ResMap Four Point Probe

User Manual

CDE

Creative Design Engineering, Inc.

ResMap Four Point Probe

User Manual

Creative Design Engineering, Inc.

CDE

20565 Alves Drive
Cupertino CA 95014
USA

Telephone: 408-736-7273

– Safety

General Safety Information

Operators and service personnel must be aware of all hazards associated with this system. They must know how to recognize and avoid dangerous and potentially dangerous situations. Improper or careless operation of the CDE ResMap Four Point Probe Resistivity Mapping System can have serious consequences. Service and maintenance of this system must be conducted by trained personnel. Every service person must read and thoroughly understand this manual before installing or servicing the system. All warnings and cautions should be read carefully and strictly observed.

The CDE ResMap Four Point Probe Resistivity Mapping System meets SEMI S2 requirements and follows the SECS equipment design checklist to mitigate ergonomic risks when applicable. All electrical components and wiring are designed to conform to electrical codes in effect at the time of assembly.

The CDE ResMap system is a metrology tool. It does not involve chemicals or environmental hazardous materials, ionizing or non-ionizing radiation, laser products, hot surfaces or fire hazardous systems. It is cord connected equipment, which may be unplugged for a Lockout/Tagout (LOTO) procedure. The ResMap system consists of the ResMap mapping unit and the computer processor unit with interfaces, including monitor, keyboard, mouse and printer. See the ResMap Service Manual for a description of the facilities involved.

The ResMap system has an “Emergency Off” (EMO) circuit which, when activated, places the equipment into a safe shutdown condition. The red EMO switch is mounted over a yellow background for easy visibility. Software checks are included in the system to detect improper operation, alert the operator, and interlock moving faults and/or operation sequencing faults. Always keep hands away from moving parts.

Hazard warning labels for hazards associated with electrical shock and moving parts or pinch points as illustrated in the next section are posted on the ResMap system to call attention to potential dangers.

Hazard Warning Labels

Shown below are examples of the hazard warning labels posted on the ResMap system.

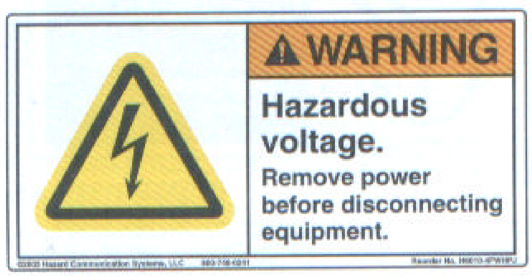
These labels are defined in Semi 13 as follows:

- “Caution” -- Indicated a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.
- “Warning” – Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
- “Danger” -- Indicates an imminently hazardous situation which, if not avoided, could result in death or serious injury

All CDE ResMap hazards are in the “Caution” category.

Mechanical Hazards:

Electrical Hazards:



Safety Instructions

Follow these safeguards when working on any CDE ResMap system

Familiarize yourself with the location of the emergency OFF (EMO) button on the system before working with the system. The red switch is mounted over a yellow background and is located at the front of the ResMap mapping unit.

Identify and observe all safety labels for electrical hazards and mechanical hazards on the system.

Ensure all the equipment and accessory electrical units are grounded to facility ground.

Use extreme caution whenever a shock hazard is present. As a safety precaution, always expect a hazardous voltage in an unknown circuit before measuring. Never connect or disconnect any cable or connections while power is applied to the component to which they are attached.

Do not operate any electrical component without its covers or panels installed. Only qualified persons aware of the electrical hazards should perform maintenance and troubleshooting.

Do not bypass electrical interlock or safety devices unless specifically required within a procedure and with proper training in such a procedure.

Be extremely careful when working around any parts that may move expectedly or unexpectedly, such as robot blade, stage, FOUP door, etc. Never get into the path of moving parts on the system during operation. In the case of incident causing potential injury, push the EMO button to activate the shutdown of the equipment.

Make sure the system is properly secured at its location based on your facility design and reasonably leveled during installation prior to operation.

The location and height of monitor display can be chosen and optimized by the user. It is recommended to be in the range of 52”-58” (130 - 150 cm) as measured from the floor to the center of screen.

During any emergency, push the EMO button to activate the shutdown of the equipment and follow the emergency procedures and instructions from the lead person in your area.

Adequate access and clearance requirements:
At lease 36” (91 cm) front to back clearance and 30” (76 cm) shoulder clearance is needed in front of all electrical enclosures or where electrical work is to be performed.

Electrical Inlet to CDE ResMap:
Electrical inlet with at least 4 receptacles must be provided. These receptacles must have on-off switch and circuit breaker is required to be UL 489 listed (or equivalent) and have a minimum 5,000 AIC rating. The total current is 10Amp for 115VAC or 5Amp for 230VAC.

Main Electrical Disconnect
The cord and plug is the main electrical disconnect. The plug should be installed at a height between 0.6 m and 1.9 m (24” and 75”). The plug should be installed where it is plainly visible to the operator and easily accessible.

SEMI S8 SESC Checklist:
Height of the cassette load position to be between 35” and 40” (89 cm and 102 cm). Since the CDE ResMap 168 is a table-top system. Its load height to the table top is 8” (20cm). The table height should be set accordingly.

The height of the monitor is to be 58” and 52” (147 cm and 132 cm) for viewing in the standing position.

The height of the mouse and keyboard is to be 40” and 38” (102 cm and 96 cm).

The height of the EMO button should be located between 33” and 64.5” (84 cm and 164 cm) , note this is automatically satisfied if the height of the ResMap is set of proper height table top above.

Turn On and Turn Off the ResMap system:
To turn of the ResMap system, simply power up the computer [push in Green power switch located in front of the computer) and the ResMap (push in the green power on button). The computer will automatically launch the ResMap software (turn key).

To turn off the ResMap system: You should (but not necessary) shut down the computer by clicking: **`start + Turn Off Computer + Shut Down`**. Turn off the ResMap by pushing the Off [Red 0] button, the motor power take about 2 seconds to bleed off the stored energy in the capacitor.

The EMO can be activated by pushing in the EMO button. This shuts off the power to the ResMap (note the computer and the monitor is not shut of – see the “**Live after EMO”** label). The EMO button will be locked in the off position. After the emergency has been fixed, re-energize the EMO switch by rotating to the right about ¼ turn and it will pop out and then reenergize the ResMap by pushing the green On button.

To perform repairs, before opening the ResMap skins. Unplug the power input cord to disconnect all live power into the ResMap. Same is true for servicing the computer or the monitor.

Facilatization of the ResMap system:
The electrical inputs to the system needed are 2 standard power input cords (to be provided by the user for his locality if it is not the same as the US plugs, these plug and cords should be rated at 10A or higher and should be UL (or equivalent) listed. The cords are plugged into the ResMap (115V 4A or 230V 2A 50/60Hz AC) or the computer 115V 4A or 230V 2A 50/60Hz AC).

The only other facility needed is house vacuum (on the ¼” outer diameter flexible plastic tubing) the vacuum spec is about 0.1 atm or 76 cm of Hg.

– General Information

Introduction

In this chapter, we shall give some background information about Four Point Probe techniques and applications, probe configurations, thickness and temperature corrections to the measured Rs, the figure of Merit, probe types, ResMap models, the coordinate systems used in the ResMap, and a useful Windows utility.

What is a Four Point Probe?

A 4 point probe measurement tool is a precision instrument for measuring sheet resistance (or Rs) in a conductive media (usually a thin film for the semiconductor applications). The unit expressed is generally called Ù/☐ or ohms per square. The symbol ☐, or square, is not a unit like cm^2, it is just a way to express the measure of a sheet or semi-large (compared with the dimension of a probe) area.
The 4 point probe has 4 pins [#1, 2, 3 & 4] in contact with the conductor sample. Two pins apply a current and the voltage is measured across the other two pins. For our applications, the 4 pins are in a straight line with equal spacing (typically 1-mm). The pins are made of metal, typically Tungsten Carbide, with pointed tips. The tips have radii of between 40 ì m to 500 ì m (0.0016” to 0.0200”, or 1.6 to 20 mils). The pins are located in a housing called a probe. It is loaded axially with springs, with forces typically of 100g. When the pins are pressed onto the sample, the spring is compressed so the pins are retracted (pushed) into the housing in order to make a good electrical contact for measurement. Later, we will show that this contact is very important.
If one induces a current I14 between pins 1 and 4, and measures the resulting voltage V23 between pins 2 and 3, then the sheet resistance is

$$Rs = \pi/\ln 2 * V_{23}/I_{14} = 4.532\ V_{23}/I_{14} \qquad (1)$$

Modern techniques allow measurement of Rs to a very high accuracy (±0.5%) and very high precision (Repeatability ±0.1%).

Types of Measurements

The 4 point probe measures sheet resistance Rs directly for many applications such as implant films, metal films, doped silicon, and epitaxial layers. One either adopts or forces to adopt Rs as the native unit. One can derive other units such as film thickness w, or bulk resistivity ñ from sheet resistance.

Film thickness

The thickness of a metal film cannot usually be measured optically like a dielectric film because it is, in general, not transparent to light. The sheet resistance measurement can be used to calculate film thickness. If one assumes the film behaves like a bulk material (or the electrical and mechanical properties do not change in the film within the thickness range), then one can express the thickness as

w = ñ/Rs (2)

where ñ is the bulk resistivity. Many films, however, do not behave nicely and ñ is not uniform within the thickness of the film. If we assume that ñ decreases as a function of thickness buildup (typical within the first few hundred Angstroms) then one can express the thickness as

w = ñ´ $Rs^{â}$ (3)

As an example for CVD W film, the thickness in Å can be expressed as $w = 1950.1\ Rs^{-0.65567}$ (with Rs in Ω/☐), within certain ranges of thickness. Following is a table of commonly used parameters as provided by Sematech, after much characterization:

Film	**r¢**	**b**
Ti	3652.99	– 0.689
TiN	3233.58	– 0.629
W	1950.1	– 0.65567
Al	337.17	– 0.92041
Cu	479.13	– 0.75681
	$w = \rho' Rs^{\beta}$	

In general, people often express Rs as basic measurement unit for metal films. In applications for film removal, such as etch back or a CMP process, one must first convert the Rs measurement to film thickness before subtracting to determine the removal rate and uniformity. One cannot subtract pre-Rs from post-Rs directly.

Bulk resistivity

Other applications of the four point probe are to determine bulk resistivity ñ, since ñ = Rs * w.
The thickness of a doped bare silicon wafer, w, can be measured mechanically. With this, one can calculate ñ from a measurement of Rs.
For epi films, one can also determine the resistivity ñ. In this case, the epi thickness w is typically measured with an FTIR type instrument.

Probe Configuration: Single vs. Dual

On page 1 above, we introduced the 4 point probe measurement principle. We have:

$$Rs = \pi/\ln 2 * V_{23}/I_{14} = 4.532\ V_{23}/I_{14} \qquad (1)$$

We flow current through pins 1 and 4 and we measure voltage across pins 2 and 3. We call this probe configuration A. We can also flow current through pins 1 and 3 and measure voltage across pins 2 and 4. We call this probe configuration B. We will rewrite equation (1) for the two configurations.

Probe Configuration	**Rs = V/I**
A:	$R_A = V_{23}/I_{14}$
B:	$R_B = V_{24}/I_{13}$
[1]: Single Configuration:	$Rs[1] = 4.532\ R_A$
[2]: Dual Configuration:	$Rs[2] = \{-14.696 + 25.173\ (R_A/R_B) - 7.872(R_A/R_B)^2\}\ R_A$

Besides a complicated equation, the dual configuration does offer some advantages as well as some penalties. These are summarized in the following table:

Advantage of Single Configuration	**Advantage of Dual Configuration**
Fast	Corrects for pin wobbling
Better Signal to Noise Ratio	Can measure closer to sample edge

In general, one should use dual configuration. One should try single configuration in difficult situations, for example, if there is too much noise (low merit), or if you are measuring thick conductors such as slugs or substrates with w/S > 0.5, where w = the thickness of the conductor and S = the pin spacing of the probe.

Corrections to Rs

In this section we present thickness and temperature corrections to the measured Rs.
Temperature Compensation
If the temperature is known during measurement, then we can correct the results to another temperature, usually 23°C, using the Temperature Coefficient of Resistivity [TCR]. The formula is linear:

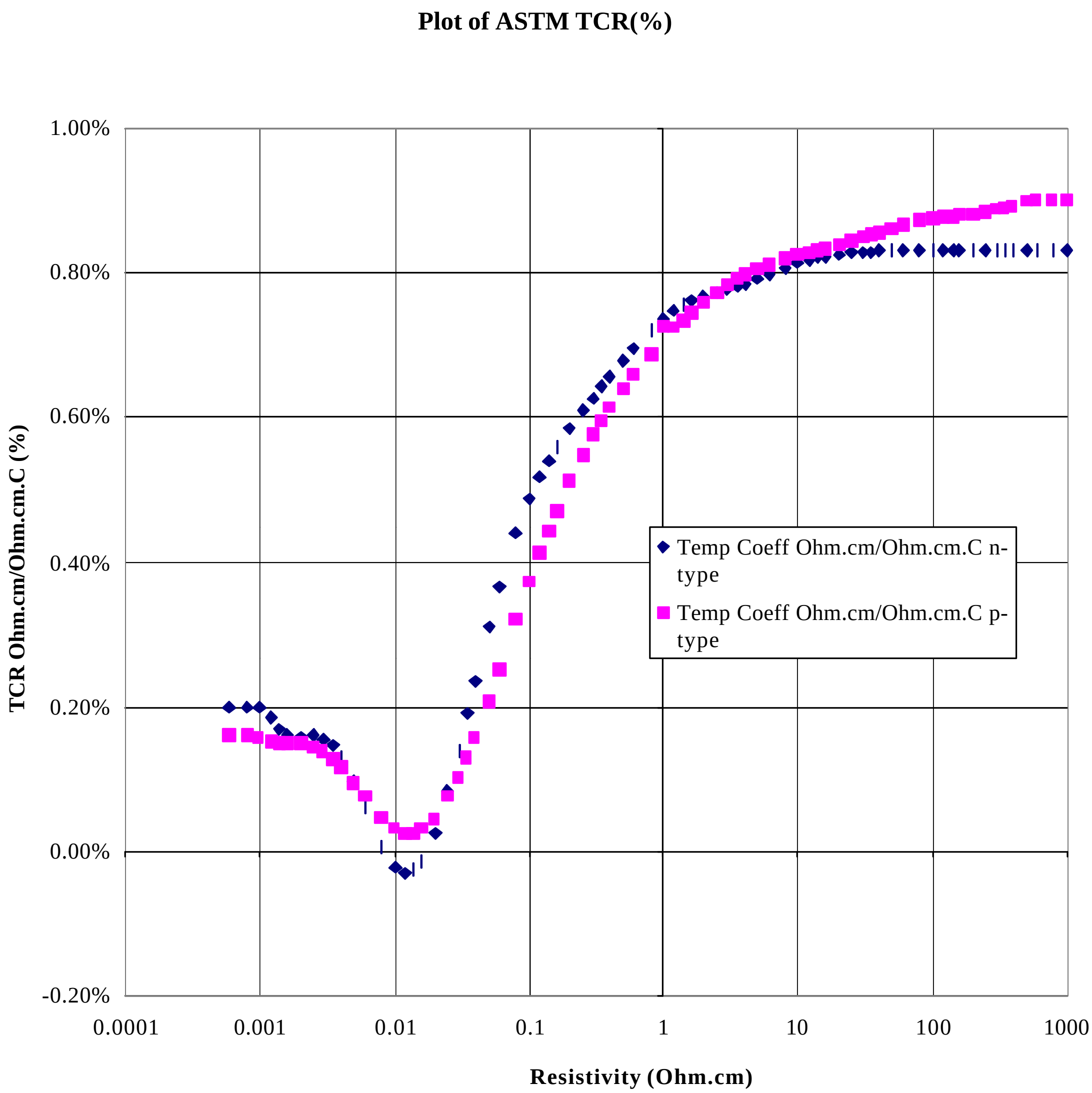
$$\rho(\text{at } 23°C) = \rho(\text{at temp } T) * [1 + (23 - T) * TCR]$$

TCR is in units $\Delta\rho$/C°.
There is a thermocouple to measure the chuck temperature, and the ASTM-F84 table of TCR has been implemented in the software, and will be applied if Automatic has been selected. Shown below are a table and a graph of the ASTM-F84 temperature correction values.

