PREFACE

The XTM Manual contains information on installation, operation, and maintenance for the Thin Film Thickness and Rate Monitor. The contents of each section of the manual are listed below.

From time to time, additional technical data or application information may become available. To be certain that you receive this updated information, please fill out and return the User Registration Card in the front of this manual.

Section 1 — GENERAL INFORMATION — contains specifications for the XTM and the sensors as well as unpacking and inspection procedures.

Section 2 — PROGRAMMING AND CHECK PROCEDURES — provides a description of the functional characteristics of the instrument and gives instructions for programming and testing the unit prior to installation.

Section 3 — INSTALLATION AND REAR PANEL CONNECTIONS — contains detailed instructions for installing the unit and the sensors, and includes information on making the back panel connections. This section also includes an explanation of the operation of the sputtering sensor.

Section 4 — CALIBRATION AND MEASUREMENT THEORY — gives instructions for calibrating density, z-ratio, tooling, and analog output, and includes a brief explanation of measurement theory for those who may be interested in the evolution of quartz-crystal film thickness monitors.

Section 5 — MAINTENANCE AND REPAIR — consists of routine maintenance procedures and a troubleshooting section to pinpoint malfunctions that can be corrected in the field by qualified personnel.

Section 6 — SCHEMATICS — includes electrical schematics and outline drawings to assist in installation and maintenance.

WARRANTY

All Inficon instruments are warranted against defects in materials and workmanship for one year from date of shipment. Sensors and oscillators are warranted for ninety days from date of shipment.

Inficon will repair or replace, at its option, products which prove to be defective during the warranty period, provided they are returned to Inficon, Inc. No other warranty is expressed or implied. Inficon is not liable for consequential damages.

Contact Inficon for return authorization. All items to be returned to Inficon must be properly packaged, insured and shipped transportation charges prepaid.

No claim will be allowed for defects caused by purchaser's modification, abuse, misuse, excessive ambient temperatures or other abnormal conditions of operation. Failure of MOS circuits due to static discharge caused by improper handling is not covered.

The instructions contained in this manual do not provide for every contingency that may arise in connection with the installation, operation or maintenance of this equipment. If you need further assistance, please contact Inficon Leybold-Heraeus Inc.

WARNING

The XTM uses CMOS and MOS devices in its memory and logic circuits which may be damaged if exposed to large static discharges. Standard precautions should be used when handling these devices.

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SECTION 1
GENERAL INFORMATION

Section 1 of the XTM Manual contains tables of specifications with performance standards, limits, tolerances, and physical data for both the unit and the sensors. The section also includes instructions for unpacking and initial inspection. The following topics are covered:

- XTM Specifications
- Specifications for the Dual Sensor
- Specifications for the Bakeable Sensor
- Specifications for the Standard Sensor
- Specifications for the Sputtering Sensor
- Specifications for the Compact (Vertical) Sensor
- Unpacking and Initial Inspection
- Inventory

Once you have inspected and inventoried the shipping cartons, we urge you to follow the test procedure outlined in Section 2. In this way, you will become familiar with the unit and can be sure it is operating properly before you interface it with your vacuum system. Do not make the back panel connections until you complete the check procedure and understand how to program and operate the XTM.

SPECIFICATIONS — XTM

Fig. 1-1
XTM

Thickness Measurement Range (three automatic ranges)	0 to 999.9 kÅ
Thickness Display Resolution	1Å from 1 to 9.999 kÅ 10Å from 9.999 to 99.99 kÅ 100Å from 99.99 to 999.9 kÅ
Rate Display	0.0 to 999 Å/sec.
Rate Display Resolution (selectable)	1 Å/sec. (1 sec. ave.) 0.1Å/sec. (10 sec. ave.)
Thickness Limit (2 set points)	0 to 999.9 kÅ
Elapsed Time	0.1 to 999.9 min.
Density	0.80 to 99.99 gm/cc
Z-Ratio	0.100 to 1.999
Tooling	10.00% to 999.9%
Sample Period (measurement frequency)	1 sec.
External Control Inputs Zero Time Zero Thickness Open Shutter Close Shutter	All require 60 to 135 Vac (Model XTM Opt. 01 requires 15 to 60 Vac)
Control Output Thickness 1 Thickness 2 Time Limit Crystal Fail Shutter Open Shutter Closed	Solid state relays; maximum 135 Vac, rated at 3 amps
Recorder (D/A) Output for Thickness or Rate (optional)	0 to 10 Vdc
Power	±10%, 110-220 volts 50-60 Hz, 30 watts
Operating Temperature Instrument Sensor	 0 to 50°C -20 to 105°C
Shipping Weight	16 lbs. (6.2 kg.)

SPECIFICATIONS
DUAL (SWITCHABLE) CRYSTAL SENSOR
IPN 007-217

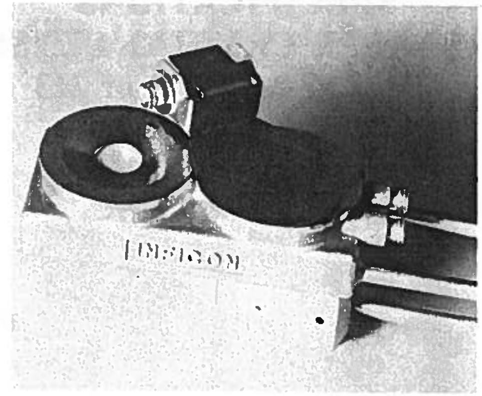

Fig. 1-2
Dual (Switchable) Crystal Sensor

Maximum temperature	105°C
Size (maximum envelope)	1.45″ (3.7 cm) x 3.45″ (8.8 cm) x 1.70″ (4.3 cm) high
Water, air and coax length	Standard 30″ (76 cm)
Crystal exchange	Front-loading, self-contained packages for ease of exchange. Shutter flips up to ease access to the holders.
Mounting	Two #4-40 on the back of the sensor body

