Digital Instruments
Veeco Metrology Group

Support Note No. 224 Rev. D

Scanning Capacitance Microscopy (SCM)

224.1 Introduction

This support note describes a capacitive technique applied to scanning probe microscopy (SPM) known as scanning capacitance microscopy (SCM) for the imaging of semiconductor dopant sites. It includes specific directions for obtaining SCM images with Digital Instruments products.

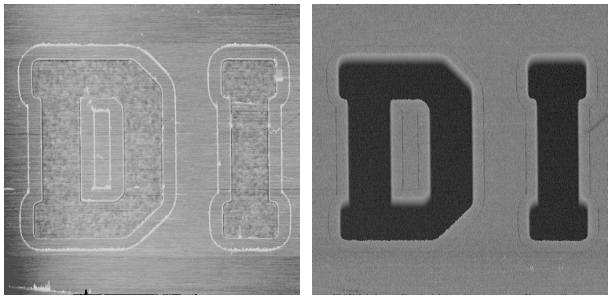

Figure 224-1 Doped regions on silicon: topography (left) and SCM (right).

Document Revision History: Support Note 224

Rev.	Date	Sections	Ref. DCR	Approval
Rev. D	4FEB99	224.1; 224.2; 224.4-6; 224.8	274	CCF
Rev. C	14MAR97	224.3—224.4	159	~~DB~~
Rev. B	15AUG96	224.2—224.4.	133	~~DB~~
Rev. A	01AUG96	Released.	113	~~DB~~

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224.1.1 Capacitance Imaging

Refer to Figure 224-1 above. The left image reveals topography of patterned oxide used as an implant mask on silicon. The letters are a thinner oxide window which received the boron implant. The bright bands surrounding the letters are a residue of photoresist after patterning the letters. The SCM image on the right shows contrast due to carrier concentration variation from the implant. The dark areas show the boron implant; lighter areas show the n-type substrate. The implant edge has undercut the oxide mask during diffusion.

224.1.2 System Requirements

- Software V4.32 or higher
- NanoScope IIIa controller

Note: SCM is not compatible with the Metrology controller.

Voltage Frequency Power

- 100 50/60Hz 36 Watts
- 120 50/60Hz 36 Watts
- 220 50/60Hz 36 Watts
- 240 50/60Hz 36 Watts

224.2 Safety Precautions

224.2.1 Safety Requirements

This chapter details the safety requirements involved in installation of the ADC5 upgrade kit. Specifically, these safety requirements include all safety precautions, non-physical conditions, and equipment safety applications. Training and compliance with all safety requirements is essential during installation and operation of the NanoScope SPM.

Figure 224-2 Safety Symbols Key

Symbol	Definition
	This symbol identifies conditions or practices that could result in damage to the equipment or other property, and in extreme cases, possible personal injury.
	Ce symbole indique des conditions d'emploi ou des actions pouvant endommager les équipements ou accessoires, et qui, dans les cas extrêmes, peuvent conduire à des dommages corporels.
	Dieses Symbol beschreibt Zustaende oder Handlungen die das Geraet oder andere Gegenstaende beschaedigen koennen und in Extremfaellen zu Verletzungen fuehren koennen.
	This symbol identifies conditions or practices that involve potential electric shock hazard.
	Ce symbole indique des conditions d'emploi ou des actions comportant un risque de choc électrique.
	Dieses Symbol beschreibt Zustaende oder Handlungen die einen elekrischen Schock verursachen koennen.
	This symbol identifies conditions or practices that involve an electrostatic sensitive work area. A grounding device must be worn at all times.
	Ce symbol signale des conditions ou pratiques sensibles aux charges électrostatiques. Un système de mise à la terre doit être porté par l'utilisateur en permanence.
	Dieses Symbol beschreibt Zustaende oder Handlungen welche elekrostatisch sensitive Arbeitsbereiche betreffen. Ein geeignetes Erdungsband zur Ableitung elektrostatischer Ladung muss zu jezeit benuzt werden.

WARNING: Service and adjustments should be performed only by qualified personnel who are aware of the hazards involved.

ATTENTION: Toute réparation ou étalonnage doit être effectué par des personnes qualifiées et conscientes des dangers qui peuvent y être associés.

WARNUNG: Service- und Einstellarbeiten sollten nur von qualifizierten Personen, die sich der auftretenden Gefahren bewußt sind, durchgeführt werden.

WARNING: Follow company and government safety regulations. Keep unauthorized personnel out of the area when working on equipment.

ATTENTION: Il est impératif de suivre les prérogatives imposées tant au niveau gouvernmental qu'au niveau des entreprises. Les personnes non autorisées ne peuvent rester près du système lorsque celui-ci fonctionne.

WARNUNG: Befolgen Sie die gesetzlichen Sicherheitsbestimmungen Ihres Landes. Halten Sie nicht authorisierte Personen während des Betriebs fern vom Gerät

WARNING: Voltages supplied to and within certain areas of the system are potentially dangerous and can cause injury to personnel. Power down everything and unplug from sources of power before doing ANY electrical servicing. (Digital Instruments personnel, *only*.)