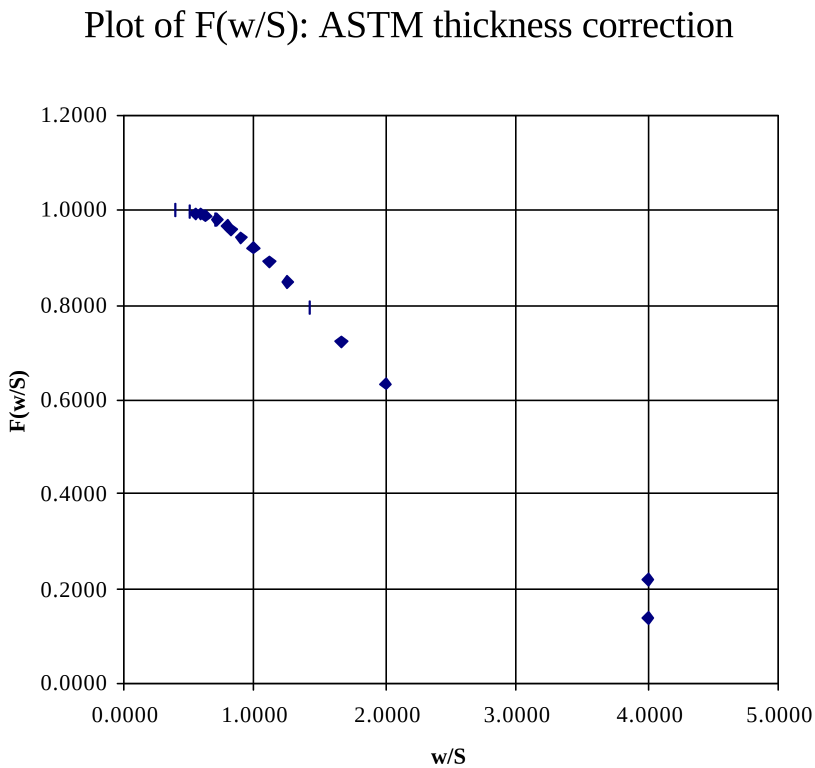
ASTM F84 TCR between 18C and 28C

Resistivity	**TCR (%)**		**Resistivity**	**TCR (%)**	
Ohm.cm	**n-type**	**p-type**	**Ohm.cm**	**n-type**	**p-type**
0.0006	0.200%	0.160%	1.0	0.736%	0.727%
0.0008	0.200%	0.160%	1.2	0.747%	0.722%
0.0010	0.200%	0.158%	1.4	0.755%	0.734%
0.0012	0.184%	0.151%	1.6	0.761%	0.744%
0.0014	0.169%	0.149%	2.0	0.768%	0.759%
0.0016	0.161%	0.148%	2.5	0.774%	0.773%
0.0020	0.158%	0.148%	3.0	0.778%	0.783%
0.0025	0.159%	0.145%	3.5	0.782%	0.791%
0.0030	0.156%	0.137%	4.0	0.785%	0.797%
0.0035	0.146%	0.127%	5.0	0.791%	0.805%

ASTM F84 TCR between 18C and 28C					
Resistivity	**TCR (%)**		**Resistivity**	**TCR (%)**	
Ohm.cm	**n-type**	**p-type**	**Ohm.cm**	**n-type**	**p-type**
0.0040	0.131%	0.116%	6.0	0.797%	0.811%
0.0050	0.096%	0.094%	8.0	0.806%	0.819%
0.0060	0.060%	0.074%	10	0.813%	0.825%
0.0080	0.006%	0.046%	12	0.818%	0.829%
0.010	-0.022%	0.031%	14	0.822%	0.832%
0.012	-0.031%	0.025%	16	0.824%	0.835%
0.014	-0.026%	0.025%	20	0.826%	0.840%
0.016	-0.013%	0.029%	25	0.827%	0.845%
0.020	0.025%	0.045%	30	0.828%	0.849%
0.025	0.083%	0.073%	35	0.829%	0.853%
0.030	0.139%	0.102%	40	0.830%	0.857%
0.035	0.190%	0.131%	50	0.830%	0.862%
0.040	0.235%	0.158%	60	0.830%	0.867%
0.050	0.309%	0.208%	80	0.830%	0.872%
0.060	0.364%	0.251%	100	0.830%	0.876%
0.080	0.439%	0.320%	120	0.830%	0.878%
0.10	0.486%	0.372%	140	0.830%	0.879%
0.12	0.517%	0.412%	160	0.830%	0.880%
0.14	0.540%	0.444%	200	0.830%	0.882%
0.16	0.558%	0.471%	250	0.830%	0.884%
0.20	0.585%	0.512%	300	0.830%	0.886%
0.25	0.609%	0.548%	350	0.830%	0.888%
0.30	0.627%	0.575%	400	0.830%	0.891%
0.35	0.643%	0.596%	500	0.830%	0.897%
0.40	0.656%	0.613%	600	0.830%	0.900%
0.50	0.678%	0.639%	800	0.830%	0.900%
0.60	0.696%	0.659%	1000	0.830%	0.900%
0.80	0.720%	0.687%			



Sample Thickness Corrections
When the sample or conducting layer is very thick, a correction should be applied to the Rs measurement. Shown below is a table of the ASTM correction factor, F(w/S) as a function of w/S, where w = conducting layer thickness (film or substrate), and S = probe pin spacing. If w is less than about half the pin spacing, the correction is unity.



w/S	F(w/S)	
0.4000	0.9995	
0.5000	0.9970	
0.5550	0.9948	
0.6000	0.9920	
0.6250	0.9898	
0.7000	0.9820	
0.7143	0.9798	
0.8000	0.9660	
0.8333	0.9600	
0.9000	0.9440	
1.0000	0.9210	
1.0000	0.9214	
1.1111	0.8907	
1.2500	0.8490	
1.4286	0.7938	
1.6666	0.7225	
2.0000	0.6336	
4.0000	0.1386	S=1.0 mm
4.0000	0.2201	S=1.6 mm

We have also implemented the J.I.T. and Yamishita methods for thickness and edge corrections.

Merit

Merit or Figure of Merit is an indicator made during data collection of the quality of a measurement. Because of the statistical and digital technology adopted for the CDE ResMap system, for each Rs measurement, the ResMap computer takes many samples -- as many as 4000 samples at different voltages and current levels. The resulting Rs is the slope of the Vin[pins 2,3] vs. Iout[pins 1,4]. Rs is calculated from a linear least squares fit of these samples. We also incorporate the range of each curve, due to limited range available for the Analog to Digital or Digital to Analog converters. The wider the range is, the finer the resolution for each measurement. We therefore empirically define Merit (sometimes called Figure of Merit) to be:

$$Merit = k * Ndata *. Vr\text{-}in^2 *. Ir\text{-}out *. Vr\text{-}drive / c^2$$

where: *k* = constant
Ndata = # of samples,
Vr-in = Vin [pins 2,3] range,
Ir-out = Iout [pins 1,4] range,
Vr-drive = Vdrive out range, and
c^2 = average distance squared from fit line to each data point (the smaller the better).

The constant *k* is empirically adjusted so that an acceptable measurement yields a Merit of 1. Merit greater than 1 is better. Likewise, for Merit less than 1, the measurement is worse; for Merit = 0.1, the measurement is less reliable, and perhaps unacceptable.

Applications:

There are many applications using Merit. We will only illustrate a few here. As time goes on and more new applications are developed, we will add them to the list here.

1. Initial setup for Gain and Rref parameters: During the Initialization phase when measuring a wafer, the ResMap control system checks many Rref and Amplifier gain combinations to find the optimum Merit for the best operating conditions.
2. Check for probe performance: If *Merit* deceases after some time, it could be due to degradation from contamination. In this case, one can recondition the probe by using the ceramic plate to clean the probe tips (see the section on **Error! Reference source not found.** in **Error! Reference source not found.**, page **Error! Bookmark not defined.**).
3. Determine the correct probe to use: What is the correct probe to use for a given film? Usually the supplier gives some kind of guidance. To optimize the probe selection, there is a function called **Rs and *Merit* vs. Probe pin pressure**, in which we measure the Rs and *Merit* as we vary the pin compression distance or the pin pressure. One can easily choose the optimum probe from these measurements by examining the measurement process window with respect to different type of probes.
4. Mapping of *Merit* on wafer to check film: A contour map of *Merit* can be performed on a wafer to check the *Merit* distributions. The variations could be due to surface condition changes, doping level changes, etc. The recipe should be set to Mode 10 to execute this function.

Types of Probes; How to Choose

Typically, the linear array 4 point probe is specified by the following parameters:

Pin material	Typically Tungsten Carbide
Pin spacing	Typically 40 mil (1mm); others available: 20 mil, 25 mil, 63 mil, etc. (1 mil = 0.001 inch = 25.4 μm)
Pin tip radius	Typically Radii: 40μm, 100μm, 200μm, 500μm, etc.
Pin compression force	Typically 100 gm to 200 gm, 70 gm on D/70 probe.

For most of the probes used, the most important feature is the tip radius, which affects the penetration or contact pressure. The following is a summary of the most commonly used probe types:

Type	Tip Radius	Force	Spacing	Typical Applications
A	40μ (1.6mil)	100g	1.0mm (40 mil)	Metal film
B	100μ (4 mil)	100g	1.0mm (40 mil)	General metal, high dose implant
C	200μ (8 mil)	100g	1.0mm (40 mil)	Medium dose implant [Rs ≈ 1000 Ω/☐]
D/70	500μ (20 mil)	70g	1.0mm (40 mil)	Low dose implant and shallow implant. Very thin metal film such as TiN, Ti, etc.
E	40μ (1.6mil)	200g	1.6mm (63 mil)	Thick substrate: doped silicon wafers, diffusion
F	40μ (1.6mil)	100g	0.635mm (25 mil)	Similar to A probe for smaller [2mm] edge exclusion, higher resolution mapping
G	100μ (4 mil)	100g	0.635mm (25 mil)	Similar to B probe for smaller [2mm] edge exclusion, higher resolution mapping
H	200μ (8 mil)	100g	0.635mm (25 mil)	Similar to C probe for smaller [2mm] edge exclusion, higher resolution mapping
FC	100μ (4 mil)	100g	0.5mm (20 mil)	Similar to A probe for even smaller [1.5mm] edge exclusion, higher resolution mapping
GC	200μ (8 mil)	100g	0.5mm (20 mil)	Similar to C probe for even smaller [1.5mm] edge exclusion, higher resolution mapping

ResMap Models

The CDE ResMap is a series of automatic resistivity mapping systems for various applications. The models and specifications are listed in the table below.

Features common to all models:

- AC Power: 50Hz to 60Hz, 110V to 240V, <10kVA.
- Computer System: Pentium class or equivalent 1.0 GHz, 3.5” diskette, 40 GB hard drive, CD-ROM, Color Monitor, Color Inkjet Printer, Win 98 now, 2003 also NT, XP.

- Measurement Range: 2m Ù/☐ - 5M Ù/☐ (can be optimized to reach down to 1m Ù/☐).
- Repeatability, 1 Sigma typical:
  - Static or ResPak: ±0.02%
  - Nearby sites: ±0.1%
- Accuracy: < ±0.5%
- Typical measurement time: 1 second per site.
- Minimum edge exclusion: <1.5mm
- Mapping patterns: Area (polar), Rectangular, Line, User defined (up to 1000 sites per map)
- Plots: Contour, 3D, Linear (Diameter), Data Values on Wafer, Histogram, Data Sequence Distribution,
- Data Radial Distribution, Data Angular Distribution, Trend Charts, etc.
- Data files portable to Spread Sheet [e.g. EXCEL], Word Processor, Main Frame, Work Station, Apple, etc. Data maps can be spliced together for mapping larger samples in pieces.
- SECS II/HSMS option and POD-ID (Asyst IR & RF ID interface) option available
- Lifetime FREE software upgrades.

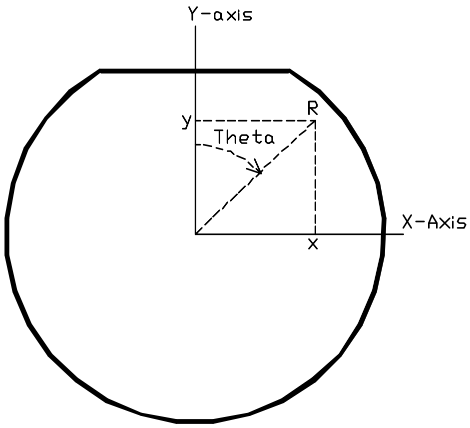
CDE ResMap 4 Point Probe Product Comparison

Model	**ResMap 168**	**ResMap 178**	**ResMap 273**	**ResMap 468-SMIF**	**ResMap 463-FOUP**	**ResMap 463-OC**
Feature:	Auto Cassette Load	Manual Load "Baby"	Manual Load 12" ('**B**ig Slice')	Floor Standing, 8" SMIF, Mini-Environment, Dual/Quad Probe Changer	Floor Standing, 12" FOUP, Mini-Environment, Dual/Quad Probe Changer	Floor Standing, 6"-12" Auto Cassette Load, Dual/Quad Probe Changer
Wafer Size:	4" - 8" Auto Load	2" - 8" Manual Load	2" - 12" Manual Load	6", 8" Auto Load 2"-12" Manual Load	12" Auto Load 2"-12" Manual Load	12", 8" & 6" Open Cassette, Auto Load
Max Round Sample: **Max Square Sample:**	8.2" ϕ 5.8" x 5.8"	8.2" ϕ 5.8" x 5.8"	8.2" ϕ 5.8" x 5.8"	15" ϕ 10.5" x 10.5"	15" ϕ 10.5" x 10.5"	15" ϕ 10.5" x 10.5"
Typical Wafer Transport time (each way):	10-sec	N.A.	N.A.	8-sec	8-sec	10-sec
Maximum Throughput	40 wph (49-sites), no NF	1-min per wafer (49-sites)	1-min per wafer (49-sites)	40 wph (49-sites) with NF	40 wph (49-sites) with NF	36 wph (49-sites) with NF
Size: Width x Height x Depth	12"W x 10"H x 26"D	12"W x 10"H x 18"D	15"W x 10"H x 18"D	22"W x 60"H x 44"D	22"W x 60"H x 44"D	22"W x 52"H x 44"D

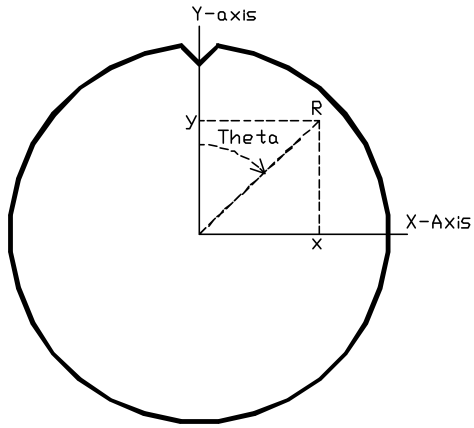
Coordinate Systems

Coordinate system on the wafer:

The coordinate system on the wafer is shown in the following figure. This places zero degrees at the flat or notch. The Y-axis increases towards the flat or notch, and if the flat or notch is up, the X-axis increases to the right.



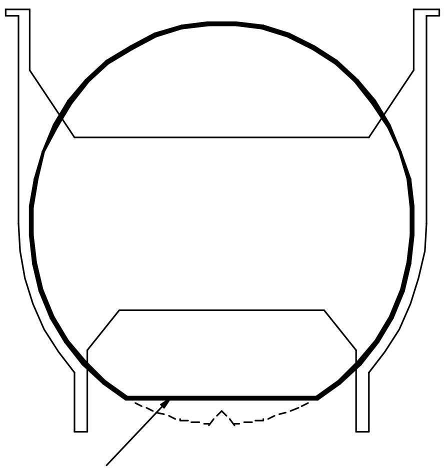
Wafer with Major Flat



Wafer with Notch

The Z axis comes out of the front surface of the wafer.

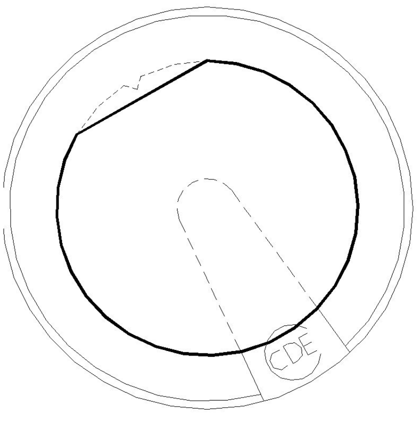
Coordinate system for the Cassette:



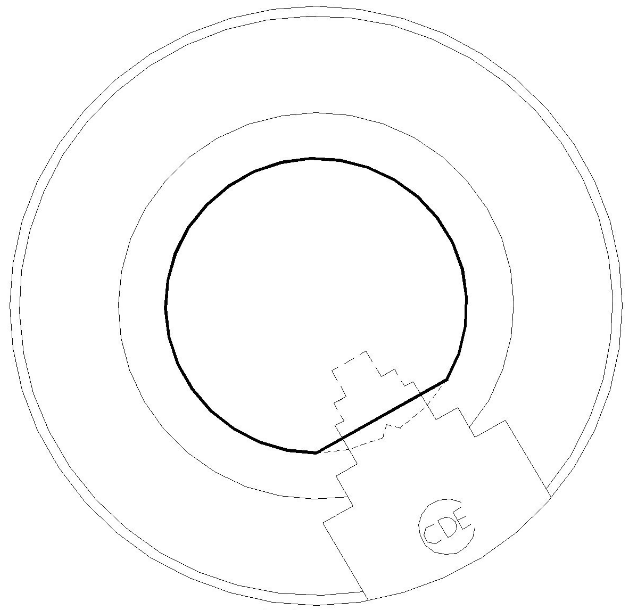
Wafer with Flat or Notch Down in Cassette

The nominal alignment is for the wafer with its flat down as shown. This can be changed in the Motion Coordinate Parameter file to any alignment desired.

Wafer Alignment on the wafer chuck:
Most ResMap systems (178, 168, 468, and 463) use the same orientation of the chuck, and by default define zero degrees to be opposite the slot for the robot blade. The 12" manual ResMap 273 alignment is opposite to the others, so the blade slot is at zero degrees. This is shown in the following figures. This orientation may be changed by the user.



ResMap 168, 178, 468, 463



ResMap 273

Shown above are ResMap chucks in the park position for ease of manual loading and unloading of wafers.

Useful Windows Utility – Screen Shots

Most of the CDE ResMap screens such as contour plots, diameter plots, etc. can be printed directly with the print button. However, there are other ResMap screens that do not have a printing button, such as repeatability data, etc. In this case, one can use the windows screen shot utility.

On the screen you want to print, key Alt+PrintScreen, this will copy the screen into the clipboard. Then go to WordPad (a Win 95 and 98 utility: click Start… Programs… Accessories… WordPad), do a paste (Edit… Paste or Ctrl+V). The ResMap screen is pasted into the WordPad document. Note: you can also use MS Office Word instead of WordPad if you have it in your system. The Office 97 Word document is in general much smaller than WordPad and has more functions. Now you can either print the WordPad or Office Word document or save it. If you choose to save it, then you can paste more than one screen and add text to make a report.