INSTALLATION

A. Feedthrough	a) Qty (1) 2¾″ Conflat® with 2 Microdot, 2 pass water and air or, Qty (2) 1″ bolt with 2 pass water and Microdot
B. Other	b) (1) Customer to provide vacuum tight braze joints or connectors for the water and air lines. (2) Valve assembly for air. (3) Two oscillators designed to interface with the deposition controller. (4) For automatic operation, the deposition process controller must be designed for the implementation of this feature.
C. Utilities	c) (1) Water 150-200 cc/min, 30°C max (2) Air, 80 psi (5.5 atmospheres) very low volume

MATERIALS

A. Body and Holders	a) 304 type stainless steel
B. Springs	b) Au plated Be-Cu
C. Water and air lines	c) S-304, 0.125″
D. Connectors (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) 99% Al_2O_3
F. Wire	f) Teflon insulated copper
G. Other mechanical parts	g) 304 or 18-8 stainless steel
H. Braze	h) Vacuum process high temperature Au-Ni alloy
I. Crystal	i) 6.0 MHz, AT-cut plano-convex with Au overcoat

*NOTE: Because the XTM was designed prior to the Dual Sensor, additional external equipment will be required when operating the XTM with the Dual Sensor option.

SPECIFICATIONS
BAKEABLE CRYSTAL SENSOR
IPN 007-211, 212, or 213

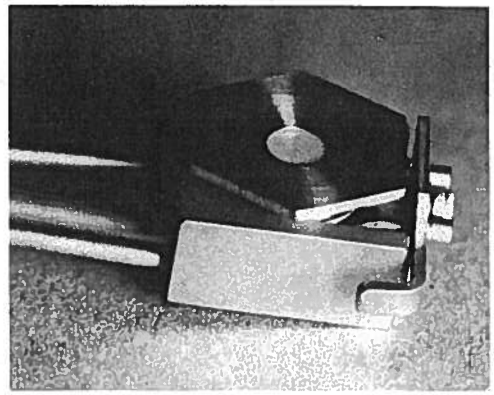

Fig. 1-3
Bakeable Crystal Sensor

Maximum temperature	450°C continuous (for bake only; waterflow recommended for actual deposition monitoring)
Size (maximum envelope)	1.35″ (3.4 cm) x 1.38″ (3.5 cm) x 0.94″ (2.4 cm) high
Water line and coax length (from face of feedthrough to center of crystal)	a) standard (1) 30″ (76 cm) IPN 007-209 (2) 20″ (50.8 cm) IPN 007-208 (3) 12″ (30.5 cm) IPN 007-207
Crystal exchange	Front-loading, self-contained package for ease of exchange. CAM type locking handle allows easy removal and good thermal contact.
Mounting	a) Standard — four #4-40 tapped holes on the back of the body b) Optional — right angle bracket

INSTALLATION

A. Feedthrough	a) 2¾″ ConFlat®, integral with sensor head
B. Other	b) (1) Oscillator designed to interface with the deposition controller (2) Water and coax lines are semi-ridged, but easily formed.
C. Utilities	c) Water 150-200 cc/min, 30°C max (Customer should provide means of easily disconnecting the ¼″ water lines during bakeout)

MATERIALS

A. Body and Holder	a) 304 type stainless steel
B. Springs	b) Molybdenum & Inconel X-750
C. Water and coax lines	c) S-304, 0.125″ (.3 cm) O.D. water 0.188″ (.5 cm) O.D. coax
D. Other mechanical parts	d) 18-8 or 304 stainless
E. Insulators	e) > 99% Al_2O_3 in vacuum; other high density ceramics used elsewhere
F. Wire	f) (1) Ni (in vacuum) (2) Ni plated Cu (elsewhere)
G. Braze	g) Vacuum process high temperature Au-Ni alloy
H. Crystal	h) 6.0 MHz AT-cut plano-convex with Au overcoat

SPECIFICATIONS
REGULAR CRYSTAL SENSOR
IPN 007-210

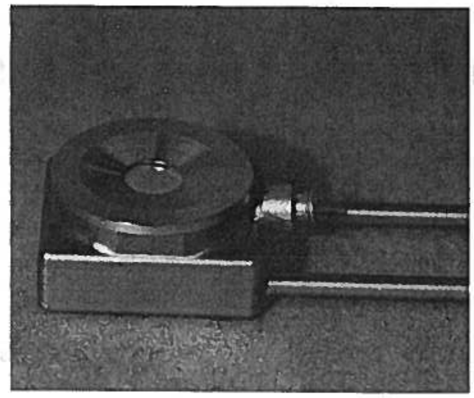

Fig. 1-4
Regular Crystal Sensor

Maximum temperature	105°C
Size (maximum envelope)	1.063″ (2.7 cm) x 2.35″ (6 cm) x 0.60″ (1.5 cm) high
Water line and coax length	Standard 30″ (76 cm)
Crystal exchange	Front-loading, self-contained package for ease of exchange
Mounting	Two #4-40 tapped holes on the back of the sensor body

INSTALLATION

A. Feedthrough	a) 2 pass water with Microdot coax connector
B. Other	b) (1) Customer to provide vacuum-tight braze joints or connectors for the water lines (2) Oscillator designed to interface with deposition controller
C. Utilities	c) Water 150-200 cc/min, 30°C max