ATTENTION: Les tensions utilisées dans le système sont potentiellement dangeureuses et peuvent blesser les Utilisateurs. Avant toute intervention électrique, ne pas oublier de débrancher le système. (Réservé au personnel de Digital Instruments seulement.)

WARNUNG: Die elektrischen Spannungen, die dem System zugeführt werden, sowie Spannungen im System selbst sind potentiell gefährlich und können zu Verletzungen von Personen führen. Bevor elektrische Servicearbeiten irgendwelcher Art durchgeführt werden ist das System auszuschalten und vom Netz zu trennen. (Nur Digital Instruments Personal.)

224.3 Theory of Operation

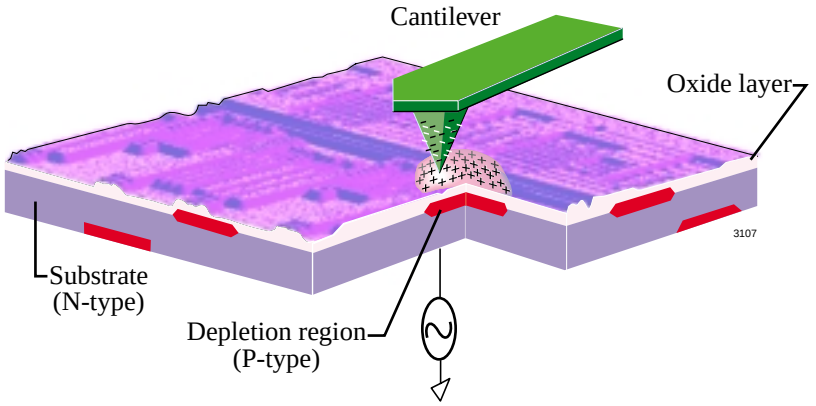

Figure 224-3 N-type silicon with P-type doped regions. When the probe is in contact with the surface, it forms a MOS capacitor.

Electrical properties of semiconductors, such as the number of free electrical carriers, may be changed drastically through doping. However, the doping provides no topographical contrast to distinguish doped from undoped regions, or to reveal levels of carrier concentration. Because the electrical properties of doped semiconductor regions have a huge impact on the operation of semiconductor devices such as computer chip integrated circuits, diode lasers, MOS and bipolar transistors and memory DRAMs, there is a need to profile the number of carriers in semiconductors. Other SPM-based techniques such as scanning Kelvin probe microscopy and electric force microscopy (EFM) have been applied to carrier profiling with limited success. The free carrier concentration in semiconductor materials may be sensed, however, using capacitive detection.

A UHF resonant capacitance sensor is the basis of this detection. The resonator is connected to a conductive SPM probe via a transmission line (Figure 224-4). When the resonating probe tip is put in contact with a semiconductor, the sensor, transmission line, probe and sample all become part of the resonator. This means tip-sample capacitance variations will load the end to the transmission line and change the resonant frequency of the system. Small changes in resonant frequency create enormous changes in the amplitude of resonance measured in volts. This system has been shown to be sensitive to variations as small as attofarads (10^{-18} farads).

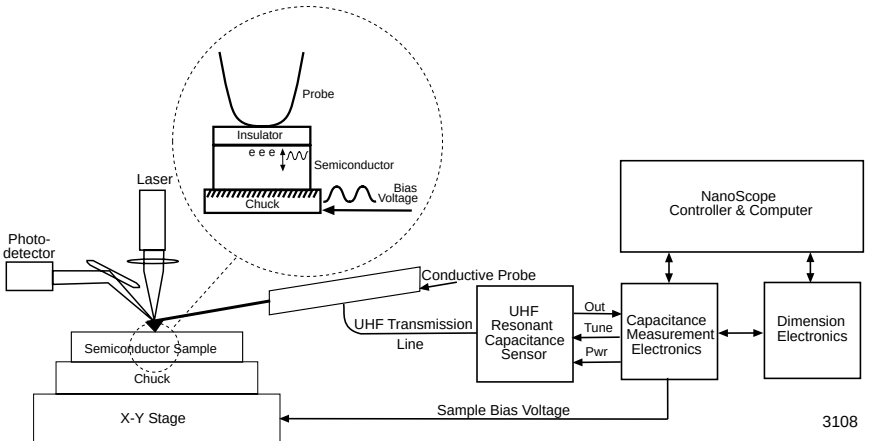

Figure 224-4 Basic SCM Detection System

SCM induces the desired capacitance variations in the sample near the tip by applying an electric field between the scanning contact AFM tip and sample. This is done using a kilohertz AC bias voltage applied to the semiconductor. The free carriers beneath the tip are alternately attracted and repulsed by the tip due to the alternating electric field. The alternating depletion and accumulation of carriers under the tip may be modeled as a moving capacitor plate (Figure 224-5). The depth of depletion and hence capacitor plate movement is determined by three quantities: 1) the strength of the applied field; 2) the quality and thickness of the dielectric (usually an oxide) between the conductive probe and the semiconductor; and, 3) the free carrier concentration.