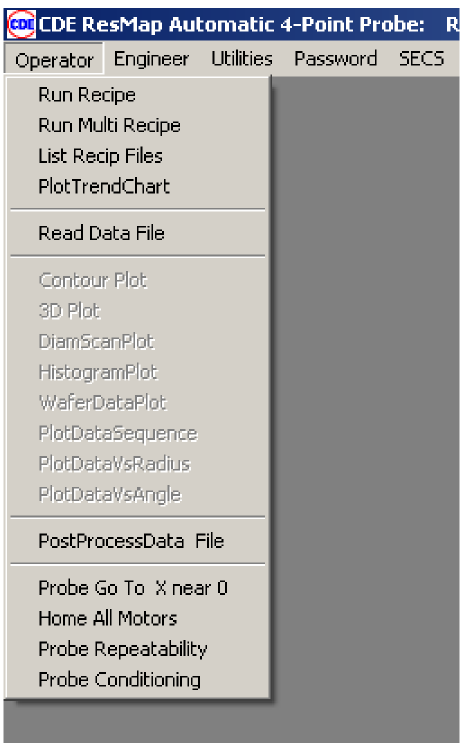
– *Operator Menu*

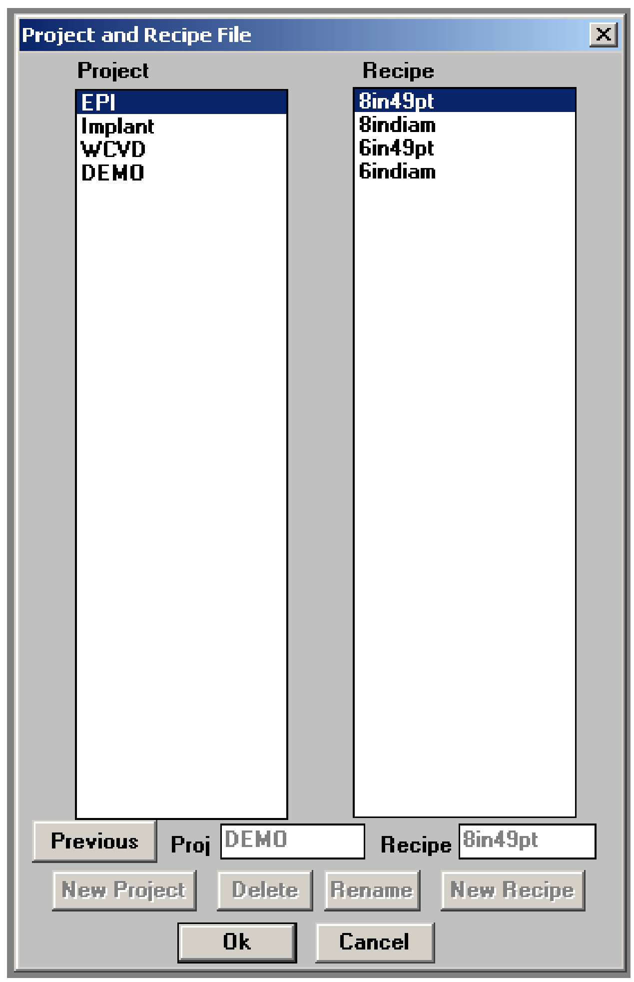
In this chapter, we will describe functions accessible through the Operator pull-down menu. These include all the routine tasks an operator might need to perform, such as how to make measurements using a recipe, how to display various graphics such as contour map, 3D map, trend charts, etc., how to monitor ResMap performance by measuring repeatability, and how to condition the probe. No password is needed to perform operator functions. The Operator pull-down menu is shown in the figure below. Each of the commands will be described in the order they appear.

Run Recipe

The simplest way for an operator to take data or map a wafer is to use a recipe. Recipes are created and modified in the Engineer menu; this is described in **Error! Reference source not found.** on page **Error! Bookmark not defined.** (**Error! Reference source not found.**). ResMap Recipes are organized in two levels: the upper level is a Project whose name is a folder, and the lower level is a sub-directory of the Project. Names for projects and recipes must be made of eight or fewer alphanumeric characters, like file names. We will describe these in detail in **Error! Reference source not found.**.

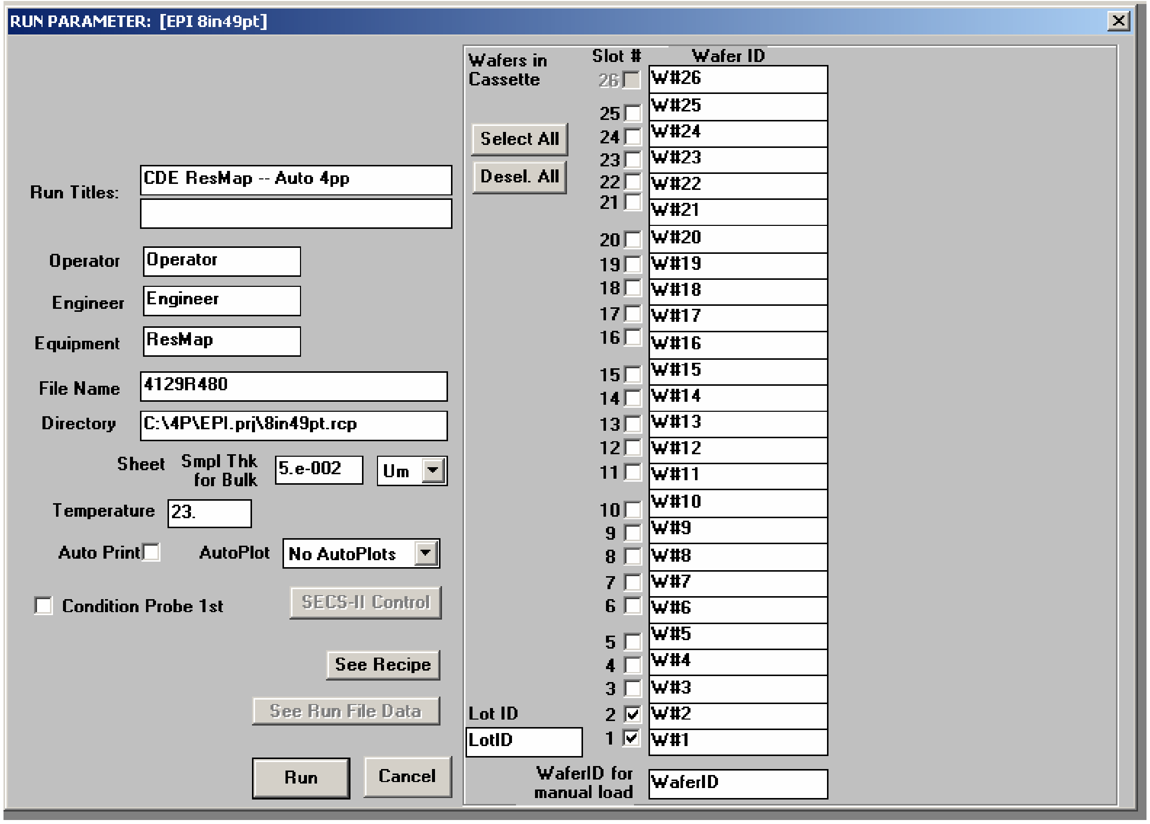
The operator selects **Operator… Run Recipe…** and then selects a **Project** and a **Recipe**, or clicks on the **Previous** button to repeat the previous recipe.





The operator enters run information in the **Run Parameter** screen shown below. Default values are provided for all fields (see descriptions below) except which slot.

The operator must select which slot(s) to measure, and may optionally enter a LOT ID or change any other field, then click the **Run** button to start the measurement. The **Cancel** button will return the user to the main screen.

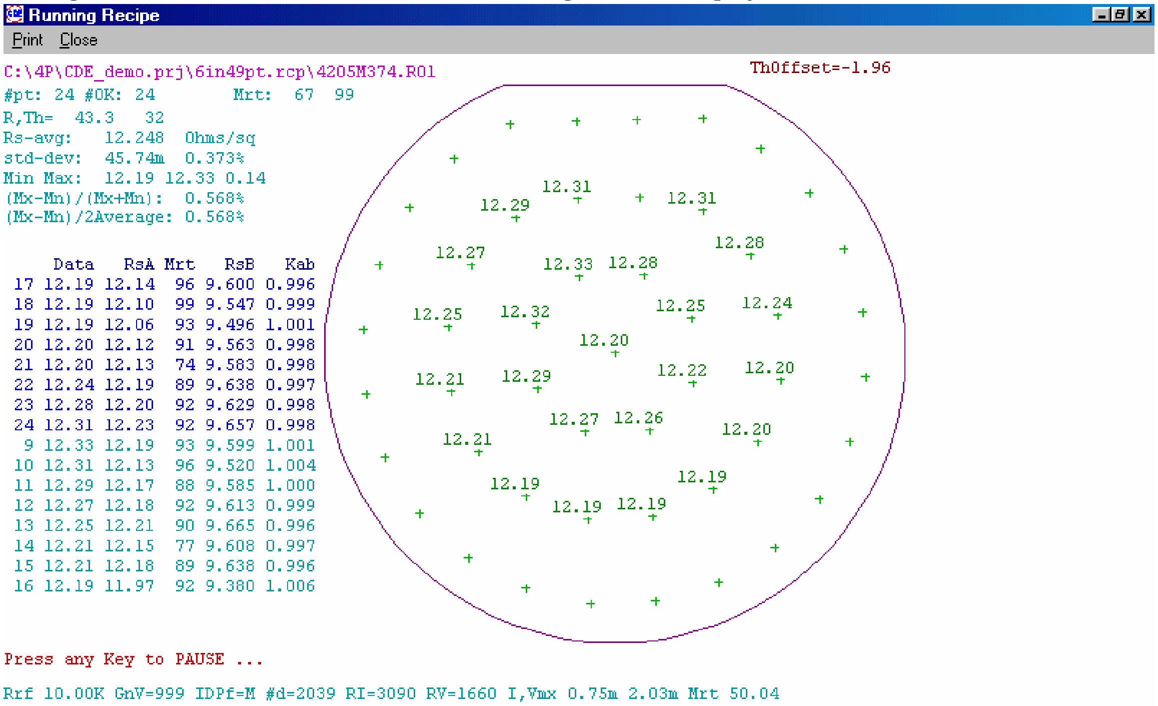


The fields **Run Titles, Operator, Engineer, Equipment** are all informational only and this information is included in the header of the data file. A default **File Name** is provided, but any valid file name may be entered by the operator (see below). The **Directory** corresponds to the recipe name, and ordinarily should not be changed. The Sample thickness is used only for bulk resistivity calculations; for **Smpl Thk**, the conducting layer thickness and units should be entered, which may be only the top layer, or the whole sample, depending on the type of sample. If temperature corrections are desired, and no sensor is present, the temperature may be entered. If **Auto Print** (text listing of the data values) or **AutoPlot** (contour/diameter, wafer data, or data sequence plot) is selected, the result will be printed automatically after the measurement is complete. If desired, the probe can be conditioned before the measurement starts by selecting the **Condition Probe 1st** check box. For more information about probe conditioning, see section 3.18 below. The operator can view the **Recipe Screen** by clicking the **See Recipe** button. The operator can not make any changes to the recipe but can switch back to the run parameter screen by clicking the **Cancel** button.

The measurement data are stored in a file on the hard drive in the selected recipe subdirectory. By default, the file name extension is .r## (with ## the slot number) on autoloader measurements, and .RSM on manual measurements. There are three options for file names:

1. If the operator does not enter a filename, the system automatically gives an eight character date-time code of the form YMDDhmms, such as 4A23G108, where Y = the last digit of the current year (4 = 2004), M=month in Hex (A=10 or October), DD is the day of the month, h=hour in alphabet (A = midnight, B=1:00 am, etc.), mm=minute, s=second/6. Note this style of file name always increases in time, and it advances every 6 seconds.
2. A file name can be entered by the operator in an eight character alpha-numeric format, such as MyData. After the run the file name will be automatically incremented to MyData_2, MyData_3, etc. for convenience.
3. The operator may enter the character string “none”. In this case the data will be stored to a file named “none”. The next time the name will be “none” again and this will overwrite the previous “none”. This means only the most recent run will be saved and all previous measurements will be overwritten.

For the Auto Cassette Load ResMap models ResMap 168, ResMap 468, and ResMap 463 the wafers to be measured are selected by clicking the Slot # boxes. If no wafers are selected, the system selects Manual Load automatically. For ResMap models 178 and 273, the wafer is always loaded manually. A Wafer ID can be entered near the bottom of the screen.
During data collection for each wafer, the following screen is displayed:

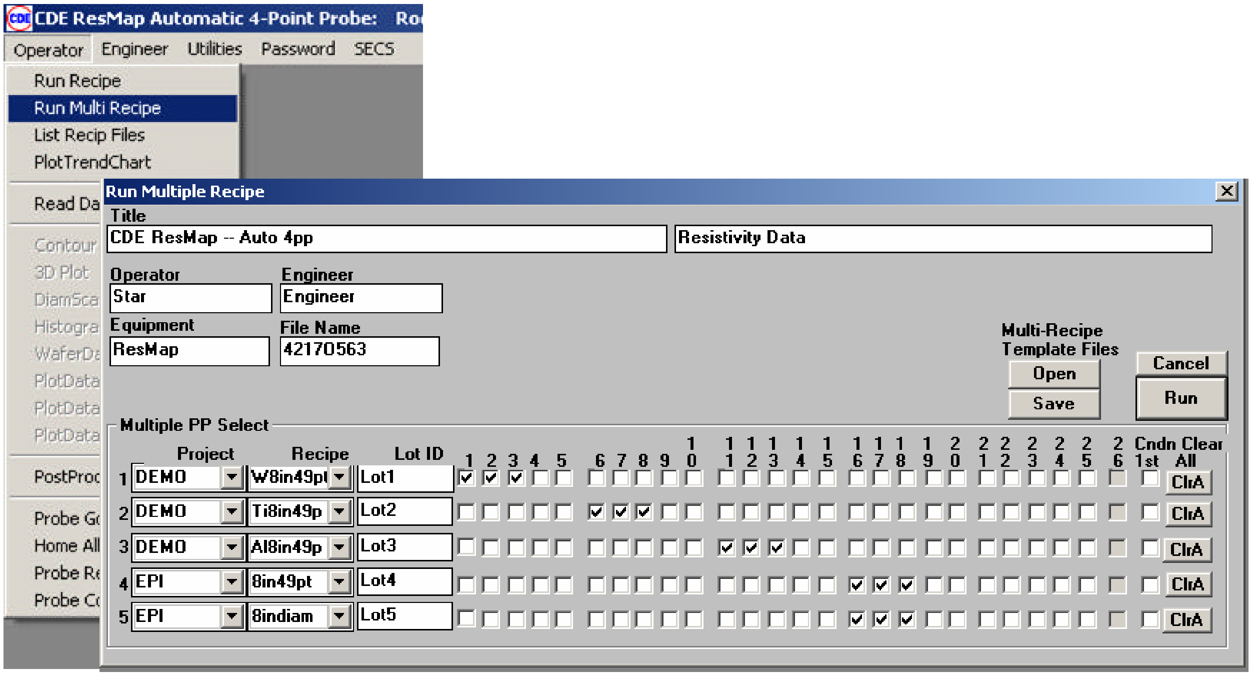


The **Running Recipe** screen shows a map of the wafer, and posts each data value as it is collected, both on the map, and in a list that also includes other information useful for diagnosis. The running statistics and relevant file information are displayed in the upper left corner.
If the sample is loaded manually, after the data collection is complete, the operator is prompted to continue, at which point the sample may be manually unloaded. On Autoloader systems, the operator is not prompted. The appropriate map (contour map or diameter scan, or none if the number of mapping points is less than five) will be displayed.
If **AutoPrint** was selected, a listing of all the data will be printed automatically after each run. If **AutoPlot** was selected, the corresponding map will be printed. Note that the plotting of the contour map takes a few minutes, which may slow down throughput.
On Autoloader systems, the ResMap software will not prompt the operator to continue after every sample. Instead, after the entire cassette is finished, a wafer summary screen is displayed.

Run Multi Recipe

This menu option permits the operator to run a series of up to 5 different recipes (under SECS II control, up to 25 different recipes, see SECS Manual). For example, you may have different types of wafers in a cassette, such as Ti, W, Al, etc. You can use a different recipe to convert Rs to thickness for each film. All recipes in a series must use the same wafer size, and use the same parameter files. For more about parameter files, see the description of the **Error! Reference source not found.** command on page **Error! Bookmark not defined.**of **Error! Reference source not found.**.

Choose **Operator… Run Multi Recipe…**



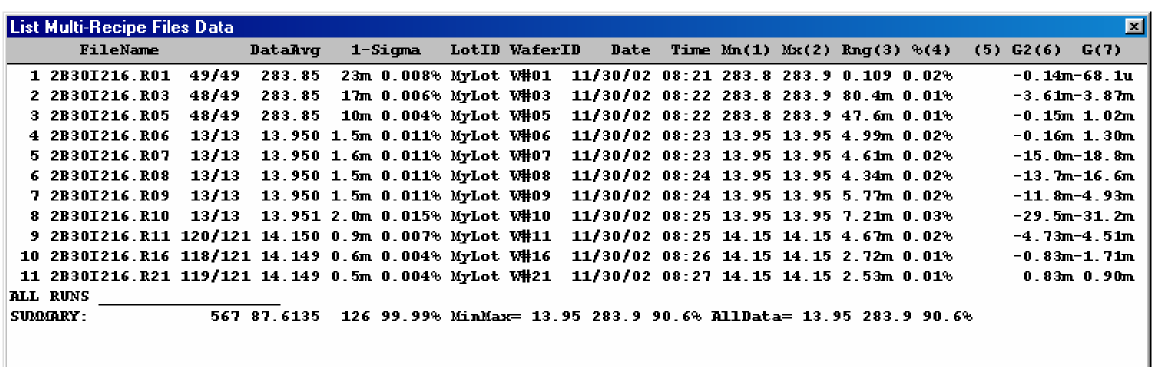
In addition to the **Title, Operator, Engineer, Equipment, and Filename** parameters, there is a **Multiple PP Select** box. You can choose up to five projects and recipes.