MATERIALS

A. Body and Holder	a) 304 type stainless steel
B. Springs	b) Au plated Be-Cu
C. Water lines	c) S-304, 0.125″ (.32 cm) OD
D. Connector (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) >99% Al_2O_3
F. Wire	f) Teflon insulated copper
G. Braze	g) Vacuum process high temperature Au-Ni alloy
H. Crystal	h) 6.0 MHz, AT-cut plano-convex with Au overcoat

SPECIFICATIONS
SPUTTERING CRYSTAL SENSOR
IPN 007-032

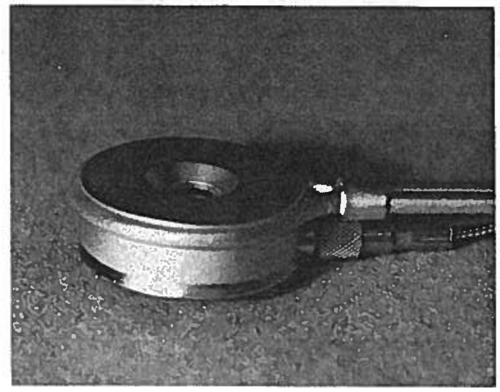

Fig. 1-5
Sputtering Crystal Sensor

Maximum temperature	105°C
Size (maximum envelope)	1.36″ (3.45 cm) ϕ x 0.47″ (1.18 cm) high
Water line and coax length	Standard 30″ (76 cm)
Crystal exchange	Front-loading
Mounting	Customer supplied

INSTALLATION

A. Feedthrough	a) 2-pass water with Microdot coax connector 2¾″ — (IPN 002-043) 1″ — (IPN 002-042)
B. Other	b) (1) Customer to provide vacuum-tight braze joints or connectors for the water lines (2) Oscillator designed to interface with deposition controller
C. Utilities	c) Water 750 cc/min, 30°C max

MATERIALS

A. Body and Holder	a) Au plated Be-Cu
B. Springs	b) Au plated Be-Cu
C. Water lines	c) Au plated Cu, 0.125″ (.32 cm) OD
D. Connector (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) 99% Al_2O_3
F. Wire	f) Teflon insulated copper
G. Solder	g) Cadmium free silver and indium alloys
H. Crystal	h) 6.0 MHz, AT-cut plano-convex with Ag overcoat
I. Magnet	i) ALNICO 5

SPECIFICATIONS
COMPACT (VERTICAL) CRYSTAL SENSOR
IPN 007-236

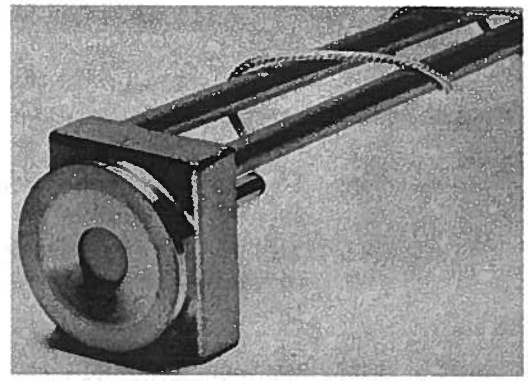

Fig. 1-6
Compact (Vertical) Crystal Sensor

Maximum temperature	105°C
Size (maximum envelope)	1.15″ (2.92 cm) x 1.062″ (2.7 cm) x .725″ (1.84 cm) high
Water line and coax length	18″ (45.7 cm) water and 12″ (30.5 cm) coax
Crystal exchange	Front-loading, self-contained package for ease of exchange
Mounting	Two #4-40 tapped holes on the back of the sensor body

INSTALLATION

A. Feedthrough	a) 2-pass water with Microdot coax connector
B. Other	b) (1) Customer to provide vacuum-tight braze joints or connectors for the water lines (2) Oscillator designed to interface with deposition controller
C. Utilities	c) Water 150-200 cc/min, 30°C max

MATERIALS

A. Body and Holder	a) 304 type stainless steel
B. Springs	b) Au plated Be-Cu
C. Water lines	c) S-304, 0.125″ (.32 cm) OD
D. Connector (Microdot)	d) Ni plated steel, teflon insulated
E. Insulators	e) > 99% Al_2O_3
F. Wire	f) Teflon insulated copper
G. Braze	g) Vacuum process high temperature Au-Ni alloy
H. Crystal	h) 6.0 MHz, AT-cut plano-convex with Au overcoat
I. Solder	i) Cd free Ag with In alloys

UNPACKING AND INITIAL INSPECTION

As soon as you receive your XTM Thin Film Thickness and Rate Monitor, please follow this procedure:

1. Unpack it immediately and examine it carefully to detect any damage that may have occurred in shipment. (This is especially important if there are obvious signs of rough handling on the shipping boxes.)

2. Report any damage you find to the carrier and to Inficon.

3. Keep the packing material until you have taken inventory and made sure you have received all the necessary parts.

4. Store spare crystals in their shipping containers for convenience and cleanliness.

INVENTORY

At this time, you should make sure you have received all the necessary equipment by checking the contents of the shipping containers with the list below:

- XTM Control Unit with mating connectors, rack-mount adaptors, and power cord.