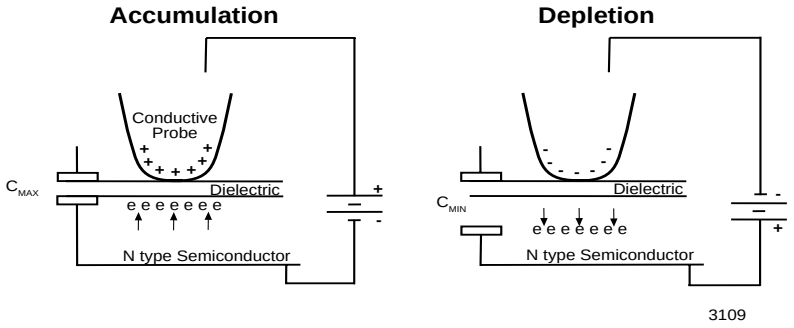

Figure 224-5 Change from accumulation to depletion during SCM due to alternating electric field

The carriers may be thought of as screening or accepting the applied field. The stronger the field or the fewer the carriers, the deeper the field depletes the surface. On the other hand, if the field is weak or the carrier concentration is high, the depletion field will be terminated very close (10—100 Å) to the surface. The dielectric insulates the tip from the sample and the thicker the dielectric is, the greater the drop in electric field across it. Therefore, if a semiconducting sample has uniform doping and different thicknesses of dielectric film, the depletion will be deeper over the thinner oxide. Similarly, in a sample having high and low carrier concentration regions, the depletion in the low-concentration region would be deeper for the same applied voltage.

The scanning capacitance microscope is measuring the movement of carriers, which translates into a stronger signal for low carrier concentration and/or thin oxide. The signal for SCM may be thought of as dC/dV, that is the change in capacitance (depletion) for a unit change in the applied voltage. Because we are applying an AC voltage waveform, dV may be thought of as the peak-to-peak voltage applied. The dC can be thought of as the total change in capacitance due to the change in depletion depth of the semiconductor under the probe.

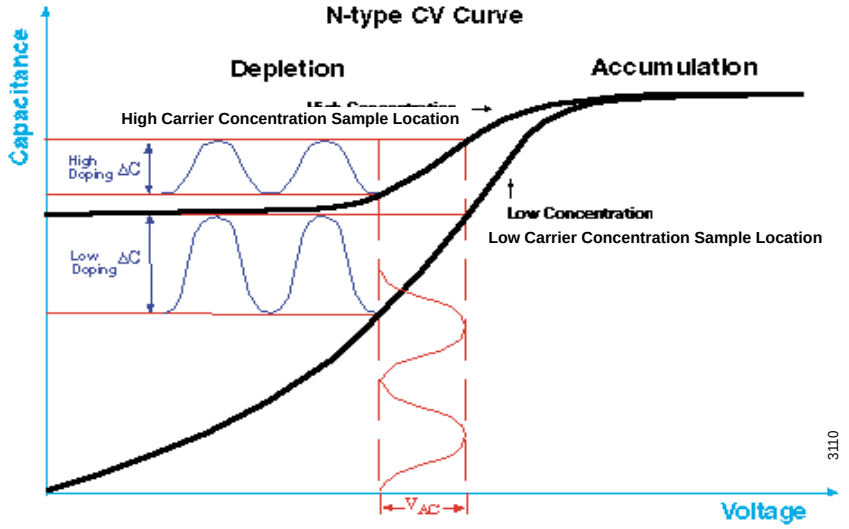

Figure 224-6 Change in capacitance versus applied AC voltage for high- and low-concentration, N-type CV curves

224.3.1 Capacitance-voltage Relationship in Semiconductors

Capacitance-voltage has been used for more than 35 years to measure important material characteristics in semiconductors. Figure 224-6 shows a typical high frequency capacitance-verses-voltage (CV) relationship for high and low concentration N-type material. For P-type material, the CV curve's polarity is inverted. At positive voltages applied to the gate (or in our case a conductive probe) the carriers in the material (electrons for N-type) are attracted to the surface and accumulate there. In accumulation, the capacitor plates for the semiconductor are very close together and the total capacitance of the system is the capacitance of the dielectric. As the voltage on the gate swings negative, the electrons move away from the gate, depleting the material of carriers and increasing the spacing between the semiconductor capacitor plates and lowering the capacitance. The lower concentration material depletes faster and hence the capacitance decreases faster with voltage. Therefore the slope of the CV curve (or dC/dV) is larger for the low concentration. The SCM can be thought of as a slope detector of the CV relationship.

The relationship between capacitance and voltage for a semiconductor is typically plotted on a C-V curve as shown in Figure 224-6. For SCM imaging, a constant amplitude sine wave voltage is applied to the sample (dV), then an image is constructed of the amplitude of the capacitance modulation (dC). The DC bias to the sample may also be adjusted, thereby moving the point around which the AC bias is applied.

Closed Loop Feedback

A feedback loop may also be applied to the dC/dV curve which enables surfaces to be imaged readily. The amplitude of the applied AC voltage (dV) is varied, while the feedback loop maintains a constant amplitude of modulation in the capacitance signal (dC). In this manner, an image is constructed showing the voltage amplitude (dV) required to maintain the chosen dC modulation. The intent of this mode of operation is to scan across the sample with a constant depletion depth. To do this, of course, requires a dielectric of uniform thickness across the sample. The general feedback loop is diagrammed below in Figure 224-8.

