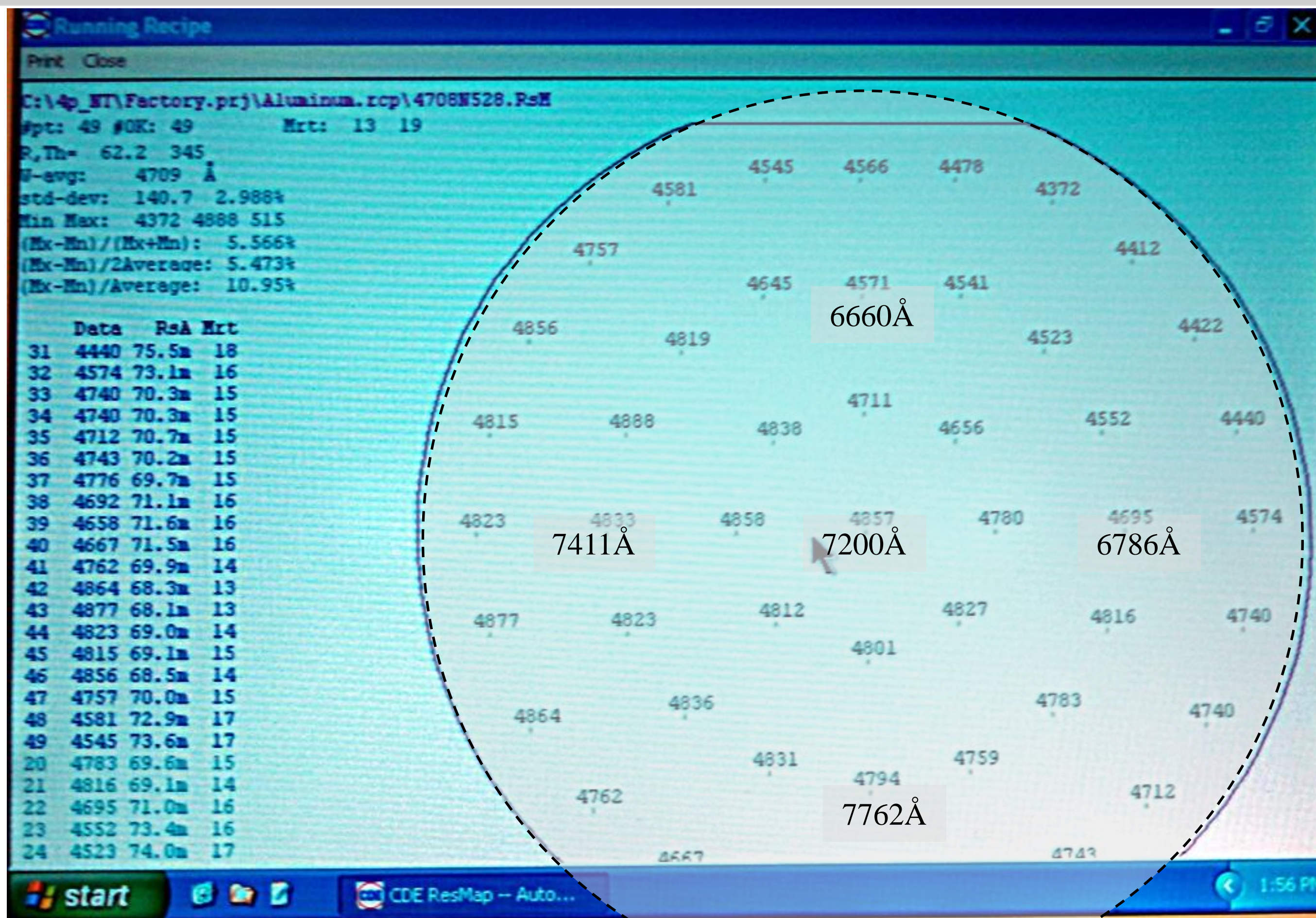




Wafer Flat

Make Aluminum thickness measurement in various locations on the wafer to compare to the 4pt probe measurements