  IPN 010-023 110V 60 Hz (standard voltage interface - 60-135 Vac)

  IPN 010-047 110V 60 Hz (low voltage interface - 15-60 Vac)

  IPN 010-049 220V 50 Hz (standard voltage interface - 60-135 Vac)

  IPN 010-050 220V 50 Hz (low voltage interface - 15-60 Vac)

- Sensor (Standard, Bakeable, Compact (Vertical), Dual, or Sputtering)

  a. Standard sensor (IPN 007-210) with integral lines

oscillator	(IPN 007-029)
interconnecting cables	(IPN 007-044)
five spare crystals	(IPN 008-010)

  b. Bakeable sensor (IPN 007-213) with 30" water lines, bakeable cable and integral 2 3/4" ConFlat® flange

feedthrough	(INTEGRAL)
oscillator	(IPN 007-029)
five spare crystals	(IPN 008-010)

Same as (b) with 12" cable (IPN 007-211)
Same as (b) with 20" cable (IPN 007-212)

c. Dual sensor (IPN 007-217) with shutter and water lines,
   oscillator (IPN 007-029)
   interconnecting cables (IPN 007-044)
   five spare crystals (IPN 008-010)

d. Sputtering sensor (IPN 007-032) with integral water lines
   oscillator (IPN 007-029)
   interconnecting cables (IPN 007-044)
   five spare crystals (IPN 008-009)

e. Compact (Vertical) sensor (IPN 007-236) with integral water lines
   oscillator (IPN 007-029)
   interconnecting cables (IPN 007-252)
   five spare crystals (IPN 008-010)

- Instrumentation Feedthrough

a. 1" bolt with one coaxial and two water lines (IPN 002-042)

b. 2 3/4" ConFlat® flange (copper gasket) with one coaxial, two water lines (IPN 002-043)

c. 2 3/4" ConFlat® flange (viton gasket) with one coaxial, two water lines (IPN 002-044)

- Instruction Manual (IPN 074-014)

In addition, you may have ordered the following:

a. D/A Converter Kit (IPN 010-036)
b. Spare crystals, gold contact (IPN 008-010)
c. Spare crystals, silver contact (sputtering) (IPN 008-009)

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SECTION 2
PROGRAMMING AND INITIAL CHECK PROCEDURE

Section 2 of the XTM Manual contains a procedure for you to check the operation of the unit before interfacing it with the coating system. It includes a description of the functional characteristics of the front and back panels, as well as programming guidelines. The following topics are included:

- XTM Front Panel Indicators and Switches
- XTM Back Panel
- Programming Guidelines
- Test Procedure
- Programming the Internal Control Switches

After you have become familiar with programming and operating the instrument, and have completed the test procedure, you are ready to install the sensors and interface the unit with your vacuum system. These instructions are included in Section 3.

Fig. 2-1 XTM Front Panel

XTM FRONT PANEL SWITCHES AND INDICATORS

The following list describes the operational characteristics of all switches and indicators on the front panel:

Zero

Pressing this button will reset any accumulated thickness and establish a new reference for the unit. This button is also used to zero the elapsed time and limit signals.

TC/CHK

Pressing this button will place both elapsed time and percent of crystal life used on the display. (Percent is based on 1.0 MHz = 100%.)

Shutter Open/Close

These two buttons provide manual control of an external source shutter. This manual shutter control can be combined with certain XTM events, such as thickness or limit, to gain precise shutter operation.

1Å or .1Å (rate resolution)

Setting this toggle switch down obtains a rate resolution of 0.1Å/second with a 10 second rate average for rates below 100 Å/second. For rates above 100 Å/second (switch down), a 10 second average is still applied, but the display is autoranged for 0.1Å/second resolution (up to 99.9Å/second). When the switch is set up, no rate averaging is applied and rate resolution is 1 Å/second (for the 1 sec. measurement) for all rates.

In addition to the control switches (above), the front panel contains a number of yellow pushbuttons and a data entry keyboard. The yellow buttons described below are used to access data when in the program mode, or to recall data when in the non-program mode.

Thickness 2

This button provides a 0.000 to 999.9 kÅ set point for the Limit 2 relay. This Limit 2 relay is activated when Thickness 2 is achieved and Thickness 1 has been achieved for at least one second.

Thickness 1

This button provides a 0.000 to 999.9 kÅ set point for the Limit 1 relay. This Limit 1 relay is activated when Thickness 1 is achieved.

Time

This button provides a 000.0 to 999.9 minute set point for the Time Limit relay. This (T Limit) solid state relay is activated when the elapsed time equals or exceeds the time set point.

Density

Density (0.80 to 99.99 gm/cc) is used to convert the measured mass to a thickness. The value used is determined by the type of material being evaporated (see p. 4-4).

Z-Ratio

Z-Ratio (0.100 to 1.999) is used to match the acoustical properties of the film to quartz, for accurate measured ranges. The value used is determined by the elastic properties of the material being evaporated (see p. 4-4).

Tooling

Tooling is a programmable (10.0 to 999.9%) constant which corrects for the geometric difference between the placement of the crystal sensor and the substrate location.

Data Entry Keyboard (1-9)

The keyboard is activated by placing the unit in the program mode. Pushing the yellow PROGRAM button near the keyboard lights the program status lamp and permits program to be entered. (See p. 2-5 for programming guidelines.)

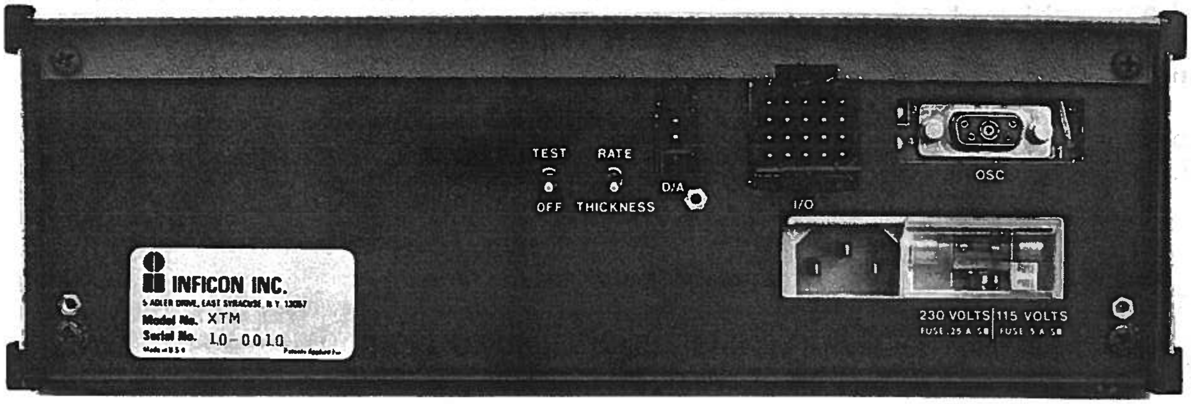


Fig. 2-2 XTM Rear Panel

XTM REAR PANEL

TEST/OFF Switch

When the test switch is set in the test position, the XTM is placed in an internal test mode. Normal operation requires that the test switch be placed "off." See page 2-6 for a description of a check procedure using the test switch.