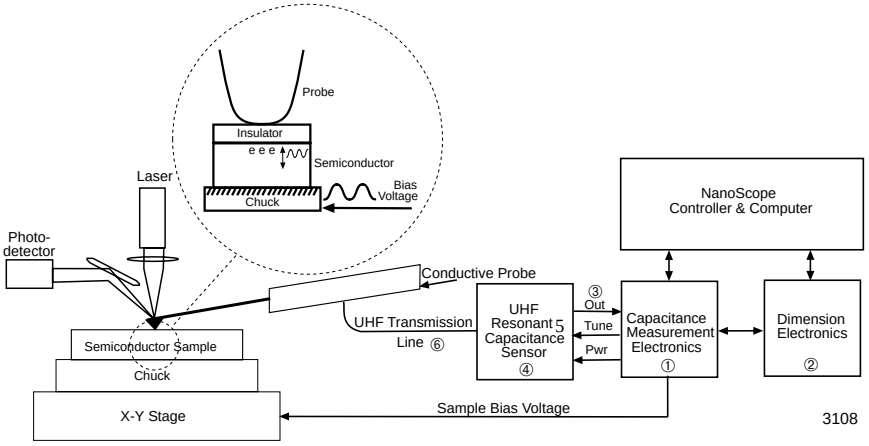

Figure 224-7 Closed Loop Feedback SCM Schematic

The capacitance measurement electronics (① from Figure 224-7) are diagrammed in detail below in Figure 224-8 and have been incorporated into the electronics package of the microscope. On Dimension Series SPMs, it is located on the backplane; on MultiMode SPMs, it is in the base. The capacitance measurement electronics are responsible for generating the sample bias voltage and for demodulating the capacitance sensor output ③.

The sample bias voltage is primarily an AC voltage that is used to modulate the depletion region under the tip but may also include a DC component for adjusting the operating point along the C-V curve.

Note that in the capacitance sensor ④, there is an inductor connecting the conducting probe to ground. This inductor has very low impedance at the frequencies of the modulation voltage, but has high impedance at the frequency of the capacitance sensor (900 MHz).

The tuning voltage ⑤ is used to adjust the resonant frequency of the stripline ⑥-probe-sample system such that it is near the 900 MHz oscillator frequency. When this resonator is driven near its resonant frequency, its amplitude response is very sensitive to small capacitance changes at the probe-sample interface.

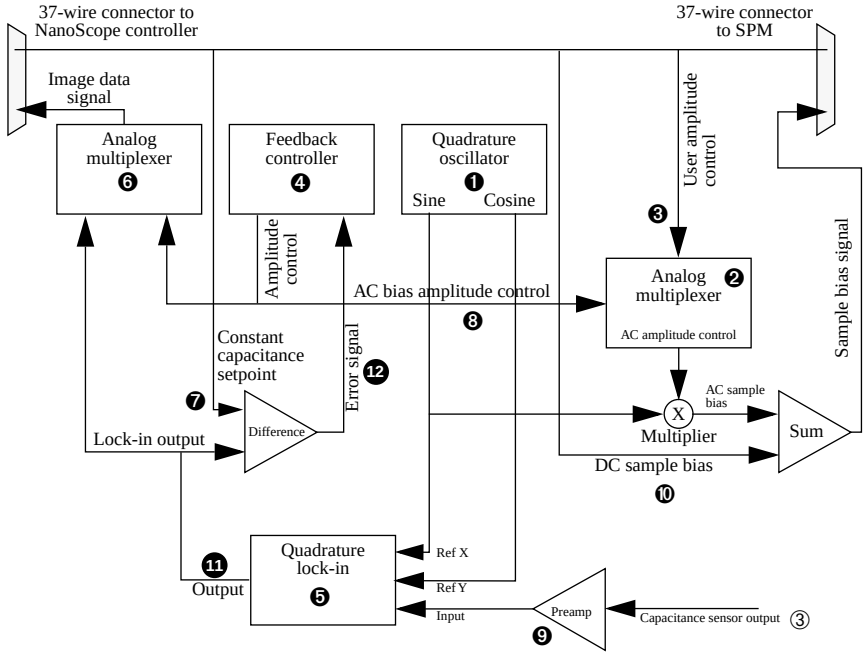

Figure 224-8 Details of Capacitance Measurement Electronics

The internal workings of the capacitance measurement electronics (① in Figure 224-7) are detailed in Figure 224-8. The origin of the AC sample bias is in the quadrature oscillator ❶. The amplitude of this signal can be controlled in two ways as selected by the multiplexer ❷.

- For open loop feedback, the amplitude will be fixed by a control signal set by the user ❸.
- For closed loop feedback, the amplitude will be servoed by the microcontroller ❹.

The quadrature lock-in ❺ is responsible for demodulating the capacitance sensor output (③ in Figure 224-7). It outputs a signal proportional to the amplitude of oscillation in the capacitance sensor output but only at the frequency generated by the quadrature oscillator.

- For open loop feedback, the lock-in output ⓫ is selected as the image data signal for a multiplexer ❻.
- For the closed loop case, the lock-in output ⓫ is differenced with the setpoint ❼ to generate an error signal for the microcontroller ⓬. In this case, the multiplexer ❻ selects the AC bias amplitude control ❽ as the image data signal.