COMPARISON OF TENCORE P2 AND CDE 4PT PROBE



RECIPE – AluminumCVC601

Wafer
Round Diameter 150 Notch Flat Size 57
Rectangular XSize 125 YSize 125
SHEET Conductor Thk For BULK 650 Um AutoSamplThk
Measurement
Probe Configuration: Dual Single Probe Select Probe #1 ThOffset 0 Randomize
Circular Area Rectangular Area Diameter Template
Sites 49 Xll -55 Yll -55 Angle 0 File Name
#Sites/Band2 8 Xur 55 Yur 55 RStart -73.2 Unused
StraddleNotch/Flat #X 5 #Y 5 REnd 67.7
Follow Flat EdgeExBoundry dR 5.032
Edge Excl 10 CutoffCorner #Sites
Data Conversion Mode 0 W = [Ratio] 1 *[0 + 615 x Rs ↑ -0.92] Å
Temperature Compensations: P/N type ? Manual TCR 0.3 %/C SPC Target 0 LCL 0 UCL 10
DataReject 3 Sigma RsA/RsB Ratio Reject ReprobeAllRejects
Merit< 0.1 Not Used ConditionProbeBeforeReprobe
Reject Sigma [1~6]: 6
Lo limit: 0.5 Hi: 3
Motor 4pMot.prm MotionCoord 4pMtCrd.prm Probe 4pProbe.prm
PostProcess 4p_PostP.prm Run Title Al Thickness
Manual Load Only ZProbeDeeper [+ >compression]: 0
Skip Notch/Flat Find <-3,1> [- >thicker sample]:
Cancel Save Recipe

Change the value for the aluminum resistivity to improve the matching of the data measured by 4pt probe and by Tencore P2.

CALCULATION FOR CALIBRATION FACTOR

Sheet Resistance Rs = (π/ln2)(V/I) ohm

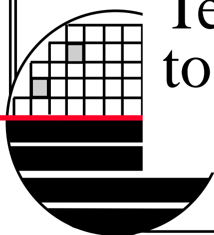
Thickness,W = Resistivity (ohm-m) / Sheet Resistance (ohm)

The resistivity for pure aluminum is 2.7E-8 ohm-m, from most references. The resistivity of alloys of aluminum can vary from 2 to 6 E-8 ohm-m. The resistivity of thin films is different than bulk resistivity and is a function of the film thickness, grain structure, etc.

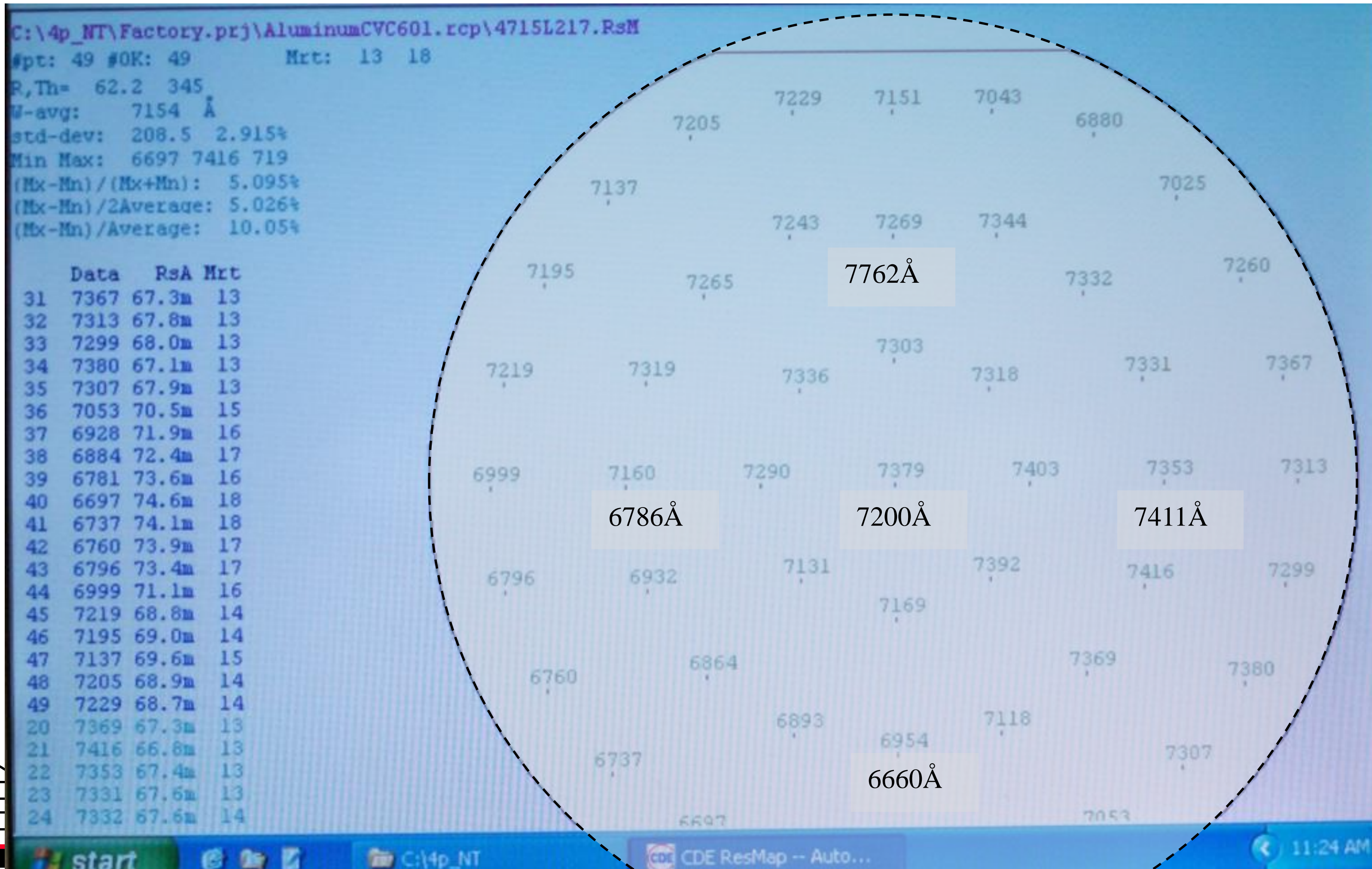
CDE gives an equation for film thickness in Å, where the values 337 and -0.92 are used to fit the data in their equation.