RATE/THICKNESS Switch

When the XTM is equipped the D/A option, this switch is used to select either rate or thickness analog output.

Main Power

The power assembly contains a male connector for line power input, the line fuse, and a selector switch for 120 or 240 Vac input operation. The unit is shipped with the switch in the 120 Vac position.

CAUTION: Be sure to change the fuse when you are using 240 Vac input.

I/O Connector — J2

Inputs and outputs are connected via these pins. See page 3-9 for connection instructions.

OSC Connection

This connector is used to connect input from the sensor head oscillator to the XTM.

D/A (Recorder Output Option)

This option provides an analog signal which is proportional to the displayed rate or thickness (as determined by the RATE/THICKNESS toggle switch on the back panel). See p. 3-12 for pin connections.

PROGRAMMING GUIDELINES

The format and general rules for programming are given below:

1. The numeric keys are used to post data on the display.

2. Digits are entered from the right, with decimals permanently programmed (except for Thickness 2 and Thickness 1).

3. The E key is pressed to enter data and step the unit to the next parameter. After the tooling entry, the unit returns to the operating mode and displays rate and thickness information.

4. The C key clears display data if it is pressed before data is entered (with the E key).

5. New data may be entered in the display without clearing data currently in memory (by posting digits and pressing the E key).

6. Thickness 2 set point is activated only after Thickness 1 set point has been activated for one second. Thickness 2 set point is normally greater than Thickness 1 set point.

7. Thickness 2 and Thickness 1 incorporate auto-ranging. Full scale ranges are 9.999 kÅ, 99.99 kÅ, and 999.9 kÅ. When entering data in these addresses, observe the decimal shift if the desired thickness is greater than 10 kÅ.

8. Data may be recalled any time by pressing the appropriate address button. If you wish to reprogram any single parameter push the Program button and then the desired address. Return to normal operating mode by pressing the Program button again.

TEST PROCEDURE

Before you plug in the XTM control unit, check to see that the power supply is the one for which the unit was ordered (see p. 1-2). Do not connect the sensors or oscillators until you have finished the check procedure. Now follow the directions below:

1. Set the rear panel toggle switch in the "test" position, and the rate resolution toggle switch (on the front panel) at 1 Å.

2. Set the front panel power switch in the "on" position.

3. Notice that the following indicators are lit:

   Shutter - either "Open" or "Close" (orange light)
   Limit 1 (green light)
   Limit 2 (green light)
   T Limit (green light)
   Thickness 2 (green light)
   Program (orange light)

   All zeros (red) will appear in the thickness (kÅ) display.

4. Press the following yellow pushbuttons to observe the preprogrammed data on the display. Notice that the unit designation changes appropriately.

Thickness 2	0.000 kÅ
Thickness 1	0.000 kÅ
Time	000.0 MIN
Density	01.00 gm/cc
Z Ratio	1.000
Tooling	100.0%

5. Press Thickness 2 to return to the beginning of the program (Thickness 2 indicator lit).

6. Program Thickness 2 to a value of .100 kÅ by pressing keys 1, 0,0,E. The unit will step to the Thickness 1 address.

7. Program Thickness 1 to a value of .050 kÅ by pressing 0,5,0,E. The unit will step to the Time address.

8. Program Time to .1 minute (6 seconds) by pressing 1,E. The unit will step to the Density address.

9. Leave Density, Z-Ratio, and Tooling at their preprogrammed values, and return to the beginning of the program by pressing the Thickness 2 button.

   NOTE: For complete programming instructions, see p. 2-5.

10. Press the (lighted) Program button. The Program and Limit lights will go off and a test run of the instrument will begin. You will notice the following:

    a. 10 Å/SEC will appear on the rate display.

    b. The thickness reading will be increasing at the rate of 10 Å/second. (If other than preprogrammed values are entered for Density, Z-ratio, and Tooling, the indicated rate will change accordingly.)

    c. The Limit 1 indicator will light when the Thickness 1 programmed value (.050) is reached.

    d. The Limit 2 indicator will light when the Thickness 2 programmed value (.100) is reached.

    e. T Limit will light when elapsed time exceeds programmed time of .1 minute. (Pressing TC/CHK allows you to read elapsed time.)

NOTE: If the thickness display does not initialize to zero when the lighted Program button is pressed, you should immediately press the Zero button. Pressing this button at any time zeros the thickness and restarts the process.