Software Capacitance Panel

Bias frequency— Controls the frequency of the AC bias voltage that is applied to the sample. The bandwidth of the preamp ❾ is 5 kHz to 100 kHz. The frequency used doesn't appear to have much effect for many samples; however, the signal-to-noise ratio is better at higher frequencies.

Stray Cap. adj— Value of the tuning voltage (⑤ in Figure 224-7). It is used to change the resonant frequency of the stripline-probe-sample system to optimize sensitivity. The resonant frequency is largely affected by the stray capacitance around the probe, which can vary with sample geometry, chuck position, humidity, etc.

DC bias— (Refer to ❿.) Summed with the AC bias and used to shift the operating voltage along the C-V curve. AC bias amplitude for open loop imaging is the amplitude of the voltage applied to the sample. In closed loop mode, this parameter is grayed out.

Fdback bias setpt— (Refer to ❼.) Voltage which the lock-in output ⓫ is servoed to in the closed loop mode. It is grayed out in the open loop.

Data type— For open loop operation, this parameter should be switched to **DC/DV**. For closed loop operation, this parameter should be set to **Feedback Bias**; this selects the AC bias amplitude control ❽ as the image data signal.

Sensor igain— When selected during closed loop feedback operation, uses *integral gain* in the microcontroller to perform servo control of the AC bias amplitude. This parameter is grayed out (disabled) during open loop operation.

Sensor pgain— When selected during closed loop feedback operation, uses *proportional gain* in the microcontroller to perform servo control of the AC bias amplitude. This parameter is grayed out (disabled) during open loop operation.


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Capacitance Tune— Replaces **Cantilever Tune** in the **Real Time / View** menu (and its icon button on the menu bar). Displays a plot of the sensor output ③ versus the tuning voltage ⑤. This helps in visualizing the effect of the stray capacitance and aids in setting the **stray cap adj** signal.

224.4 Installation

Installation of a Dimension™ SPM with Scanning Capacitance Microscopy differs only in the installation of the SPM head. For other installation issues, see your Dimension manual.

224.4.1 Install the Head on the Stage

Prepare to install the microscope onto the Z-Stage's SPM mounting groove by releasing the Z-stage SPM microscope mounting clamp located on the right side of the Z-stage. The clamp is released by tightening the knurled screw on the right of the SPM head mount groove. (This may at first seem counter-intuitive; however, it is very important for proper operation of the instrument.) Clamp engagement is actuated by a spring. Failing to engage the spring-loaded clamp will cause a large increase in image noise due to reduced rigidity of the mechanical support of the SPM head.

Install the SPM microscope head on the Z-stage SPM mounting groove by slowly and carefully sliding the SPM microscope head's dovetail (located on the back of the SPM head) into the Z-stage's SPM mounting groove. Check that clearance between the sample and tip/scanner is sufficient to prevent the tip/scanner from crashing into the stage or sample upon insertion. If the Initialize command has just been run, there should be ample clearance, unless the sample is unusually thick.

Push the SPM microscope head to the end of the Z-stage SPM mounting groove, being very careful about crashing (see cautions above). If it appears the SPM microscope head may crash when fully inserted, remove the SPM head completely and execute Motor / Withdraw or Stage / Focus Surface commands to obtain sufficient clearance.

224.4.2 Lock the Head

Lock the SPM head into the Z-stage SPM mounting clamp by releasing the knurled head clamp screw, located at the upper right of the Z-stage, until the thread is just loosened plus approximately 1-1.5 turns. This causes the spring loaded clamp to engage the SPM head's dovetail, locking the head to the Z-stage.

224.4.3 Connect the Head to the Stage Controller Electronics

Insert the SPM microscope head's black 21-pin connector plug into the connector socket just behind the Z-stage located on the stage control electronics box. Insert the Scanning Capacitance 9-pin connector socket into the connector plug just behind the Z-stage located on the stage control electronics box.

224.5 SCM Procedure

SCM uses contact AFM to obtain images, and it is useful to decrease contact forces as much as possible to reduce wear. This may be done by first obtaining a force plot as described in Chapter 11 of your SPM's *Instruction Manual*. The setpoint can then be set to a level just above the pull-off value, minimizing force.

Two 1 cm square practice samples are supplied with the SCM system and may be used to obtain images and learn about SCM. The samples consists of alternating heavily and lightly doped stripes, interspaced with an alternating oxide and window area (Figure 224-9). One sample consists of P+ zones implanted into a P- substrate; the other sample consists of P+ zones implanted into a N- substrate (Figure 224-10).

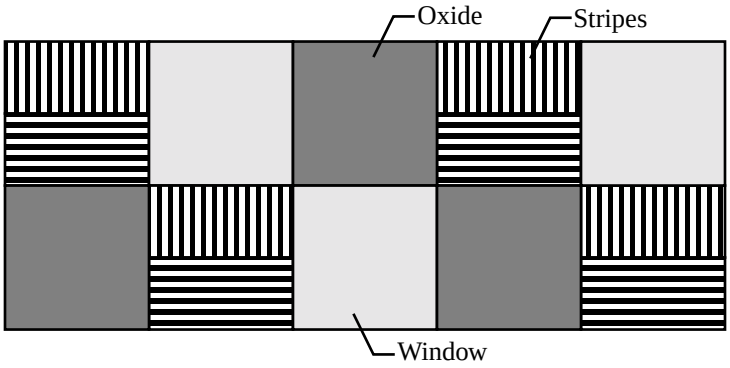

Figure 224-9 Pattern Used on SCM Practice Samples

The P+ implant strips are doped between oxide stripes as shown here.