After you have entered your recipes, you can save the multi-recipe by clicking the **Save** button. You can select a previous file to write over, or enter a new file name. All the multi-recipe template files have the form *.MRp.

When you click the **Run** button, the recipe template will be automatically saved as _Last.MRp, to facilitate reuse of the previous multi-recipe.

If you want to run a previously saved recipe template, or the previous template _Last.MRp, you can click the Open button.

You get a Run File list at the completion of the run.



List Multi-Recipe Files Data

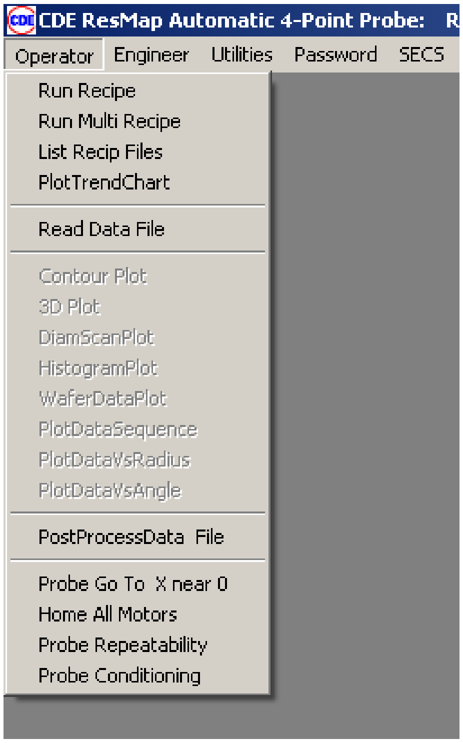
	FileName		DataAvg	1-Sigma		LotID	WaferID	Date	Time	Mn(1)	Mx(2)	Rng(3)	%(4)	(5)	G2(6)	G(7)
1	2B30I216.R01	49/49	283.85	23m	0.008%	MyLot	W#01	11/30/02	08:21	283.8	283.9	0.109	0.02%		-0.14m	-68.1u
2	2B30I216.R03	48/49	283.85	17m	0.006%	MyLot	W#03	11/30/02	08:22	283.8	283.9	80.4m	0.01%		-3.61m	-3.87m
3	2B30I216.R05	48/49	283.85	10m	0.004%	MyLot	W#05	11/30/02	08:22	283.8	283.9	47.6m	0.01%		-0.15m	1.02m
4	2B30I216.R06	13/13	13.950	1.5m	0.011%	MyLot	W#06	11/30/02	08:23	13.95	13.95	4.99m	0.02%		-0.16m	1.30m
5	2B30I216.R07	13/13	13.950	1.6m	0.011%	MyLot	W#07	11/30/02	08:23	13.95	13.95	4.61m	0.02%		-15.0m	-18.8m
6	2B30I216.R08	13/13	13.950	1.5m	0.011%	MyLot	W#08	11/30/02	08:24	13.95	13.95	4.34m	0.02%		-13.7m	-16.6m
7	2B30I216.R09	13/13	13.950	1.5m	0.011%	MyLot	W#09	11/30/02	08:24	13.95	13.95	5.77m	0.02%		-11.8m	-4.93m
8	2B30I216.R10	13/13	13.951	2.0m	0.015%	MyLot	W#10	11/30/02	08:25	13.95	13.95	7.21m	0.03%		-29.5m	-31.2m
9	2B30I216.R11	120/121	14.150	0.9m	0.007%	MyLot	W#11	11/30/02	08:25	14.15	14.15	4.67m	0.02%		-4.73m	-4.51m
10	2B30I216.R16	118/121	14.149	0.6m	0.004%	MyLot	W#16	11/30/02	08:26	14.15	14.15	2.72m	0.01%		-0.83m	-1.71m
11	2B30I216.R21	119/121	14.149	0.5m	0.004%	MyLot	W#21	11/30/02	08:27	14.15	14.15	2.53m	0.01%		0.83m	0.90m

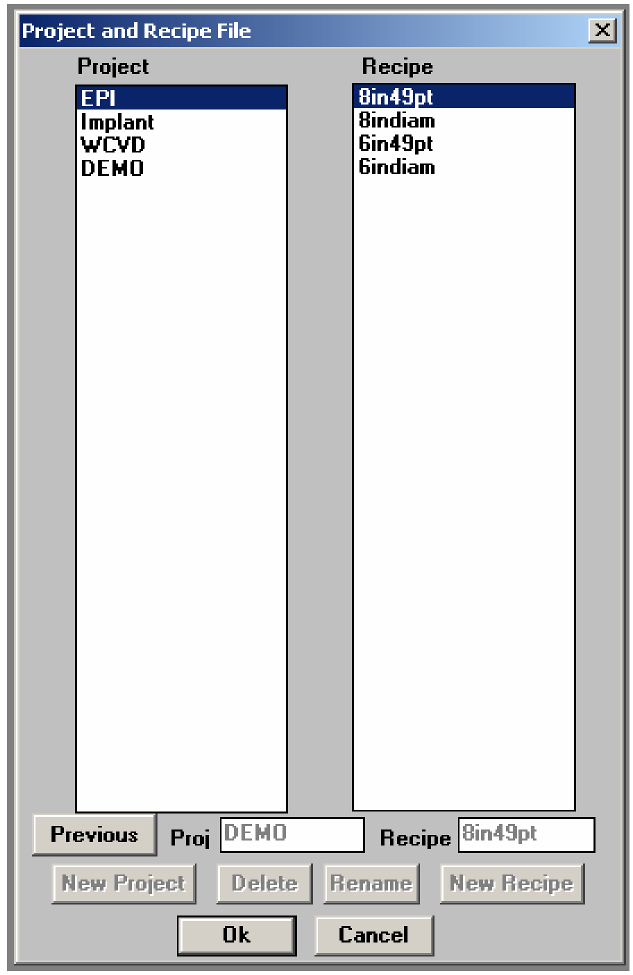
ALL RUNS

SUMMARY: 567 87.6135 126 99.99% MinMax= 13.95 283.9 90.6% AllData= 13.95 283.9 90.6%

List Recipe Files

This allows the operator to display the summary information for all the data files in the recipe. Select **Operator… List Recipe Files…** then select the **Project** and **Recipe** for the listing in the dialog box.





A list of all measurement results is displayed for each file, the overall data summary, and the data summary sorted by slot number. Manually loaded samples are treated as a single slot, and if there is only one run for a slot, the data will not be shown in the slot summary. Each summary line contains the Average, Standard Deviation of the Average for all runs from each slot (and manual load), Min and Max of average and for all data, as well as (Max–Min)/(Max+Min) % for both cases.

List Recipe Files Data: [TestMult | 8i3pNN]

	FileName		DataAvg	1-Sigma		LotID	WaferID	Date	Time	Mn(1)	Mx(2)	Rng(3)	%(4)	(5)	G2(6)	G(7)
1	3310I265.R01	2/3	452.34	47m	0.010%	Lot1	W#01	03/10/03	08:29	452.4	452.4	452.3			0.000	2.31m
2	3310I265.R03	3/3	452.34	17m	0.004%	Lot1	W#03	03/10/03	08:29	452.4	452.3	452.3			0.000	-6.32m
3	3310I265.R05	3/3	452.33	21m	0.005%	Lot1	W#05	03/10/03	08:29	452.3	452.3	452.3			0.000	7.97m
4	3310I310.R01	3/3	452.29	25m	0.006%	Lot1	W#01	03/10/03	08:31	452.3	452.3	452.3			0.000	8.50m
5	3310I437.R01	3/3	452.24	47m	0.010%	Lot1	W#01	03/10/03	08:43	452.2	452.3	452.2			0.000	4.70m
6	3310I491.R01	3/3	452.21	31m	0.007%	Lot1	W#01	03/10/03	08:49	452.2	452.2	452.2			0.000	8.85m
7	3310I491.R02	2/3	452.24	36m	0.008%	Lot1	W#02	03/10/03	08:49	452.3	452.3	452.2			0.000	13.5u
8	my_file.R01	2/3	452.25	43m	0.010%	Lot1	W#01	03/10/03	08:50	452.2	452.3	452.3			0.000	0.000
9	my_file.R02	2/3	452.23	8.3m	0.002%	Lot1	W#02	03/03/03	03:03	452.2	452.2	452.2			0.000	0.000
10	my_file.R03	3/3	452.22	45m	0.010%	Lot1	W#03	03/03/03	03:03	452.2	452.3	452.2			0.000	16.8m
11	123.R01	3/3	452.21	4.6m	0.001%	Lot1	W#01	03/03/03	05:35	452.2	452.2	452.2			0.000	1.60m
12	3303G203.R01	3/3	452.18	14m	0.003%	Lot1	W#01	03/03/03	06:20	452.2	452.2	452.2			0.000	-0.24m
13	my_file.R01	3/3	452.24	53m	0.012%	Lot1	W#01	03/10/03	12:24	452.2	452.2	452.3			0.000	13.3m
14	my_file.R02	2/3	452.24	40m	0.009%	Lot1	W#02	03/10/03	12:25	452.3	452.2	452.2			0.000	0.000
15	my_file2.R03	3/3	452.24	17m	0.004%	Lot1	W#03	03/10/03	12:27	452.3	452.2	452.2			0.000	-3.94m
16	my_file2.R04	2/3	452.22	17m	0.004%	Lot1	W#04	03/10/03	12:27	452.2	452.2	452.2			0.000	-0.43m
17	my_file3.R05	3/3	452.22	19m	0.004%	Lot1	W#05	03/10/03	12:28	452.2	452.2	452.2			0.000	5.30m
18	my_file3.R06	2/3	452.22	17m	0.004%	Lot1	W#06	03/10/03	12:28	452.2	452.2	452.2			0.000	-0.83m
19	3310M338.RsM	61/61	452.20	33m	0.007%	Lot1	W#04	03/10/03	12:33	452.1	452.3	0.146	0.02%		5.01m	3.26m
20	3310M357.RsM	61/61	452.20	24m	0.005%	Lot1	W#04	03/10/03	12:35	452.2	452.3	0.100	0.01%		2.39m	2.62m
21	3324H410.R01	3/3	4580.1	0.48	0.011%	Lot#1	W#01	03/24/03	07:41	4580	4580	4580			0.000	-12.2m
22	3324H410.R03	3/3	4580.4	0.64	0.014%	Lot#1	W#03	03/24/03	07:41	4580	4580	4581			0.000	6.22m
23	3324H410.R05	2/3	4580.7	0.88	0.019%	Lot#1	W#05	03/24/03	07:41	4582	4580	4580			0.000	0.000
24	3324H410.R07	3/3	4579.7	1.29	0.028%	Lot#1	W#07	03/24/03	07:41	4578	4580	4581			0.000	43.0m
25	3324H410.R09	3/3	4579.7	0.74	0.016%	Lot#1	W#09	03/24/03	07:41	4580	4581	4579			0.000	4.00m

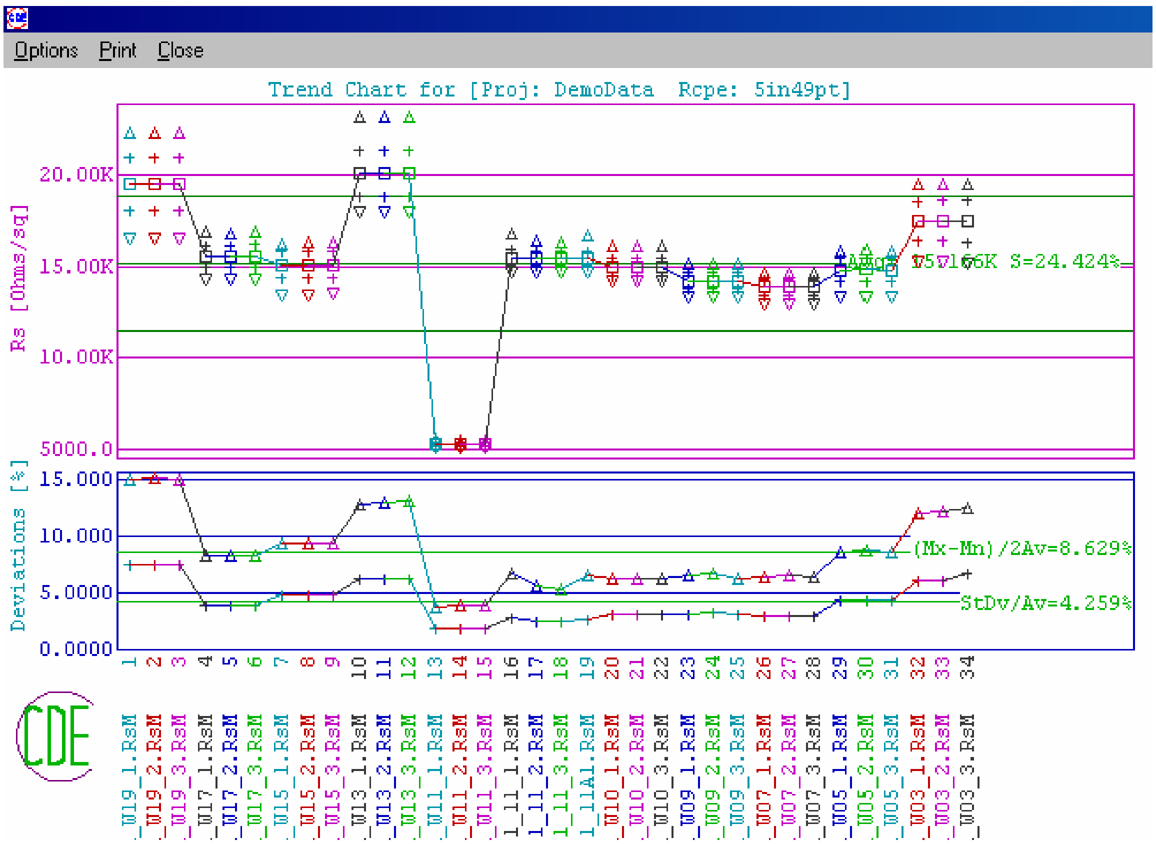
ALL RUNS SUMMARY:	183	1277.8	1685	99.99%	MinMax=	452.2	4581	82.03%	AllData= 452.1	4582	82.04%
Manual #2	122/122	452.20	2.1m	0.000%	MinMax=	452.2	452.2	0.000%	AllData= 452.1	452.3	0.016%
SLOT 1 #9	25/27	910.89	1376	99.99%	MinMax=	452.2	4580	82.03%	AllData= 452.2	4580	82.03%
SLOT 2 #3	6/9	452.24	4.9m	0.001%	MinMax=	452.2	452.2	0.001%	AllData= 452.2	452.3	0.002%
SLOT 3 #4	12/12	1484.3	2064	99.99%	MinMax=	452.2	4580	82.03%	AllData= 452.2	4580	82.03%
SLOT 5 #3	8/9	1828.4	2384	99.99%	MinMax=	452.2	4581	82.03%	AllData= 452.2	4580	82.03%

Plot Trend Chart | Print List | Read Selected File | Close

The slot summary is useful for day-to-day process monitoring if the same process appears always in the same slot. It is also useful for doing repeatability studies with a single cassette of wafers measured many times.
Buttons at the bottom of the List Recipe screen allow the user to plot a trend chart, print the listing, or read one of the files in the list. These options are also available from the **Operator** menu and are described below.

Plot Trend Chart

This command allows the operator to plot all the data in a recipe as a trend chart which can be used for statistical process control (SPC). It is available from the **Operator** pull-down menu (**Operator… Plot Trend Chart…**) and from the display window of the **List Recipe Files** command. It gives a graphical display of the summary information shown in the **List Recipe Files** command. The chart shows for each data file, the average, standard deviation, minimum, and maximum. Also shown are the average and the standard deviation of the averages for all the runs, as well as the target value, the Upper Control Limit (UCL) and Lower Control Limit (LCL) if they are defined.

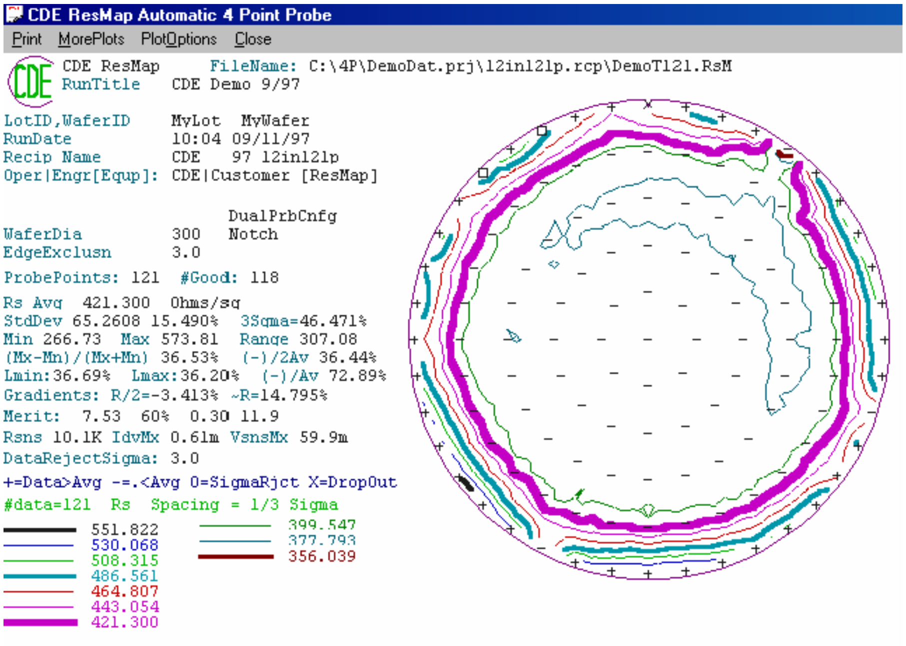


Read Data File

This command allows you to read any data file in any directory. The corresponding map (contour or diameter) or listing (for files with fewer than 5 points) will be displayed. The operator selects which file from the project/recipe dialog box. It may be easier to use the **List Recipe Files** command to read data.