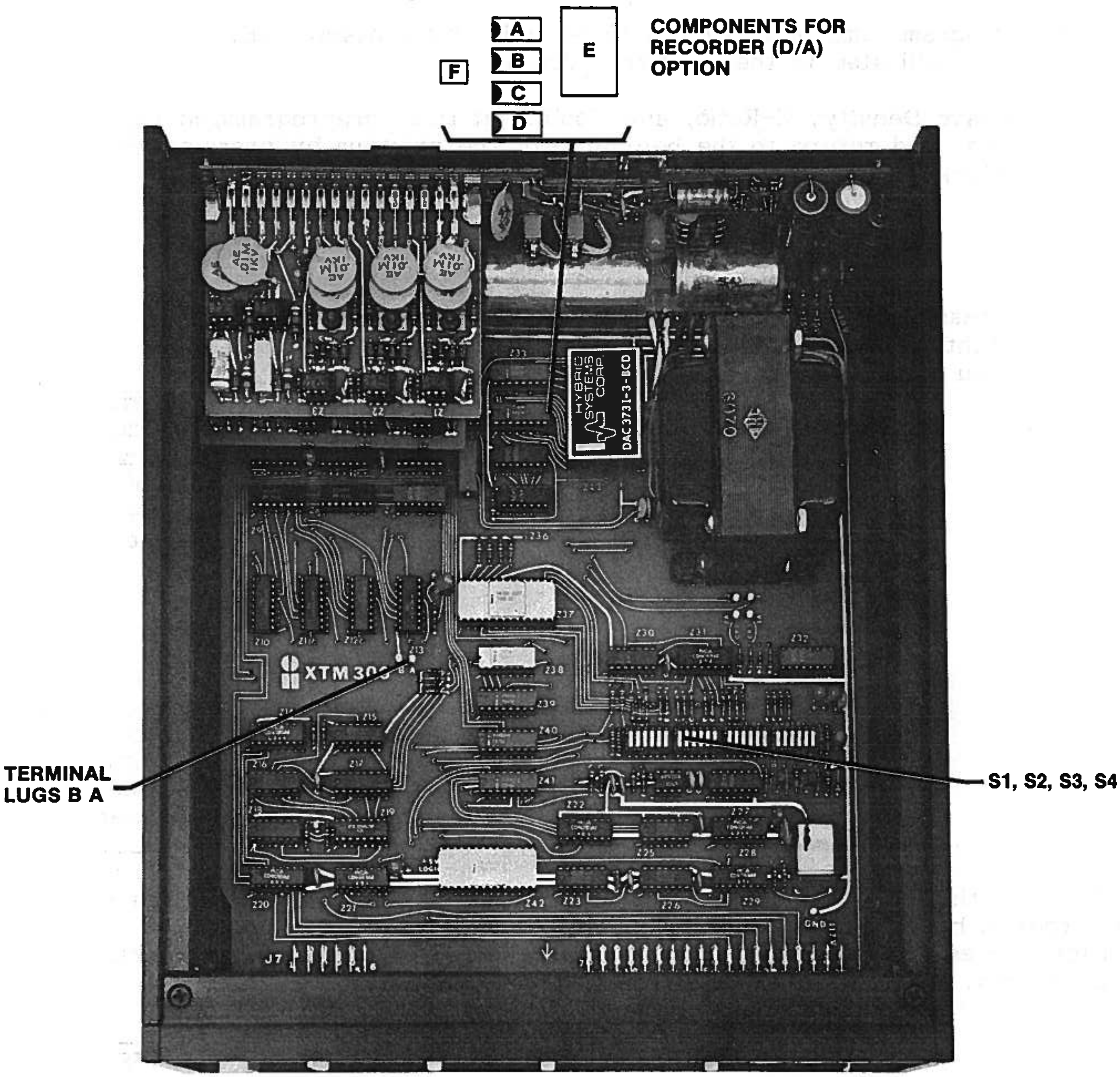


Fig. 2-3 XTM Chassis Interior

INTERNAL CONTROL SWITCHES

The front panel external inputs - Zero Time, Zero Thickness, Shutter Open, and Shutter Close - can also be triggered by any of the six events occurring within the XTM. Figure 2-3 shows the location of the switch blocks used to internally program these inputs.

Each of the four internal control switch blocks correspond to a front panel input (change).

Block S1 - Zero Time
Block S2 - Zero Thickness
Block S3 - Shutter Open
Block S4 - Shutter Close

Each of these blocks contains six switches, with each numbered switch corresponding to an event or machine state which may be used to trigger the desired change. (All six events are available on each block.)

The XTM is shipped with all the switches off. To activate a particular function, turn the appropriate switch to "on" (down), using a pointed object. For example, if you wanted to trigger the following sequence of events

a. exceeding the time limit zeros the thickness
b. exceeding thickness 1 opens the shutter
c. exceeding thickness 2 closes the shutter

the required switch pattern would appear as in the illustration below:

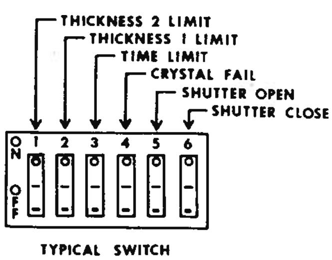


Fig. 2-4 Typical Switch

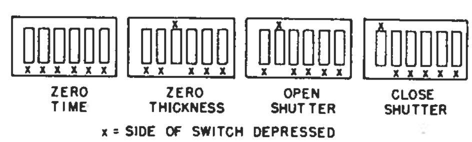


Fig. 2-5 Sample Switch Pattern

Section 3 of the XTM Manual covers installation procedures and instructions for back panel connections. The following topics are included:

- Electrical Connections
- Installation in the Coating System
- Installing the Regular, Compact (Vertical), Dual, and Bakeable Sensors
- Installing & Operating the Sputtering Sensor
- I/O Connector (J2)
- Recorder (D/A) Output Option
- Changing the XTM Time Display

After installation is complete, you are ready to program and operate the XTM. To determine values for Density, Z-Value, and Tooling, refer to Section 4.

INSTALLATION

Now that you have tested the unit you are ready to install the sensor and interface the unit with the coating system.