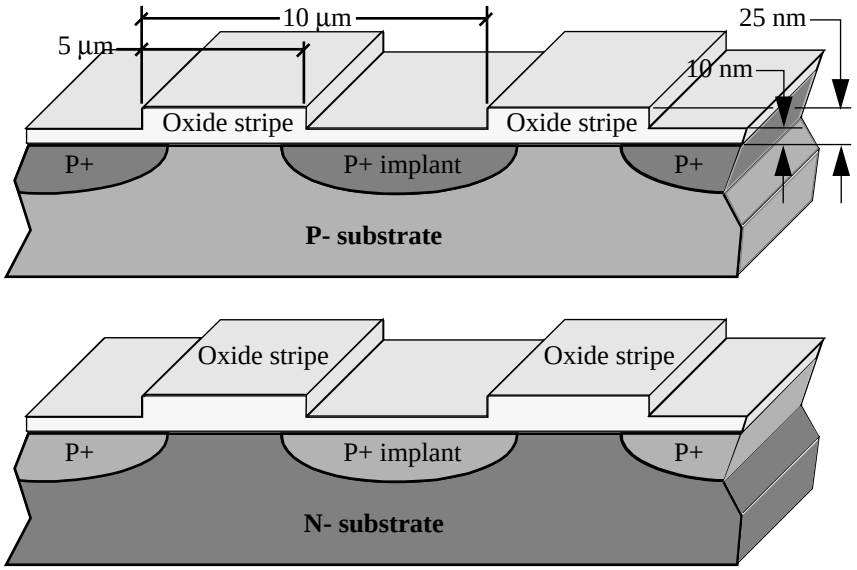

Figure 224-10 SCM Practice Samples Use Both P- and N- Substrates

To image the sample, do the following:

1. Attach the sample to a magnetic puck, making certain that good electrical contact is obtained. Attach the puck and sample to the sample chuck.

2. Obtain a contact AFM image of the surface using instructions found in Chapter 6 of your SPM's *Instruction Manual*.

CAUTION: The sample chuck is an electrostatic sensitive area. Wear a grounding device at all times.

3. Set control parameters to the following settings:

Parameter	**Initial Setting**	**Typical Adjustment Range**
Stray Cap. adj.	5.0 V	0 – 10.0 V
DC bias	0.0 – 0.2 V	±5 V
AC bias ampl	4.0 V	0.5 – 8.0 V
Data type (channel 2)	DC/DV	N/A
Setpoint	0.2 V above **vert. defl.**	N/A
Scan rate	0.5 Hz	0.1 – 1.5 Hz
Scan size	20 µm	1 – 100 µm
Integral gain	2	1 – 6
Proportional gain	4	2 – 12
Realtime planefit	Offset	N/A
Offline planefit	None	N/A
Z range	1.0 V	As needed.

4. Engage the sample and begin imaging. It will probably be necessary to make adjustments to a number of parameters before the image is optimized. Generally, parameters can be adjusted within the ranges shown in the table. As parameters are adjusted, differences in the image will become more apparent, leading to a better understanding of SCM.

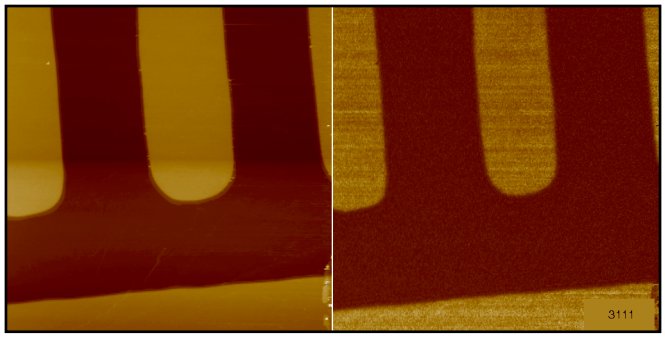

Figure 224-11 SCM Practice Sample: P+ / P

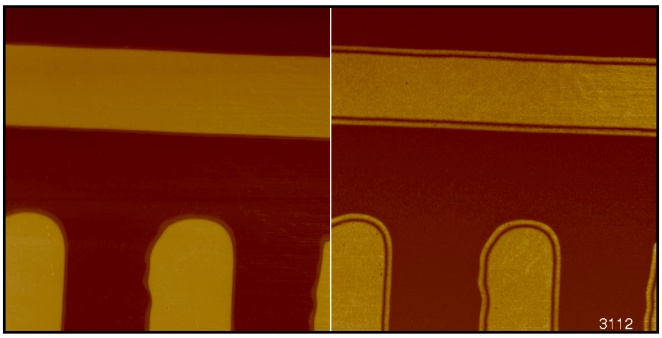

Figure 224-12 SCM Practice Sample: P+ / N

5. Switch to the **Feedback bias** control panel and adjust parameters as follows:

Parameter	Initial Setting	Typical Adjustment Range
Stray Cap. adj.	5.0 V	0 – 10.0 V
DC bias	0.0 V	± 5 V
Sensor igain	100	20 – 500
Sensor pgain	100	20 – 500
Feedback bias setpoint	100 mV	50 – 250 mV
Scan rate	0.5 Hz	0.1 – 1.0 Hz

Depending upon the sample's capacitance properties, the image should be optimized within the range of values shown above.