$$W (Å)=337 (V/I)(\pi/\ln 2)^{-0.92}$$

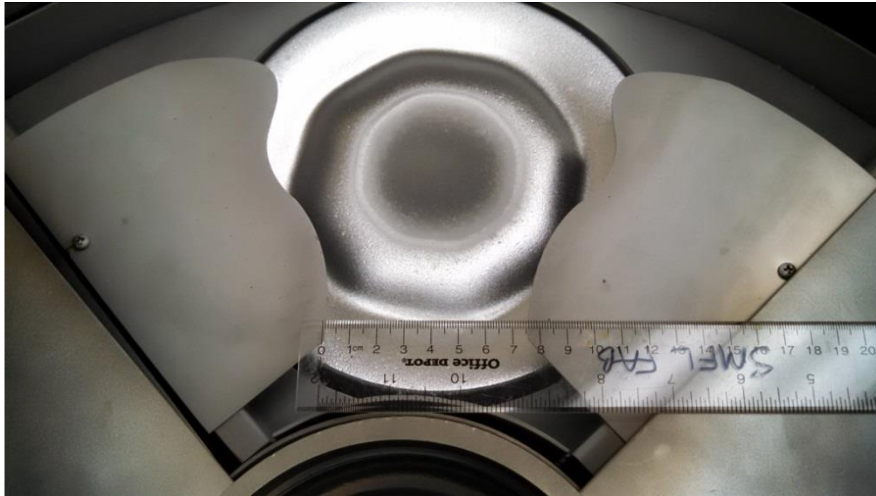
Our calibration was made by comparing 4pt probe with Tencor P2 measurements. Empirically finding 616 and -0.92 to give good results. See recipe on the previous page.