Electrical Connections

1. Plug the power cord into the unit and into a power source for which it was ordered (see p. 1-2).

2. Connect the oscillator cable to the oscillator connector located on the back panel of the instrument.

3. Attach the sensor cable Microdot® connector to the oscillator by way of the feedthrough. If the proper electrical feedthrough is not available, you can use a Microdot to BNC adaptor (not supplied).

Installation in the Coating System (Fig. 3-1)

Observe the following precautions when interfacing the XTM with the coating system:

1. Be sure there is adequate ventilation when rack or cabinet mounting the XTM.

2. Provide a ground braid between the lug on the rear panel of the XTM and the common system ground point.

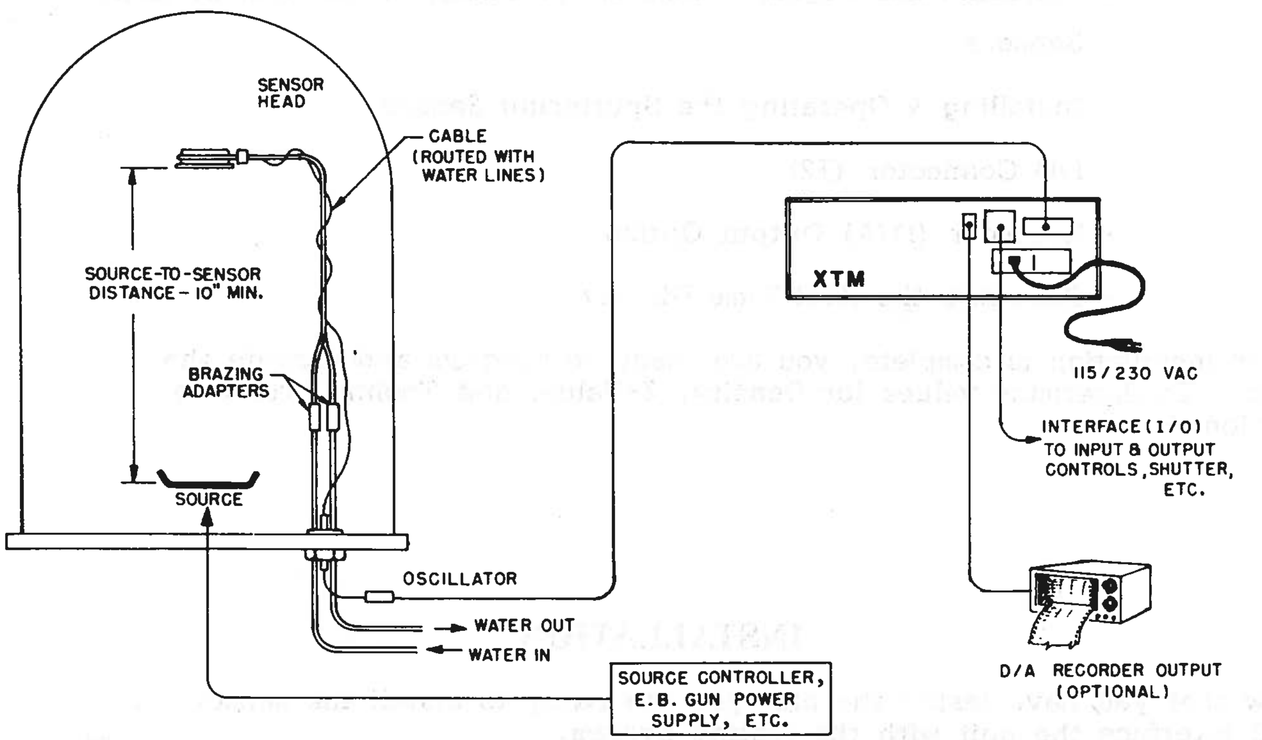


Fig. 3-1 Typical Installation

3. Remove ac line power from the unit whenever connections are being made.

4. Do not exceed the input or output power ratings (p. 1-2) at any time.

5. Change the position of the (back panel) selector switch, if necessary, by removing the fuse and sliding the switch to the extreme left.

   Note: Changing the selector switch does not change the ratings on external inputs and outputs (maximum 135 Vac).

INSTALLING THE SENSORS

The following general installation guidelines refer to the regular, dual, and bakeable sensors only. If you ordered a sputtering sensor, please refer to p.3-4.

General Guidelines

- The sensor should generally be installed as far as possible from the evaporation source (a minimum of 10" or 25.4 cm), while still being in a position to accumulate thickness at a rate which is proportional to accumulation on the substrate.

- To guard against spattering, use a shutter to shield the sensor during the initial soak periods. If the crystal is hit with even a minute particle of molten material, it may be damaged and stop oscillating. Even in cases when it does not completely stop oscillating, it may become unstable.

Installation Procedure — Regular, Compact/Vertical, and Dual Sensors

The regular and dual sensors may be installed in any appropriate location within the vacuum system. Two tapped holes are provided on the back of the sensor body for attaching to the system. In the compact sensor the water lines are of sufficient strength to be used as a mounting structure after they are formed to your specific sensor alignment. The cable length should not exceed 40 inches (101.6 cm) from the sensor to the feedthrough. Cut the water cooling tubes and air lines to the proper length and connect them to the feedthrough by brazing or vacuum couplings. (Use a bending tool to form the tubes to the system.) Shield the coax cable from heat radiating from the evaporant source or substrate heater. You can do this very simply if your process allows, by wrapping aluminum foil around the cable and water lines. *See note below.

Installation Procedure — Bakeable Sensor

The bakeable sensor may be installed as described above, or with the clamps on the lines running to the sensor. The cable length and air lines are not adjustable. It will not be necessary to shield the cables. We do suggest, however, that you install a deposition shield to prevent accumulation of material on the cam mechanism. If the water and coax lines require bending, we suggest a minimum bend radius of 1/2" (1.3 cm). Always use a bending tool or form to avoid kinking.