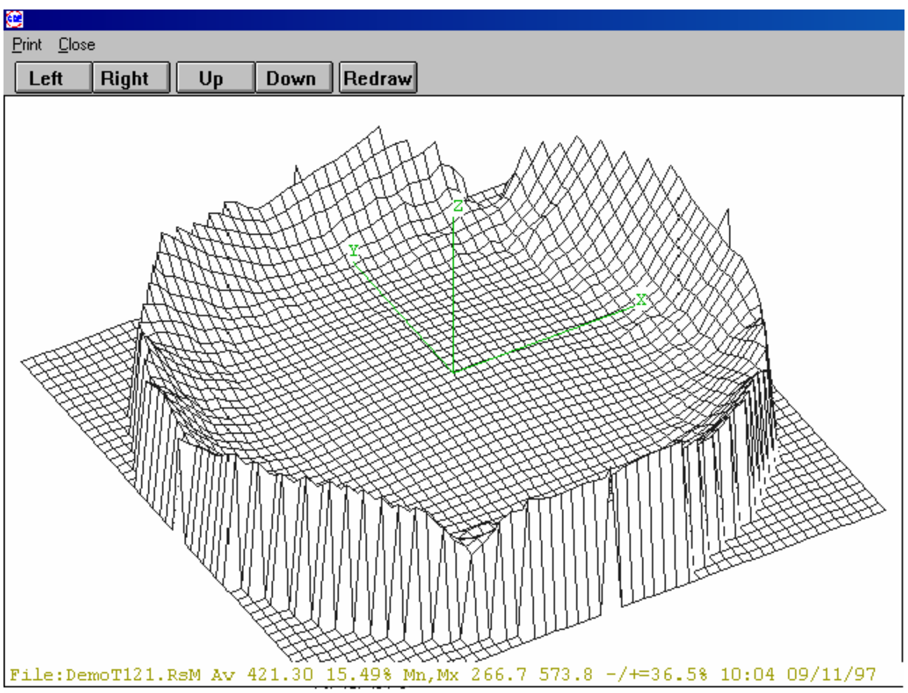
Contour Plot

This command displays a contour plot of the current measurement. This is either the last one made, or the last one selected by the **List Recipe Files** command, or by the **Read Data File** command



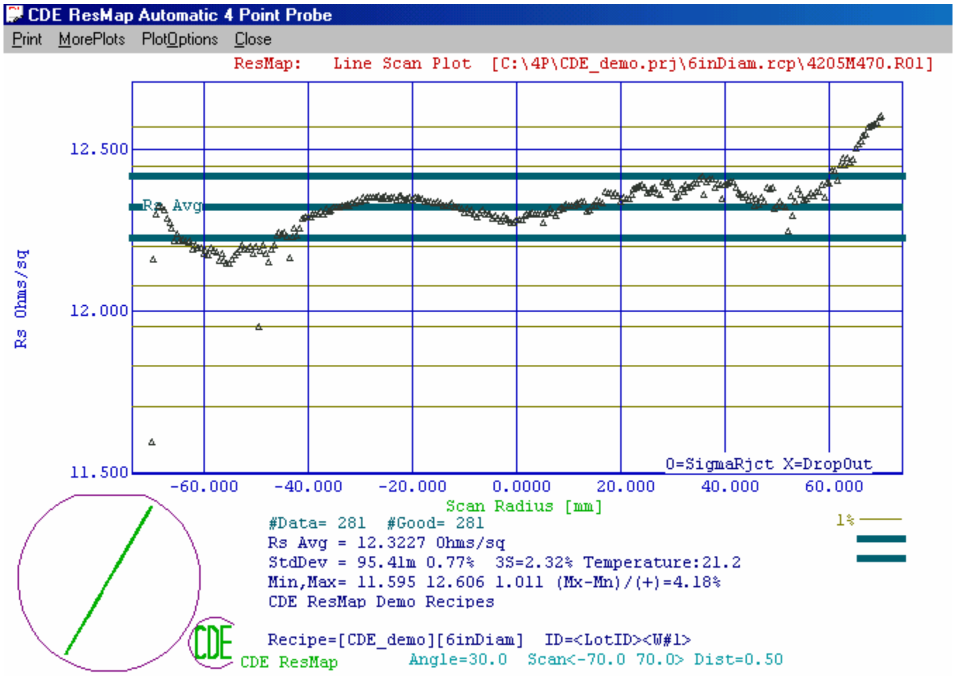
3D Plot

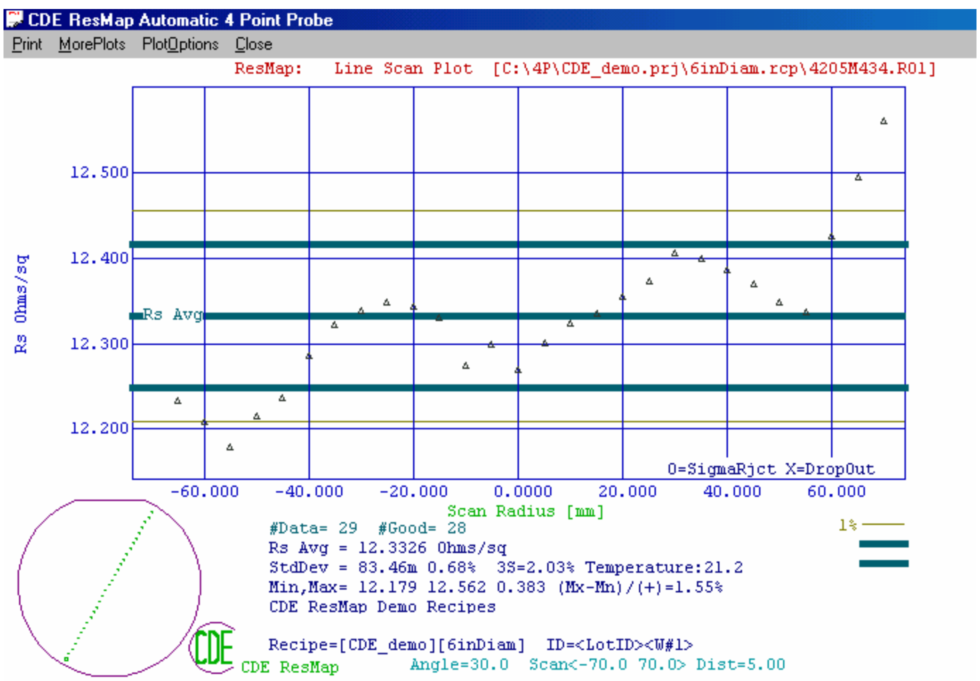
This command displays a three dimensional plot of the current measurement. This is either the last one made, or the last one selected by the **List Recipe Files** command, or by the **Read Data File** command.



DiamScan Plot

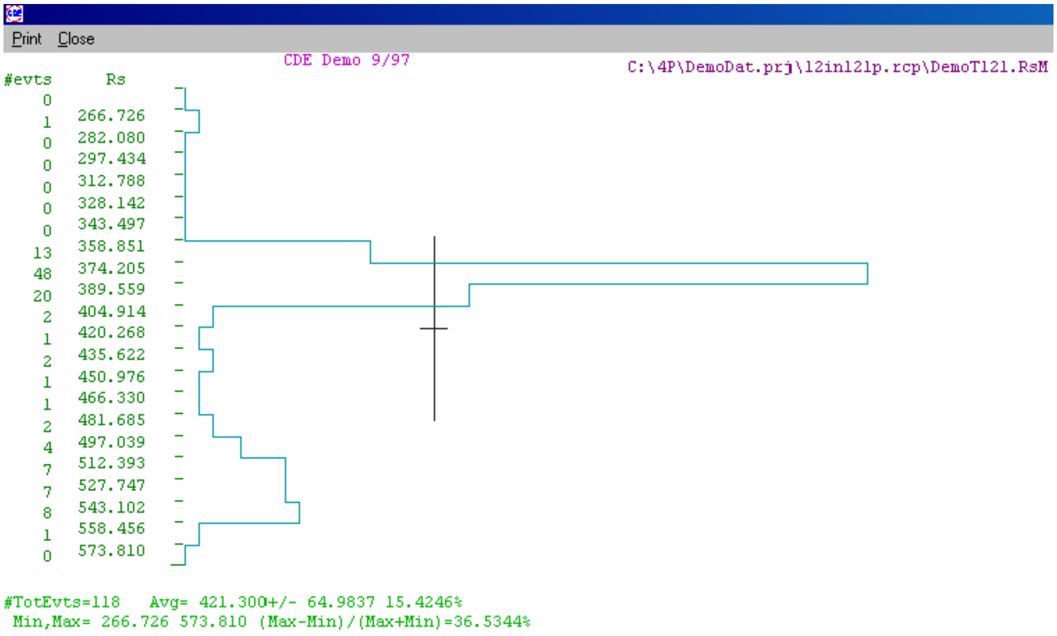
This shows a graph of a diameter scan data file. This is either the last one made, or the last one selected by the **List Recipe Files** command, or by the **Read Data File** command.





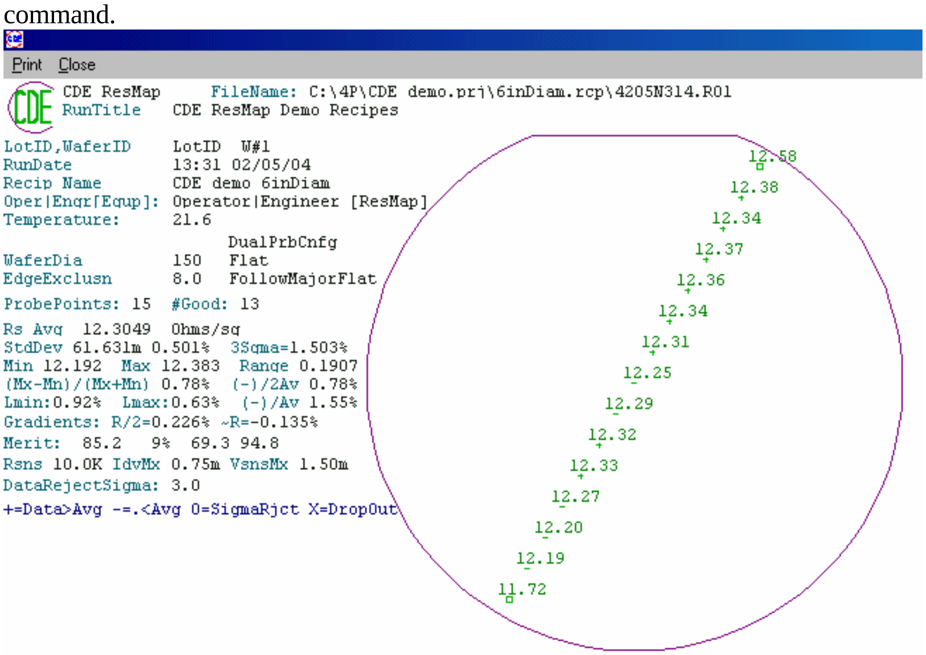
Histogram Plot

This shows a histogram of the values of the current measurement. This is either the last one made, or the last one selected by the List Recipe Files command, or by the Read Data File command.



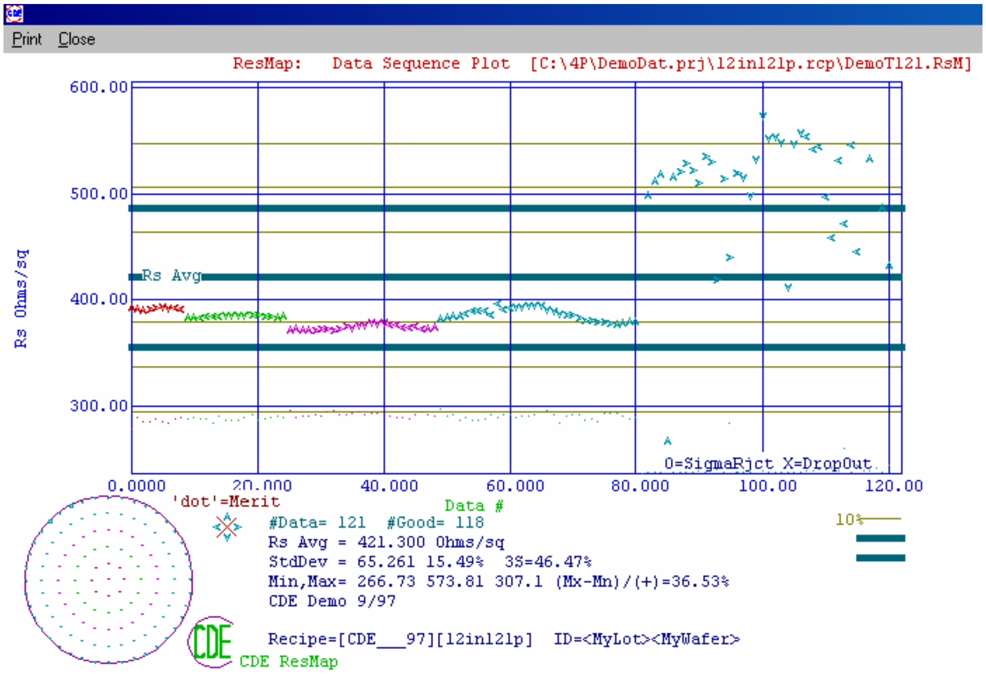
WaferData Plot

This displays a map of the current data (either the last one made, or the last one selected by the **List Recipe Files** command, or by the **Read Data File** command) showing the measured value at each site. This is similar to the data acquisition screen that is displayed while the ResMap is collecting data in real time. See page 1 on the **Run Recipe** command.



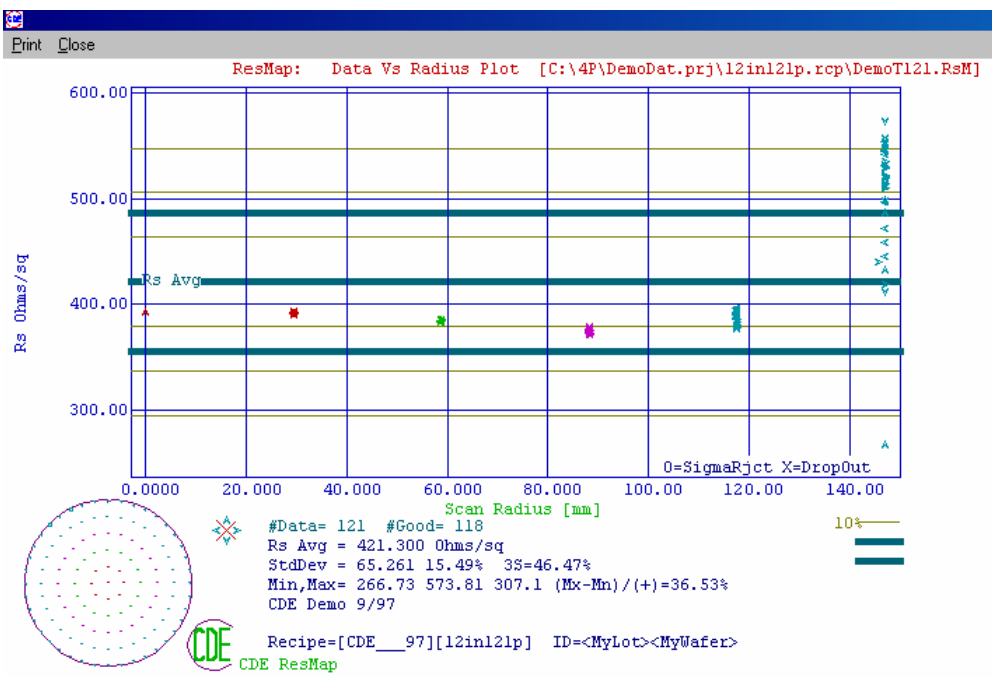
PlotDataSequence

This command displays a graph of the current data (either the last one made, or the last one selected by the **List Recipe Files** command, or by the **Read Data File** command) as a function of site number. Shown below is an example of a data sequence plot from a contour map showing a high degree of circular symmetry. Each ring of the contour map is displayed with a different color.