6. Once the image has been optimized, the parameter settings may be saved using the **Real Time / Microscope / Settings / Save** command. This will save time for future adjustments on similar samples.

224.6 Sample Cleaning Procedure

The two practice samples provided with the instrument may from time to time require cleaning. Just as topographic imaging can be adversely affected by contamination on the surface of the sample, an electrical measurement technique such as scanning capacitance can be fundamentally changed by the presence of water layers, ionic residue or charges trapped in the oxide. After time, the images obtained

from samples may change relative to what was imaged in final tests at the factory. After failure modes such as broken tips and incorrect measurement parameters have been ruled out, the next most likely problem lies with the samples themselves.

The SCM applies a local field between the tip and sample and measures the response of carriers to that field. Local charge may create fields which counteract the applied field, thus nulling the capacitive effect. This is seen in SCM as a loss of contrast or variation in the expected sample response (such as losing the bright junction stripes in the P+/N sample). Due to the geometry of the tip / dielectric / silicon of the samples, a local packet of charge can produce a localized effect equivalent to many volts of applied field either pinning the carriers at the surface or depleting the surface of free carriers. Each of these charge effects will destroy contrast in the SCM. It is nessesary to remove this charge in order to achieve the contrasts shown in the images of the practice grids (Figure 224-11).

Another source of lost (and unrecoverable) contrast are trapped and mobile charges. These are charges in the dielectric material (in this case oxide). The trapped charge can be due to charge pumped into the oxide by applying a voltage sufficient to flow current (i.e., ± 8 V). Some of the charge (both positive and negative) may remain trapped and create local fields. Mobile charge refers to predominately sodium and potasium ions from contamination (usually from your fingers!) which may diffuse into the oxide. These sources of charge are not removable and may only be avoided by reducing the amount of handling and voltage stress applied to the material. Regular cleaning and careful handling can mitigate further deterioration of the samples.

The cleaning and handling proceedures described here are for use on the practice samples, but may be transferred to other samples.

Don't use your fingers! Only handle samples with clean tweezers. Preferable storage would be in the sample's box and inside a nitrogen or dessicated dry box. This is particularily true for humid climates. Much of the cleaning effect will be to provide a hydrophobic (water hating/fearing) surface on the oxide. This effect will last longer if the sample is kept dry.

For cleaning, there are two prefered methods which may be used seperately or in combination to achieve the best results. You may find that one or the other works best.

The easiest one first: Cover the sample with a spray of clean acetone and set a square of acetate replicating tape[1] over the surface. Replicating tape—which is commonly used in electron microscopy—will partially dissolve in the acetone and then dry and adhere tightly to the sample surface. When you peel the tape back, the tape holds on to whatever was on the surface of the sample. The tape may also be left on the sample as a protective coating.

CAUTION: Clean samples with solvents only in a well ventilated area. Dispose of all wipes and swabs properly.

The next method requires a little bit more sophistication and treats the surface with a passivation associated with the alkali solution in a common chem-mechanical polishing compound. The first step may be an acetone or alcohol wipe to remove oils. Next apply colloidal silica suspension[2] to the sample surface and rub it around with a Q-tip. Rinse this off with deionized water. Next, use a few drops of soap[3] and another Q-tip to clean the surface of the silica particles. Lastly, rinse the sample again in deionized water and blow dry from one edge with clean filtered air or nitrogen. This method may be more effective against the charge layer on surface.

224.7 Sample Preparation for SCM

Some SCM work is conducted on sectioned and polished semiconductor samples. This section provides a quick overview of possible sample preparation techniques, which the microscopist may employ using a diamond saw, a lapper and some silver epoxy. A sputtering chamber may also be required. In general, standard electron

1. I use something from Ted Pella, Redding, CA called replicating tape. It is the thinnest variety. Every microscopy supply lab sells a similar product.
2. The Silica solution I use is from Allied Hi Tech products, Rancho Dominuez, CA. It is standard 0.05 um colloidal silica suspension, non-crystallizing (the blue stuff). Everybody claims that their suspension is non-crystallizing but none really is and care must be taken not to get the dry flakes onto the sample. Every shop that sells polish equipment and supplies will have an equivalent product.
3. Joy® soap seems to be the domestic product of choice if you don't have the micro clean variety from a scientific supply store.

microscopy techniques for sample preparation will work well for SCM, however, the surface finish required is more exacting. The following technique may be carried out and a sample prepared within a few hours with a little practice.