CDE RESISTIVITY MAPPER DATA AFTER CALIBRATION

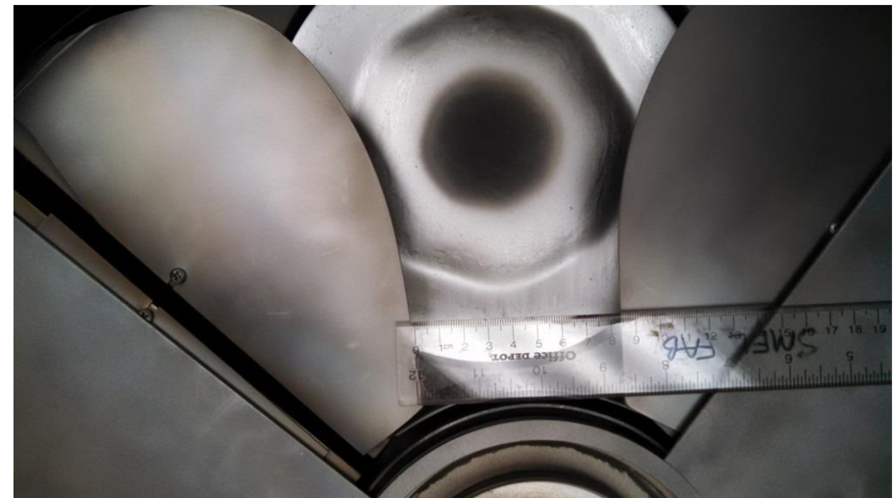


SHIELDS

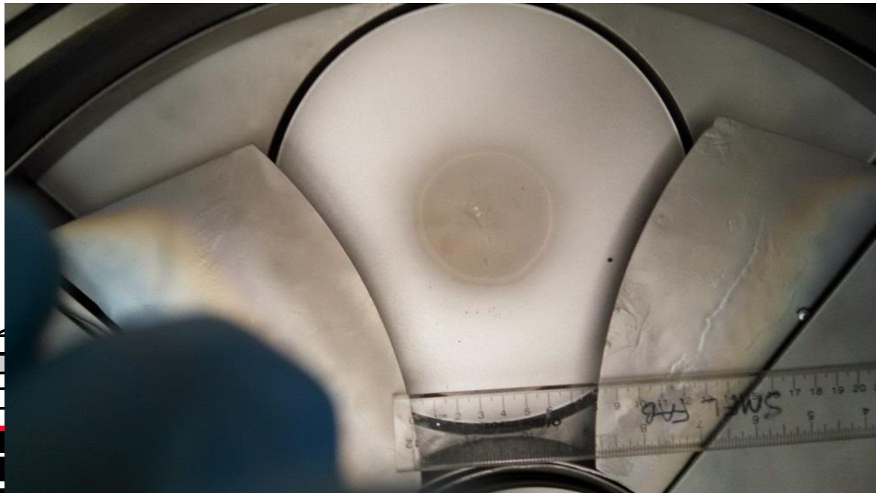


Aluminum-1%Si

Why are these shields all diferent shape?



Moly



Titanium

SHIELDS

Shields are used to block some of the deposition with the goal of improving the uniformity at the expense of lowering the deposition rate slightly. The plasma density is not uniform because of the magnets under the target. The target erosion indicates that the aluminum is sputtered from a octagon shaped ring area of the target. Most of the center of the target is not sputtered. The wafers rotate over the target. As the target erosion increases the sputter uniformity may change

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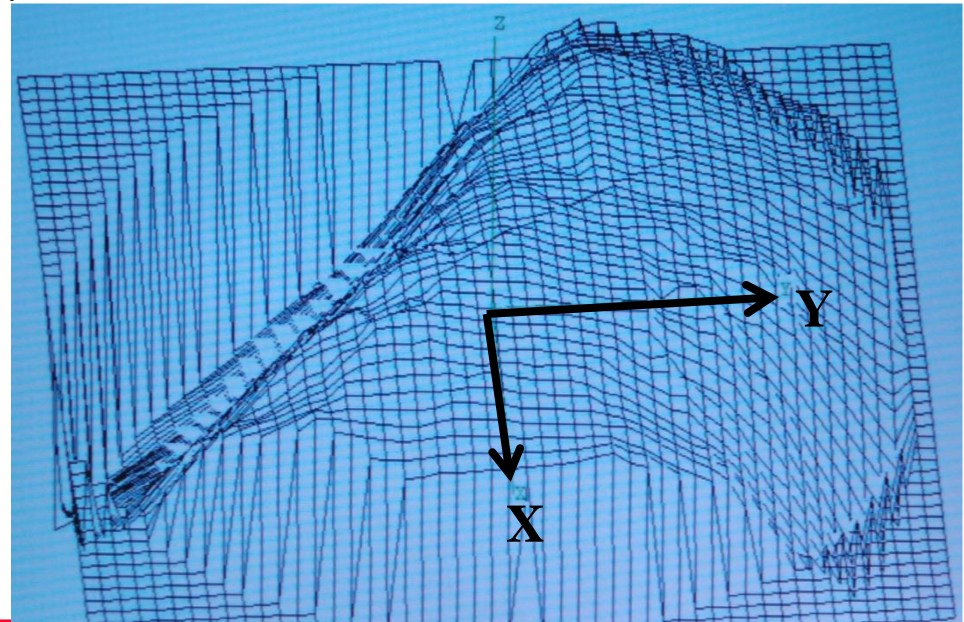
SUMMARY

The shields appear to be too narrow near the center of the tool giving thinner coating on the inside edge of the wafer. This was verified using the 3D map from the 4pt probe.

Periodic shield shape and location adjustments may be required to keep the uniformity as desired.

Using the four point probe gives accurate film thickness and uniformity information.

Using Kapton tape and Tencore P2 can give misleading and incomplete results.



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REFERENCES

1. Dr. Lynn Fuller's Webpage
2. http://microlab.berkeley.edu/text/SarahIp.pdf
3. CDE users manual