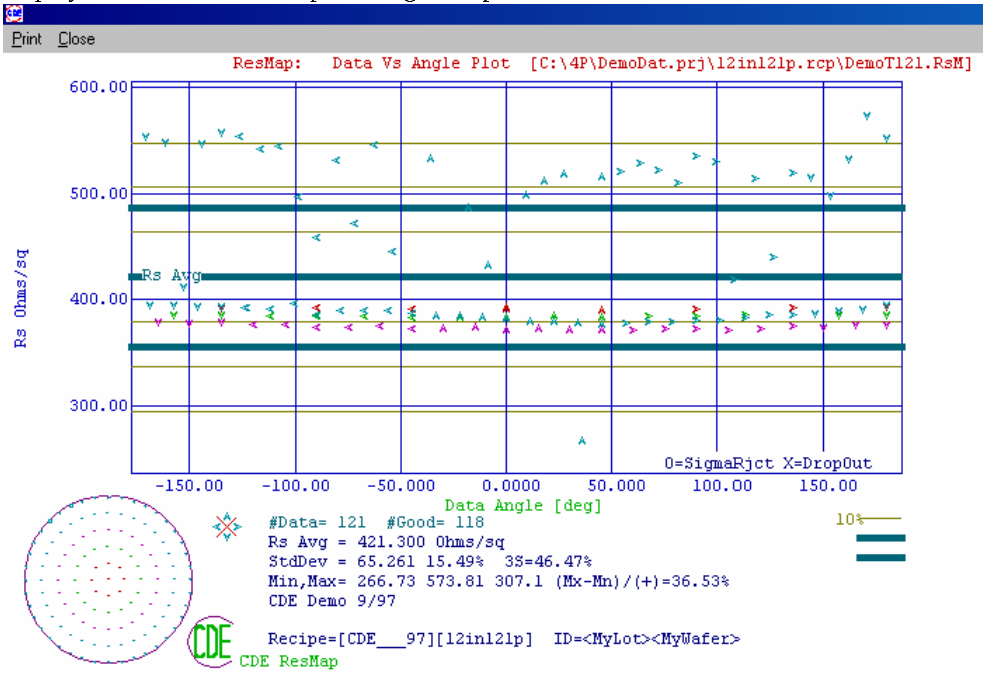
PlotDataVsRadius

This command displays a graph of the current data (either the last one made, or the last one selected by the List Recipe Files command, or by the Read Data File command) as a function of radius. The example below shows the same data as in the figure above for the **PlotDataSequence** command.



PlotDataVsAngle

This command displays a graph of the current data (either the last one made, or the last one selected by the List Recipe Files command, or by the Read Data File command) as a function of angle. Once again, the same data is displayed here as in the two preceding examples.

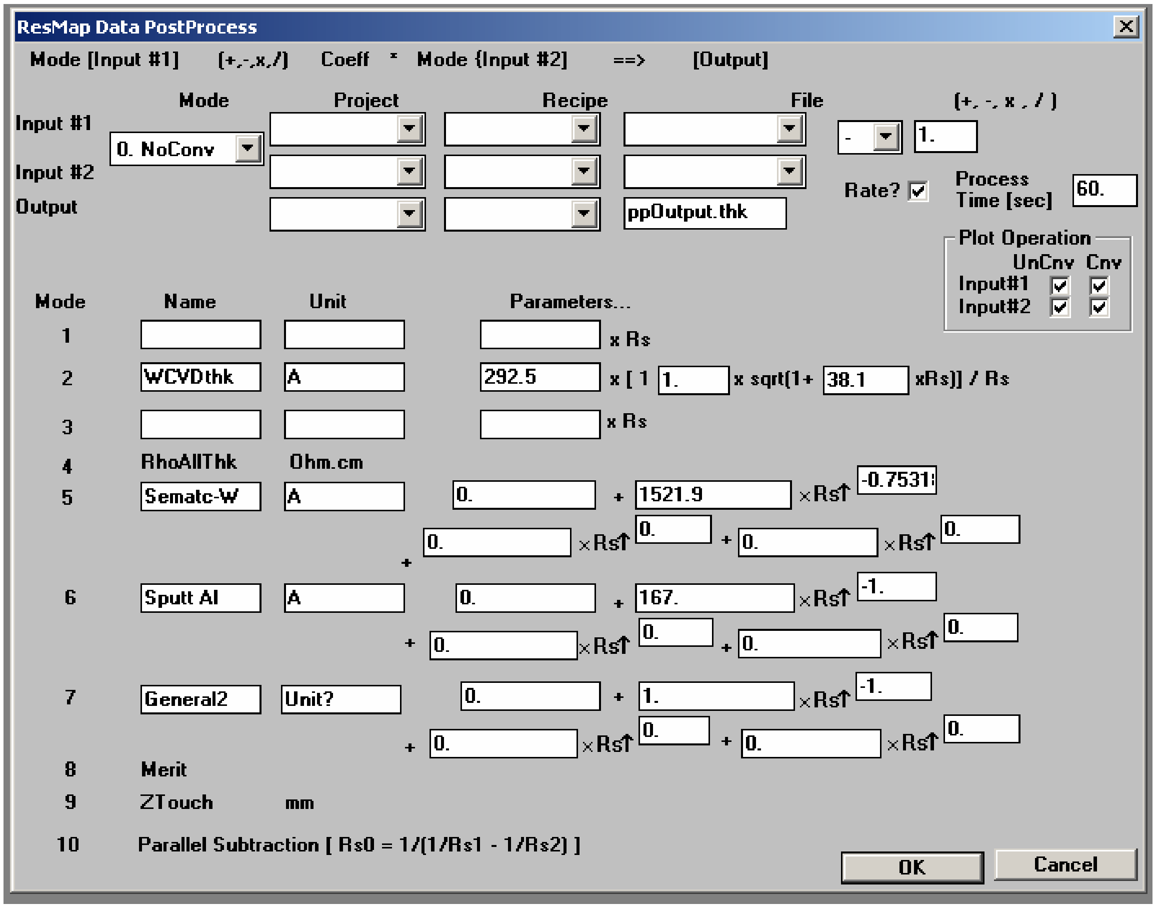


Post Process Data File

This is a very powerful command which allows one to manipulate the data you have collected. It operates on data files *.RsM or *.R##. Some of the applications are:

1. Convert units from the measured Rs to thickness using conversion formulas stored in "modes".
2. Perform operations on two files such as subtractions for CMP or Plasma etch back of metal films. In this case one can calculate and display removal rate and distributions. An example is shown below.
3. Other operations such as multiplication of two files point by point for = Rs x W, where the W = film thickness measured by another operation such as FTIR for epi thickness, or thickness of bare wafers measured with another gauge.

The post process screen is shown below. The upper portion of this screen is used to select the data file(s) you wish to process. The input file(s) can have a conversion operation performed, selected by the Mode pull-down menu. The conversion is defined in the Mode section, in the lower portion of the screen. Several Modes are pre-defined, and others may be entered by the user. The definitions are summarized in the table that follows.

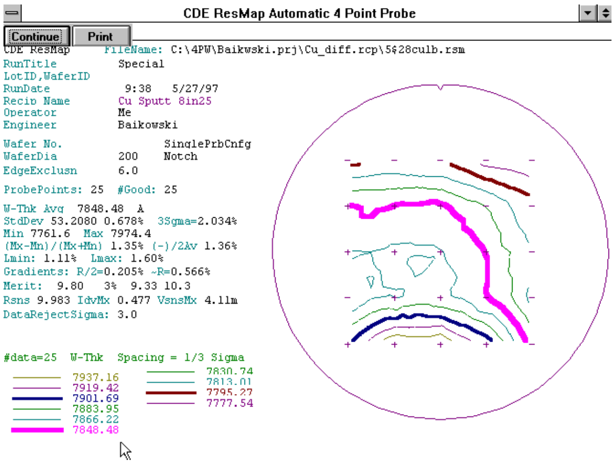


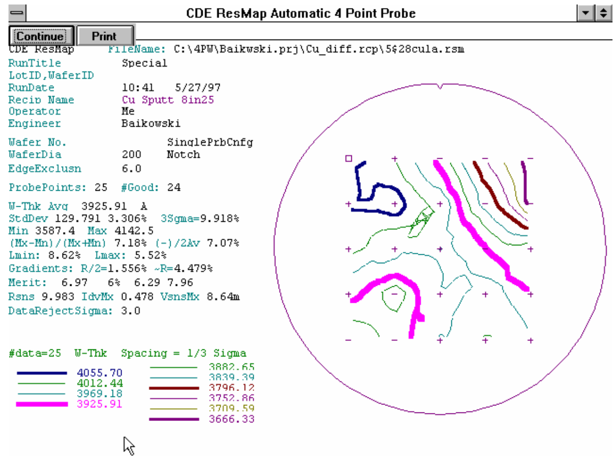
Mode	Result	User inputs	Note
0	Rs	None	
1	a × Rs	a	
2	a × [1 + b sqrt(1 + c×Rs)] / Rs	a, b, c	
3	a × Rs	a	
4			
5	$a + b \times Rs^c + d \times Rs^e + f \times Rs^g$	a, b, c, d, e, f, g	
6	$a + b \times Rs^c + d \times Rs^e + f \times Rs^g$	a, b, c, d, e, f, g	
7	$a + b \times Rs^c + d \times Rs^e + f \times Rs^g$	a, b, c, d, e, f, g	
8	Merit	None	
9	Ztouch	None	
10	1 / (1/Rs1 – 1/Rs2)	None	Parallel subtraction

If two input files are selected, the same **Mode** (conversion operation) will be applied to both. An arithmetic operation (add, subtract, multiply, or divide) must be selected, and a coefficient to apply to the second file. For example, if you wish to subtract post-process thickness from pre-process thickness of Tungsten films using the Sematech standard model. Mode 5 will perform the conversion from Rs to thickness, the coefficient will be 1.0, and the operation will be subtraction. The second (converted) file will be subtracted from the first (also converted). In addition, a growth or removal rate may be calculated by selecting the **Rate** check box, and entering a value in the **Process Time** (sec) box. An example of thickness subtraction is shown below:

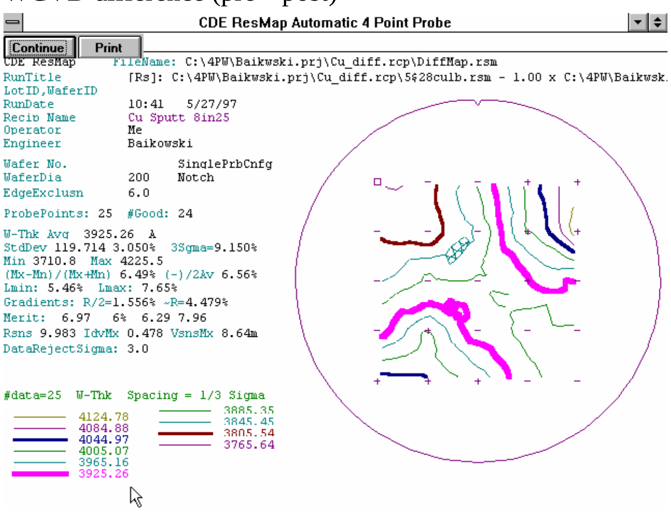
WCVD film as-deposited (pre)

WCVD film after CMP (post)





WCVD difference (pre – post)



Here is a second example: You wish to report thickness of a copper film. **Mode 7** can be configured to do this. The coefficients a = 0, b = 479.13, c = – 0.75681, d = 0, e = 0, f = 0, g = 0 are entered in the formula for Mode 7. The name Cu, and units A are chosen. Only one input file is used.

Probe Go To X Near Zero

This command moves the probe near the center of the chuck. It is useful for changing the probe, or for measuring a single point near the center of a wafer. For the latter, one can use the **GainSet/1pt Meas** command in the **Engineering** Menu.

Home All Motors

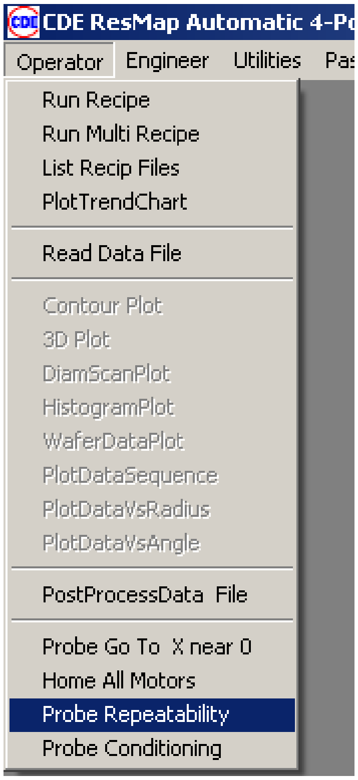
This command homes all motors in the following sequence:

1. Home Chuck Elevation motor
2. Home Chuck Rotation motor
3. Home Probe Arm motor
4. If present, Home Cassette Elevation motor.

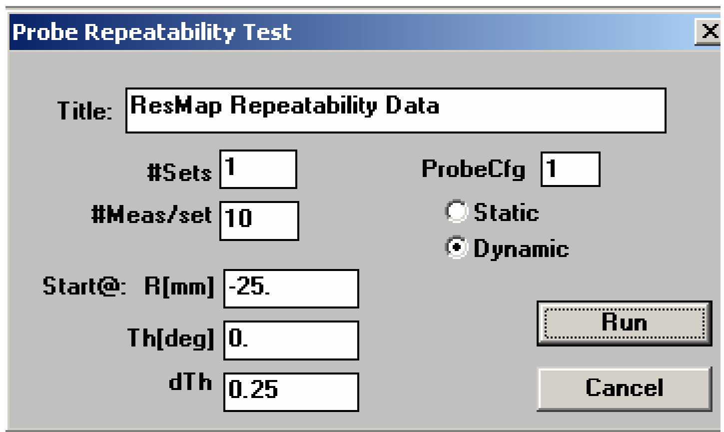
This sequence is safe in most circumstances. If there is a wafer on the blade, the operator must remove it manually afterwards.

Probe Repeatability

This command allows the operator to monitor the performance of the ResMap system. A series of closely spaced measurements is made and the standard deviation is calculated. Repeatability is defined as the standard deviation divided by the average of the series.



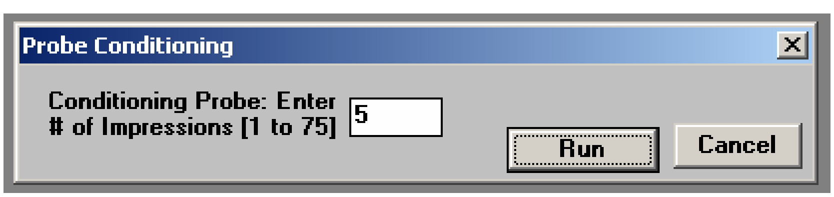
The operator selects **Operator… Probe Repeatability…** A probe configuration must be chosen (**single** or **dual**, see page **Error! Bookmark not defined.** in **Error! Reference source not found.** on how to choose), and whether **Static** or **Dynamic** repeatability is desired. If **Static** is chosen, the wafer and probe are not moved between measurements, so contact between the wafer and the probe tips is made only once. If **Dynamic** is chosen (sometimes called reproducibility), the wafer is moved a small angular amount, given by **dTh**, for each measurement. The user must choose how many sets, the number of measurements per set, and a starting location (radius and angle). Click the **Run** button to start the measurement.



Static Repeatability should be no greater than about 0.02%. Dynamic repeatability should be no greater than about 0.1%.

Probe Conditioning

After repeated use, the probe may become contaminated, and the repeatability may degrade. To restore probe performance, it should be conditioned. This is done by contacting the probe tips to a ceramic plate, which is mounted at the edge of the chuck. This may be performed with or without a wafer on the chuck. The operator chooses the number of times to touch the probe tips to the ceramic plate, the clicks the **Run** button.



– *Engineer Menu*

In this chapter, we will describe the commands available in the Engineer pull-down menu. This includes creating and editing a recipe, the project and recipe file structure, making measurements without a recipe, and how to calibrate.

Project and Recipe folders

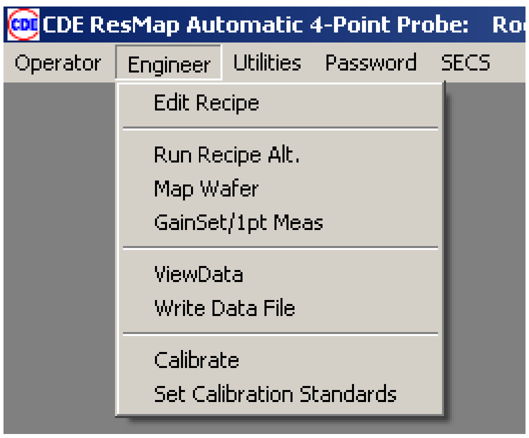
ResMap Recipes are organized into folders called Projects and are stored in the c:\4p directory. The names of each project are stored in a file called c:\4p\Project.lst. Each project has a one to eight character name and corresponding folder, such as c:\4p\Implant.prj. Stored in the project directory is a file containing a list of recipes with the name Recipe.lst, such as c:\4p\Implant\Recipe.lst. Each recipe has a name like 8in49pt.rcp and a corresponding folder. Each map that is measured is stored in a file in the recipe folder. In each recipe folder is also the file Recipe.dat, with a list of all the parameters of a recipe, and RunFile.lst, with summary data for each measurement.

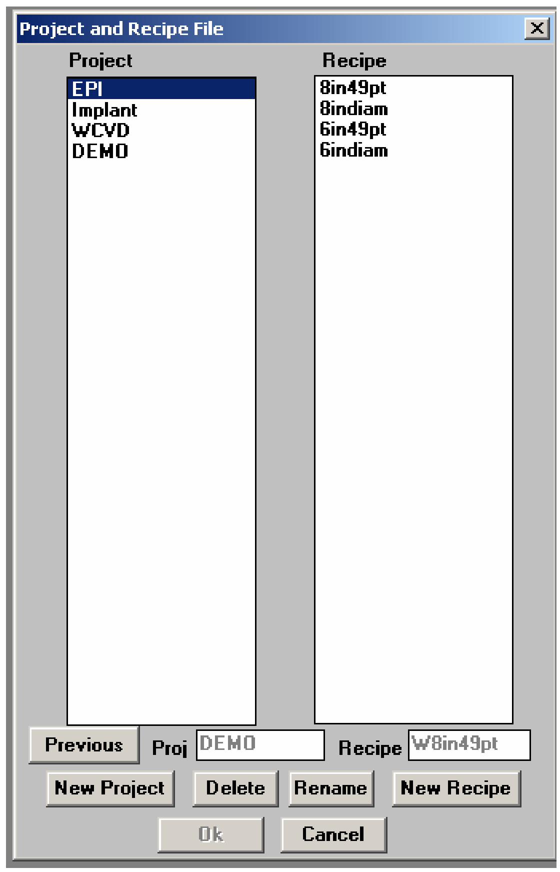
Engineer Menu

The Engineer menu is shown below. We will describe the commands in order.