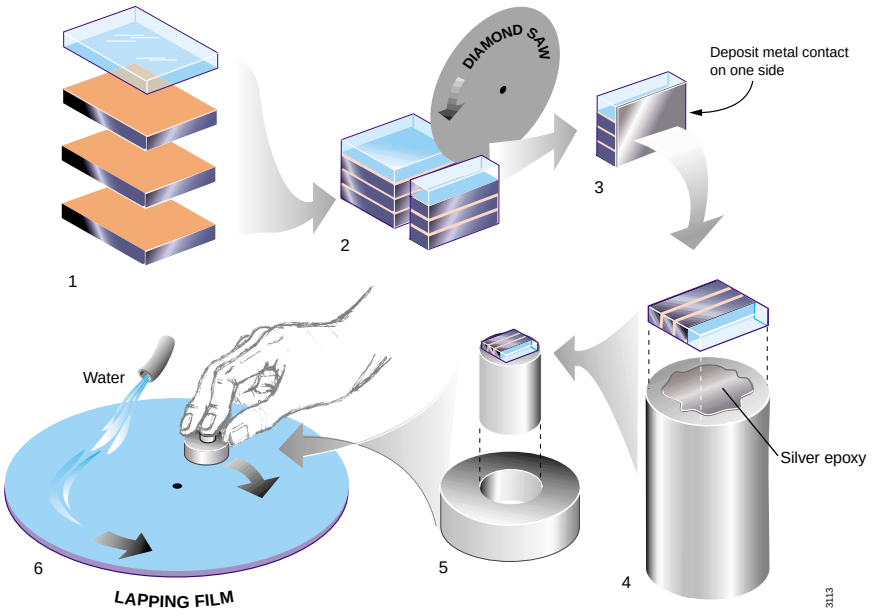

Figure 224-13 Basic steps in preparing a sectioned semiconductor sample for SCM

For the steps below, refer to Figure 224-13 above.

1. Cement the semiconductors into a stacked “sandwich” using G1 epoxy or equivalent. The pieces should be pressed together to remove all air bubbles. Finally, glass plates can be epoxied to the bottom and top of the sandwich to protect the semiconductors within and provide strength. Allow the epoxied stack to heat cure thoroughly.

2. Use a diamond saw to remove a slice of the semiconductor sandwich approximately 0.5 mm thick.

3. To ensure optimal electrical contact, sputter the semiconductor stack with gold on its underside where it will contact the puck and/or stage of the microscope. It is best to leave this side unpolished before sputtering.

Attach the coated side of the sample to the underside of a polishing fixture using silver epoxy. The coating should be spread evenly to leave a broad contact area.

4. Lastly, it will be necessary to polish the top (imaging) side of the semiconductor sandwich. The sample should be ground and polished flat to an RMS roughness of < 0.2 nm to produce a superior image.

To polish, the sample may be mounted on the underside of a cylindrical fixture by heat blocking with a low-temperature wax, or with silver epoxy as shown in Figure 224-13. The fixture, in turn, is inserted into a separate ring to keep the fixture perpendicular to the lap.

When grinding and polishing, maintain a small, constant downward pressure against the lap and move the fixture in small, counterrotational circles. The lap can be run at 90-120 rpm. Start with a 10-micron diamond grit paper and grind the sample until a uniformly flat surface is achieved; all traces of the saw cut should be thoroughly removed. Next, use a 3-micron diamond paper to remove approximately 30 microns. *NOTE: a good rule of thumb is to remove at least three times the material of the previous (larger) grit size before proceeding to the smaller grit.*

Diamond lapping films come in different sizes and may be used to incrementally achieve a finer and finer grind until a final polish is achieved. Generally, diamond paper may be used in 5-minute sessions, proceeding in the following order:

- 10-micron..... Use to remove saw marks and flatten sample.
- 3-micron..... 5 min.
- 1-micron..... 5 min.
- 0.5-micron..... As needed.
- 0.1-micron..... As needed.

Next, remove the surface damage left by the diamond paper process by using a colloidal diamond slurry. To avoid contamination, use a new polish pad dedicated to one grit (e.g., napless cloth). The following grinding order gives good results:

- 1-micron.....5 min.
- 0.5-micron.....10 min.
- 0.25-micron.....20 min.
- 0.1-micron.....As needed.
- 0.05-micron.....As needed.

Lastly, 0.05-micron colloidal silica is used to do the final cleaning and polishing of the sample surface by applying for 15-30 seconds, followed by running clean water for at least 30 seconds. Clean the sample surface with a swab and soapy running water, then wipe or blow dry.

If a powered lap is unavailable, the sample may also be ground and polished on a stationary flat lap by moving the fixture and ring in small figure-eight motions while periodically rotating the fixture within the ring to ensure even abrasion. Be certain to keep the fixture and lap wetted, and always clean completely before switching to a smaller grit.

NOTE: The most important tools in polishing are patience and a good optical microscope for inspection of the sample surface—e.g., bright field (BF), dark field (DF) and differential interference contrast (DIC) combined objectives in sizes of 5X, 20X and 50X. When grinding and polishing are complete, clean the sample thoroughly using water and wipe or blow dry. When attaching samples to the SCM stage, verify that electrical contact is maintained.

224.8 Maintenance

No additional maintenance is required for Scanning Capacitance Microscopy. For other maintenance issues, see your Dimension manual.

224.9 Bibliography

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