Edit Recipe

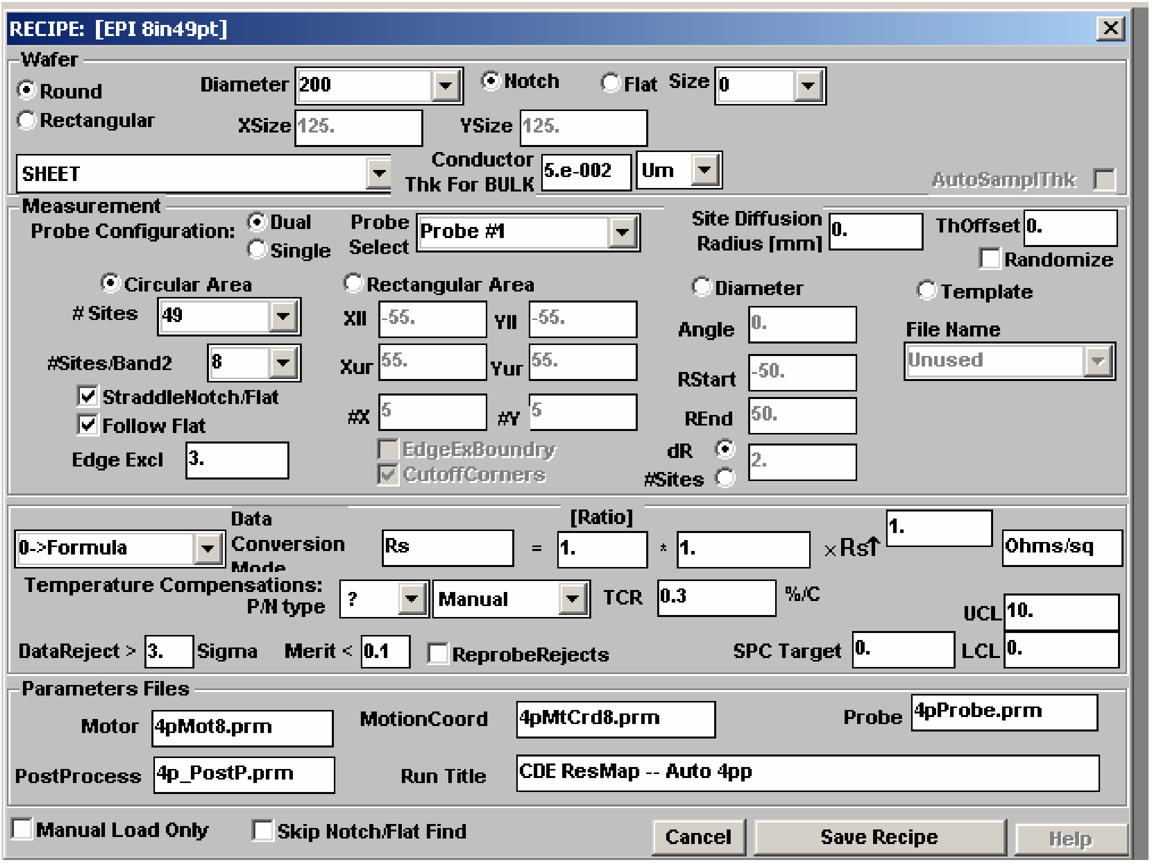
To create or modify a project or recipe, select Engineer… Edit Recipe… The Project and Recipe dialog box will appear.





To create a new project folder, click the **New Project** button. A dialog box will prompt you to enter the project name, and a recipe name. To select an existing project, click on its name, then either select an existing recipe by clicking on its name, or create a new one by clicking on the **New Recipe** button. The **Previous** button will select the last project and recipe used. You may select an existing recipe to use as a starting point for a new recipe. Click the **Ok** button.

The ResMap Recipe Screen will appear and you can configure the recipe to perform the mapping functions you desire. We will describe each parameter in the Recipe Screen in order. The Recipe screen is divided into five parts. First, the wafer parameters are defined.



Wafer parameters:
If **Round** is selected, then the **Diameter** pull-down menu becomes available. This is the wafer size, not the map diameter. The available sizes are: 75, 100, 125, 150, 200, and 300 mm. It is necessary to select **Notch** or **Flat**, and if **Flat** is chosen, the **Size** (length) of the flat in mm.
If **Rectangular** is selected, the **XSize** and **YSize** become available. This is the sample size in mm, not the map size.
The must choose whether to report the measured Sheet Resistance or to perform one of the three Bulk Resistivity calculations on the Rs result. The sample (conductive layer) thickness is entered in the **SmplThk** box, along with the corresponding units (, ìm, mm, cm). For **Sheet Resistance**, the thickness value is not used. If one of the Bulk methods is selected, the layer thickness (**Conductor Thk**) and **Units** must be entered. We have implemented the ASTM thickness correction, and J.I.T. and Yamishita methods for thickness and edge corrections (see explanation in **Error! Reference source not found.Error! Reference source not found.**, page **Error! Bookmark not defined. Error! Reference source not found.**). To select any of these for a recipe, choose **BULK ASTM Thk Corr**, **BULK JIT Thk&Edge Corr** or **BULK Yamashita Thk&Edge Corr**, respectively.

Measurement Parameters:
It is necessary to select either **Single** or **Dual** probe configuration. Most measurements use a dual configuration. For a detailed explanation of how to choose single versus dual, see **Error! Reference source not found.** in **Error! Reference source not found.**. On ResMap systems with more than one probe, it is necessary to chose which one from the **Probe Select** pull-down menu.
Next are four options for the type of map: Circular Area, Rectangular Area, Diameter, or Template (user defined, see description below). For each of these options, only the corresponding measurement parameters are used; the rest are ignored. These parameters are described in the following table.

Option	Parameter	Description
Circular Area	# Sites	Number of sites
	#Sites/Band2	Number of sites in the ring around the center site
	Straddle Notch/Flat	Rotates the map so edge points avoid the notch or flat
	Follow Flat	
	EdgeExcl	Distance in mm from edge of wafer to map edge sites
Rectangular Area	Xll	X value of lower left corner
	Xur	X value of upper right corner
	#X	Number of sites along X direction (number of columns)
	Yll	Y value of lower left corner
	Yur	Y value of upper right corner
	#Y	Number of sites along Y direction (number of rows)
	EdgeExBoundry	Use edge exclusion for boundary (instead of Xll, Xur, Yll, Yur)
	CutOffCorners?	If box is checked, the corner sites of the map will be eliminated.
Diameter	Angle	Angle of diameter. If 0 is chosen, the map starts at the notch/flat.
	RStart	Radius of starting site
	REnd	Radius of ending site
	dR	If dR is selected, distance between neighboring sites.
	#Sites	If #Sites is selected, number of sites
Template	File Name	File containing user-defined map; format is described below; the name must be of the form *.tpl

If a wafer is to probed more than once, it may be desirable to choose map sites that are slightly displaced from the nominal locations. Each map site will be displaced by a random amount that is less than **Site Diffusion Radius** given in mm. To probe precisely at each nominal map site, **Site Diffusion Radius** should be set to zero. Similarly, an entire map will be rotated by an angle equal to **ThOffset** in degrees (all sites rotated by the same angle). To rotate the map by a random amount less than **ThOffset**, select the **Randomize** box. Again, to probe precisely at the nominal map sites, **ThOffset** should be set to zero.

Data manipulation parameters
Data Conversion Mode: a number from 0 to 10; if 0 is chosen, the formula to the right of this box is use. Units, coefficient, and exponent must be entered in the respective boxes. By default, the coefficient and exponent have a value of 1.0, which doesn't transform the measured Rs. For modes 1 through 7, the formula is defined in the Post Process parameter file (usually 4p_PostP.prm), and can be modified in the **Operator… PostProcessData File…** command (see **Error! Reference source not found.Error! Reference source not found.**). Modes 8, 9, and 10 are pre-defined, and report Merit, Ztouch (chuck height when pins make electrical contact), and TouchNoMeas, respectively, instead of Rs.
Temperature Compensation: First, the type of silicon dopant (P or N type) is selected. If manual Temperature Compensation is chosen, a correction value in % per degree Celsius must be entered (0 means no correction). If ASTM F84 is selected, then the table (see explanation in **Error! Reference source not found. Error! Reference source not found.**) will be used.
Outlying data points may be rejected with the **DataReject** parameter. If the measured value differs from the average by greater than the value of **DataReject** times the standard deviation, it will be excluded from the reported statistics. It will still be recorded in the data file.
Data points with a Merit value less than that given by the **Merit <** parameter will be rejected. If the **ReprobeRejects** box is selected, rejected data points will be re-probed.
A statistical process control (**SPC**) **target** value, upper control limit (**UCL**), and lower control limit (**LCL**) may be entered. These will be displayed with the measured data on a trend chart.

Parameter files
The four types of parameter files are Motor, Motion Coordinates, Probe, and Post Process, and they are machine and wafer size specific. Usually the default entries are correct.
If the **Manual Load Only** box is checked, the recipe can not be used with automatically loaded wafers.
To avoid notch or flat finding, select **Skip Notch/Flat Find**.

Once all recipe parameters have been selected, the recipe can be saved by clicking the **Save** button. The **Cancel** button will return the user to the previous screen.

Template Files

Predefined maps (contour, rectangular, diameter) are provided, but the user may define any arbitrary map with up to 1000 sites in a Template. Template files have the following format:

Line 1:	Title	for comment
Line 2:	Reserved	leave blank
Line 3:	Reserved	leave blank
Line 4:	N P	N=Number of sites, P = 1 (single probe configuration) or 2 (dual)
Lines 5 through end:	[G] R Th	[G]*, R = radius, Th = theta for each site, one site per line

*The letter G is optional. If present, **GainSet** will be performed at that site. If absent, **GainSet** will not be performed at that site, and settings from the previous site will be used.

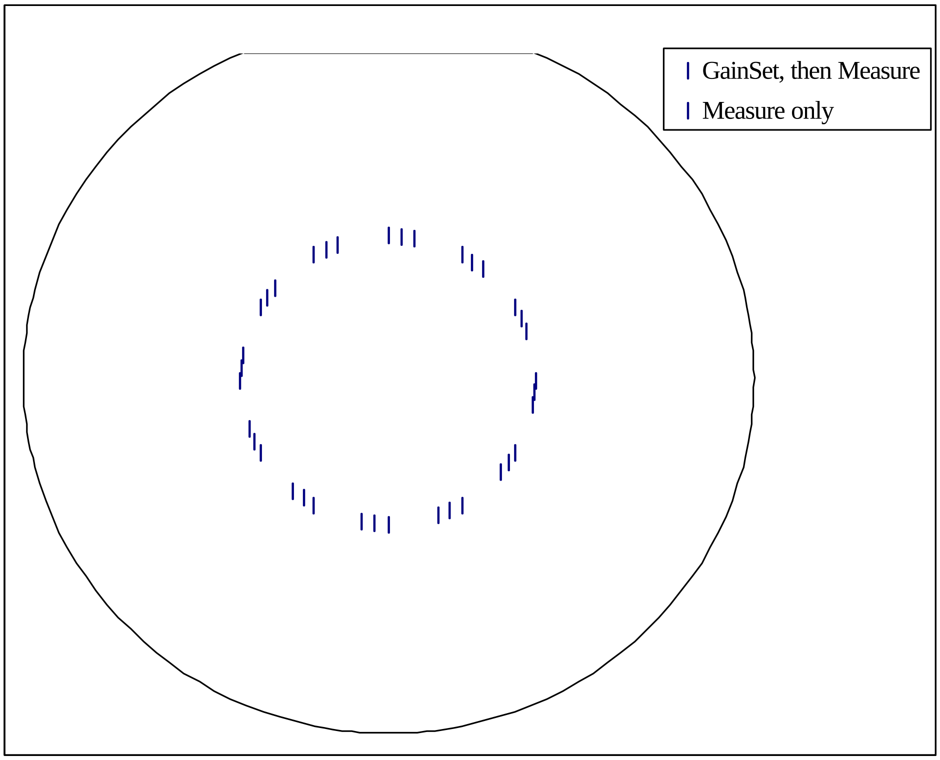
The values in lines 4 through the end of the file may be separated by space or tab characters, but not commas.

Shown below is an example of a template file named Example.tpl that measures 36 sites, all at a radius of 20mm, and distributed in 12 groups of three sites each separated by 5 degrees. The groups are distributed every 30 degrees. **GainSet** is performed at the first site of each group (every third site).

Line	**Contents**	**Note**
1	Example.tpl sample template file	Title
2		Reserved
3		Reserved
4	36 2	number of sites single or dual probe configuration
5	G 20 0	[G] R Theta
6	20 5	[G] R Theta
7	20 10	[G] R Theta
8	G 20 30	[G] R Theta
9	20 35	[G] R Theta
10	20 40	[G] R Theta
11	G 20 60	[G] R Theta
12	20 65	[G] R Theta
13	20 70	[G] R Theta
14	G 20 90	[G] R Theta
15	20 95	[G] R Theta
16	20 100	[G] R Theta
17	G 20 120	[G] R Theta
18	20 125	[G] R Theta
19	20 130	[G] R Theta
20	G 20 150	[G] R Theta
21	20 155	[G] R Theta
22	20 160	[G] R Theta
23	G 20 180	[G] R Theta
24	20 185	[G] R Theta
25	20 190	[G] R Theta
26	G 20 210	[G] R Theta
27	20 215	[G] R Theta
28	20 220	[G] R Theta
29	G 20 240	[G] R Theta
30	20 245	[G] R Theta

Line	Contents	Note
31	20 250	[G] R Theta
32	G 20 270	[G] R Theta
33	20 275	[G] R Theta
34	20 280	[G] R Theta
35	G 20 300	[G] R Theta
36	20 305	[G] R Theta
37	20 310	[G] R Theta
38	G 20 330	[G] R Theta
39	20 335	[G] R Theta
40	20 340	[G] R Theta

The corresponding pattern is shown in the figure below.



Run Recipe Alt

This command allows an engineer to modify (alternate) the parameters for a run, while the original recipe remains unchanged. The data file will be saved in the corresponding recipe directory. This can be useful for doing diagnostics. For instance, if a recipe has 5 sites for a production monitoring, and there is something unusual for a particular wafer, the engineer can make a 49 point map for the same wafer without creating a new recipe. Another example: if something does not look right near the edge of a wafer, the engineer may want to make a series of runs with different edge exclusions.

Map Wafer

This is similar to Run Recipe Alt. There is no recipe associate with the data. The engineer must enter all the important parameters. This is like a one of a kind data. This is useful for unknown wafer or doing R&D or engineering studies.

GainSet/1pt Meas

This command is for doing a single point measurement at the present probe position. In conjunction with the Operator… Probe Go To X Near 0 command, this allows the engineer to make a (near) center point measurement on a wafer without using a recipe and without unloading the sample. If the sample is very small or irregular, the engineer can jog the probe (see the Utilities…Control… command) to the correct position over the sample and do the measurement where desired.
This command displays a sequence of values of gain settings of amplifiers and choices of the proper reference resistors for the measurement. This can give helpful diagnostic information.

View Data

This command allows the user to view any text file, such as event and error log files, map data files, template files, or Run List files.

Write Data File

This command allows the engineer to write a data file from memory to the present subdirectory. This is useful for making a copy of data with a different name (like the Save As command), or to save data converted by the PostProcessing option. With this command, a data file can be saved to a floppy disk or to a remote drive.

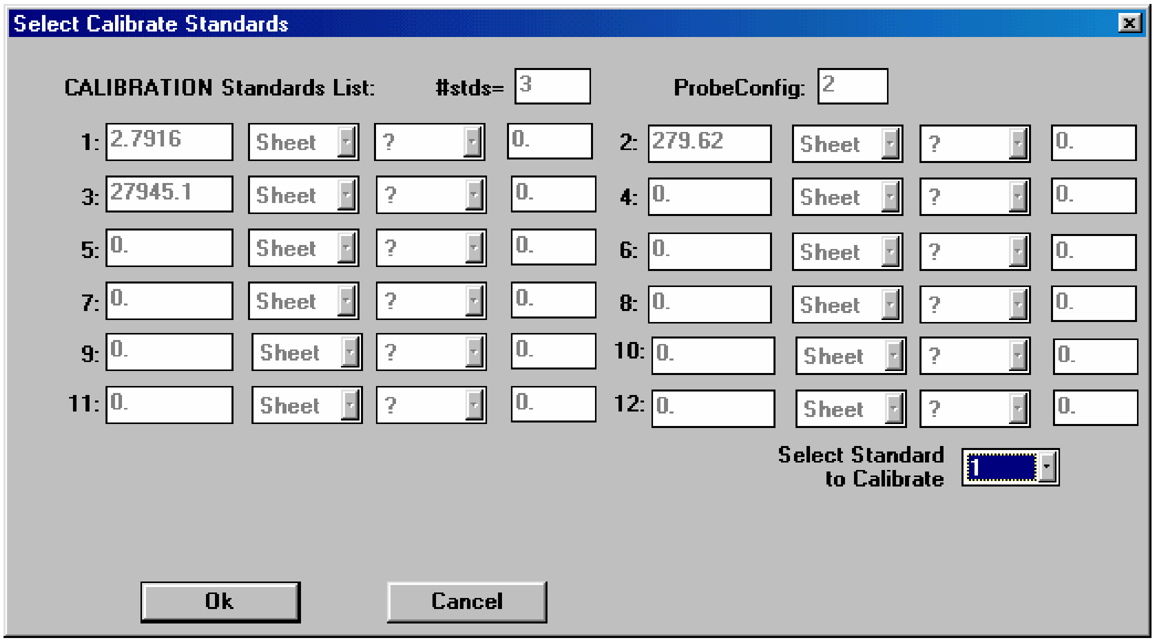
Calibrate

This command allows the user to perform a calibration. Note that the ResMap does not need frequent calibrations. We strongly recommend that you calibrate with the ResCal standard resistor packs supplied with your system. Here is the step by step procedure:

Step 0) This is to be done **only once** for your standards. If it has not already been done at the factory or during system installation, choose **Engineer… Set Calibration Standards…** (see section 4.10 below).

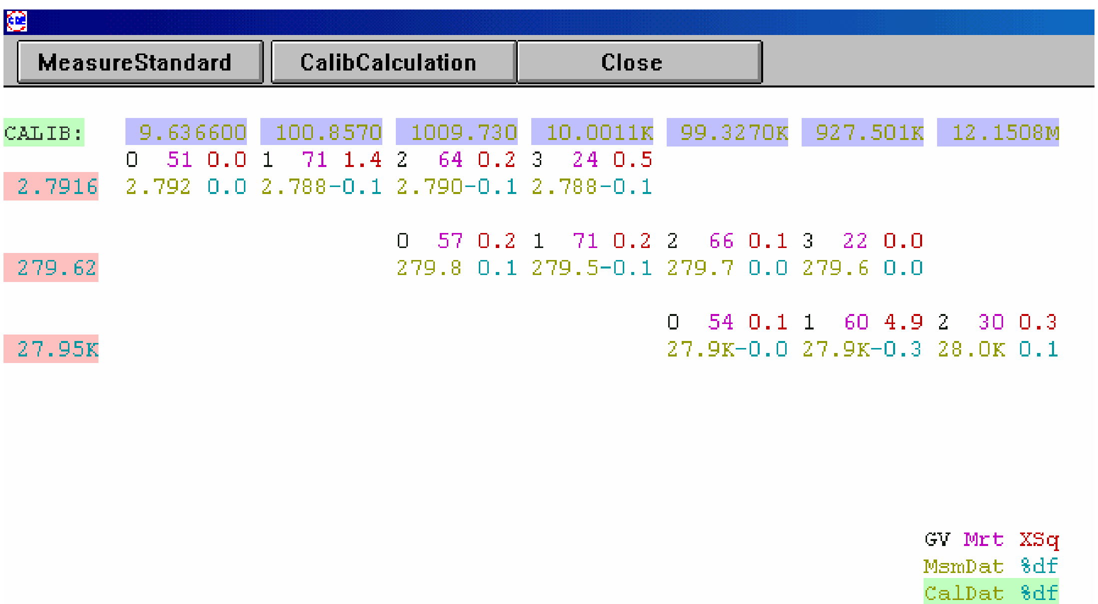
Step 1) Now you are ready to calibrate. Select **Engineer… Calibrate...** You should see a window with three buttons: **MeasureStandard**, **CalibCalculation**, and **Close**.

Step 2) Select **MeasureStandard**. The following window should appear. Select a probe configuration (usually 2) Select **Standard 1**. The value shown on the ResCal standard resistor pack number 1 should match what is shown for Standard 1 in this window. Click **Ok**. When prompted, unplug the cable that connects to the probe, and connect ResCal standard resistor pack number 1 to the cable in place of the probe. Click **OK** and the software will measure standard #1.

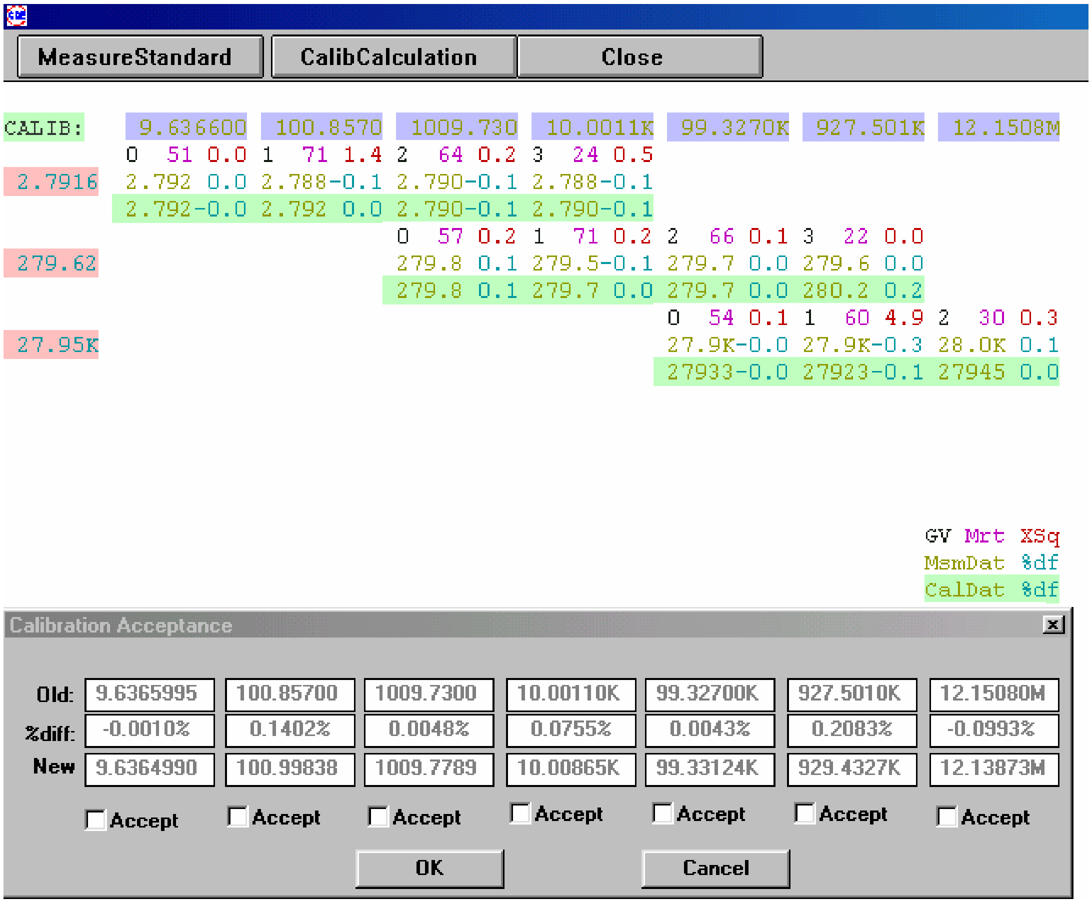


Step 3) The previous screen will appear, but now should have some numbers filling in the first few cells of a table. Select **MeasureStandard** again.

Step 4) Select the next standard and repeat Step 2, until each of the ResCal standard resistor packs has been measured, and each of the columns has numbers below it. The column headers across the top show the internal resistor values, and each row will be labeled with a ResCal standard resistor pack value.

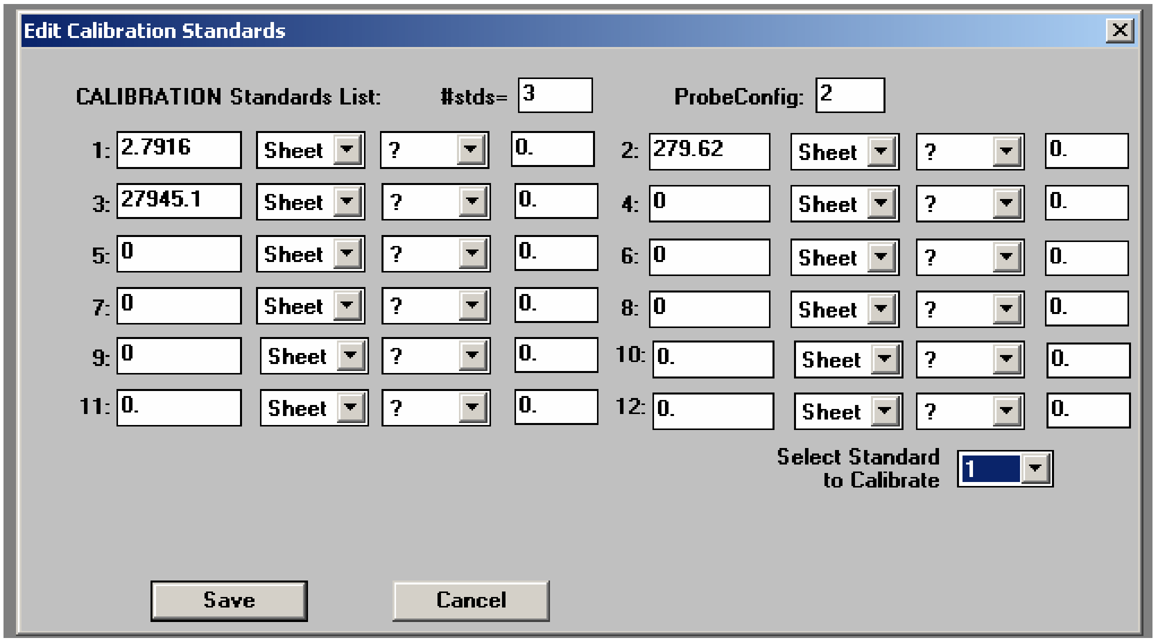


Step 5) Press **CalibCalculation** button and the system will calculate the best calibration from the data and display the results in the dialog box. For each internal resistor, the old value, the calculated new value, and the relative change (%diff) is shown. A change greater than 1% usually indicates a problem. Now you can accept or not each new value for internal resistor. Then, click **OK** to save the newly calibrated results.


MeasureStandard
CalibCalculation
Close
CALIB:
9.636600
100.8570
1009.730
10.0011K
99.3270K
927.501K
12.1508M
0 51 0.0 1 71 1.4 2 64 0.2 3 24 0.5
2.7916
2.792 0.0 2.788-0.1 2.790-0.1 2.788-0.1
2.792-0.0 2.792 0.0 2.790-0.1 2.790-0.1
0 57 0.2 1 71 0.2 2 66 0.1 3 22 0.0
279.62
279.8 0.1 279.5-0.1 279.7 0.0 279.6 0.0
279.8 0.1 279.7 0.0 279.7 0.0 280.2 0.2
0 54 0.1 1 60 4.9 2 30 0.3
27.95K
27.9K-0.0 27.9K-0.3 28.0K 0.1
27933-0.0 27923-0.1 27945 0.0
GV Mrt XSq
MsmDat %df
CalDat %df
Calibration Acceptance
Old: 9.6365995 100.85700 1009.7300 10.00110K 99.32700K 927.5010K 12.15080M
%diff: -0.0010% 0.1402% 0.0048% 0.0755% 0.0043% 0.2083% -0.0993%
New 9.6364990 100.99838 1009.7789 10.00865K 99.33124K 929.4327K 12.13873M
Accept Accept Accept Accept Accept Accept Accept
OK
Cancel

Set Calibration Standards

Normally, the user should not use this command. This command is ordinarily performed only once, either at the factory or during installation. Information about the calibration standards can be saved to a file with the Set Calibration Standards command. We normally store the values from the ResCal standard resistor packs.

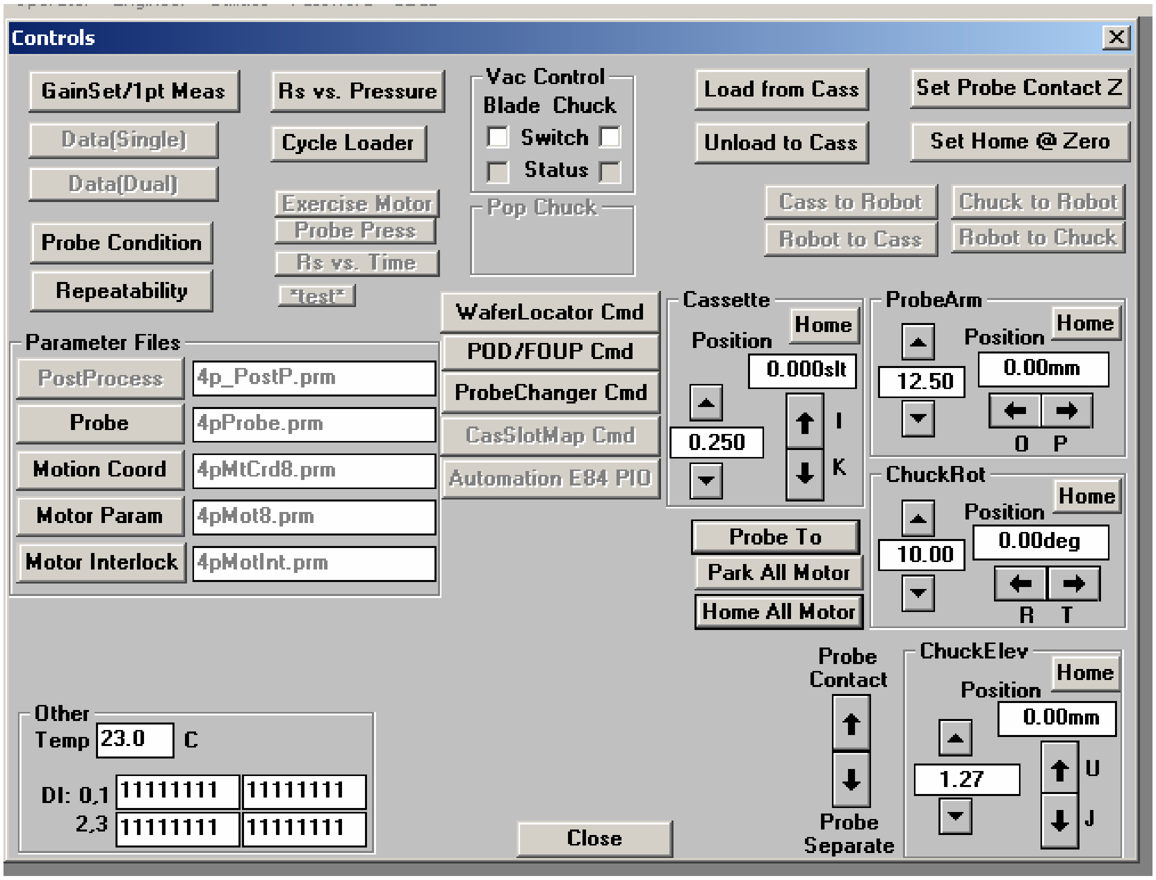


– *Utilities*

In this chapter we describe the Utilities menu items, some simple maintenance, and password protection.

Utilities… Control…

This menu item is described in detail in the Service manual. Many of the commands here are dangerous when used by an untrained or inexperienced user. Many diagnostic tools are provided here, as well as configuration



parameters. Some of the functions available here, like Probe Condition, Repeatability, and GainSet/1pt Meas are accessible from the Operator and Engineer menus, and are not password protected.

Utilities… Loadport Set AUTO…

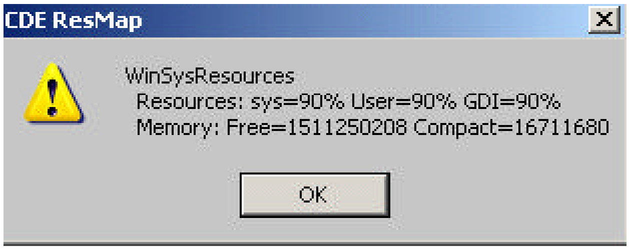
This command, only available on ResMap model 463-FOUP, sets the FOUP load port to automatic mode.

Utilities… Loadport Set MANUAL…

This command, only available on ResMap model 463-FOUP, sets the FOUP load port to manual mode.

Utilities… SysResources…

This command displays the Windows System Resources and available memory.



Utilities… Exit…

This command allows the user to exit the ResMap software.

Maintenance of the ResMap

There are no regular preventive maintenance [PM] or lubrication requirements for the ResMap system, due to its simplicity and robust design. The following is a common sense guide.

- If a wafer breaks, clean up the debris, and vacuum clean all exposed surfaces, especially below the chuck. You may want to remove the chuck to do this. The X-Arm lead screw may be coated with Silicon dust which could prevent smooth operation. In this case, remove the covers, and clean the lead screw with isopropyl alcohol (IPA) and then put a coat of light oil on the shaft.
- Clean the wafer chuck and the robot blade with IPA or de-ionized (DI) water and lint free towel once per week.
- Condition the probe once per week or when the merit value drops to about one half of its usual value. Do not over condition the probe.

Password

There are six levels of password access in the ResMap software. From the lowest level, which requires no password at all, all **Operator** menu items are available. It is possible to make measurements and display or print reports from this level. From the next level, a password is required, and **Engineer** menu items are available, such as creating and editing recipes, and calibrating. From the highest level, it is possible to access all menu items, including those of the **Utilities… Control…** screen. Use **Password… Log ON…** and **Password… Log OFF…** to do just that, i.e. log on and off.

Password… Edit Password…

Each user has a level of access defined here. A user who has Level 3 or higher access may add, delete, or modify User Names and Passwords. If no passwords are defined (i.e. no password file exists), the ResMap software allows full access. The password levels are:

Level	Access
0	Operator, [default] do not need to log in
1	Engineer
2	Service
3	Manager (can setup password for others)
5	CDE