Please refer to the specifications on pages 1-2 through 1-6 for other installation requirements, including maximum operating temperatures.

*Note: Because the XTM was designed prior to the Dual Sensor, additional external equipment will be required to operate the XTM with the Dual Sensor option.

INSTALLING AND OPERATING THE SPUTTERING SENSOR

Preliminary Checkout of the Sputtering Sensor

Before you install the sputtering sensor in the vacuum system, you should make sure it is in proper working condition by following the procedure outlined below:

1. Connect the free end of the coaxial cable to the oscillator, using the feedthrough ordered (p. 1-8), or a coax adaptor (Microdot® BNC).

2. Plug the multipin connector from the oscillator to the matching receptacle on the back panel of the XTM.

3. Set Density at 01.00 gm/cc, and zero the thickness. The display should stop at either 0.000, 9.999, or 0.001. Crystal life should read from 1 to 7%.

4. Breathe on the crystal and observe whether a thickness indication of between 1.000 and 2.000 kÅ appears on the display. When the moisture evaporates, the thickness indication should return to approximately zero.

If the above conditions are observed, you can assume the sensor is in proper working order, and you can install it.

Installation

The sputtering sensor can be installed in any position, and supported by the water-cooling tube. Cut the water-cooling tube to the proper length and connect it to the feedthrough with brazing adaptors or vacuum couplings. Avoid exposing the sensor cable to the glow discharge by wrapping the cable around the water-cooling tube and covering it with aluminum foil. Figure 3-2 shows several possible locations for the sensor in various sputtering systems.

Because of geometric factors, variations in surface temperature, and differences in electrical potential, the crystal and substrates often do not receive the same amount of material. If you want the thickness indication on the unit to represent the thickness on the substrates, calibration is required to determine the tooling.

The following precautions must be observed when installing the sputtering sensor:

1. Use water cooling during the sputtering process. Approximately 0.2 (750 cc/min) gpm water flow should be sufficient for most applications. Always check the water flow before starting the glow discharge.

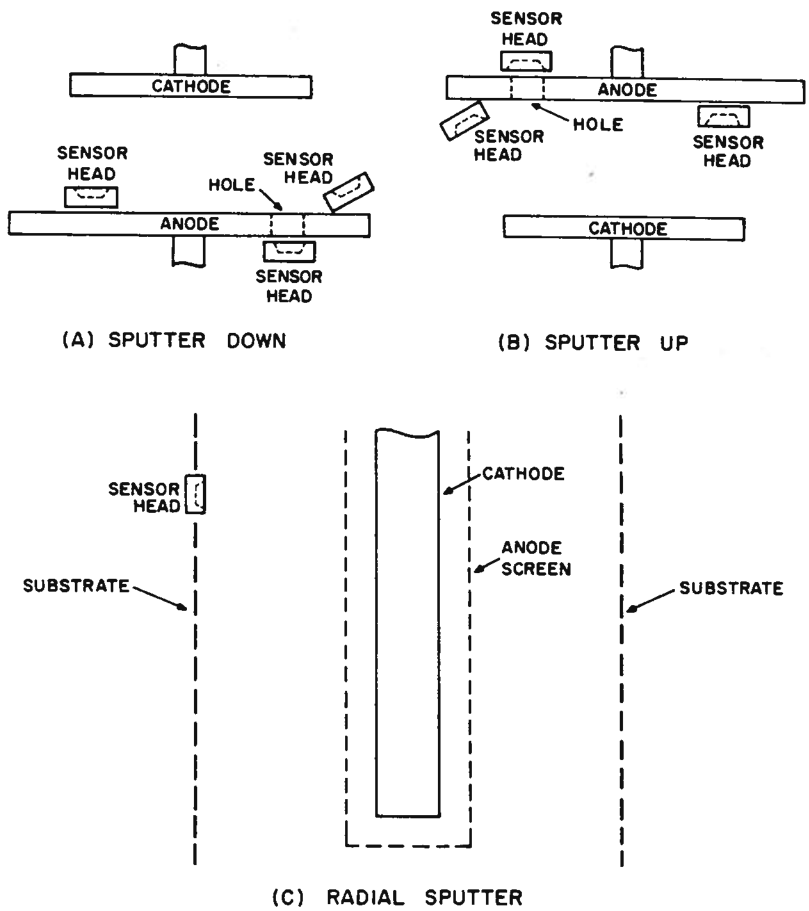


Fig. 3-2 Suggested Sensor Locations (Sputtering System)

2. In sputtering systems which use a substrate shutter, the sensor should be mounted in a location where it is always exposed to the glow discharge. If it is not, and the shutter is covering the sensor, there will be a small thickness jump when the shutter is opened, caused by thermal stress in the crystal.

3. The sensor contains a permanent magnet (Fig.3-3). If the sensor is to be installed in a sputtering system which employs external magnetic fields, make sure the magnetic field direction of the sensor is not opposing the external magnetic field (Fig.3-4). The cancellation of magnetic fields near the sensing crystal may cause undesirable heating of the crystal. Use a small magnet to determine the field direction and rotate the magnet in the sensor to a desirable position. The sensor magnet can be held in position by inserting a small piece of thin non-magnetic metal wire or sheet into the gap between the circumference of the magnet and the opposing wall. The sensor's magnetic field is localized, and will not affect the external magnetic field to any extent.

4. The sensor is always at ground potential and cannot be made floating. In sputtering systems where the substrate holder (anode) is biased, the sensor should be located where it is electrically isolated from the substrate holder and where it does not affect the electric field near the substrates.

5. Be sure both the sensor and the vacuum system are adequately grounded.

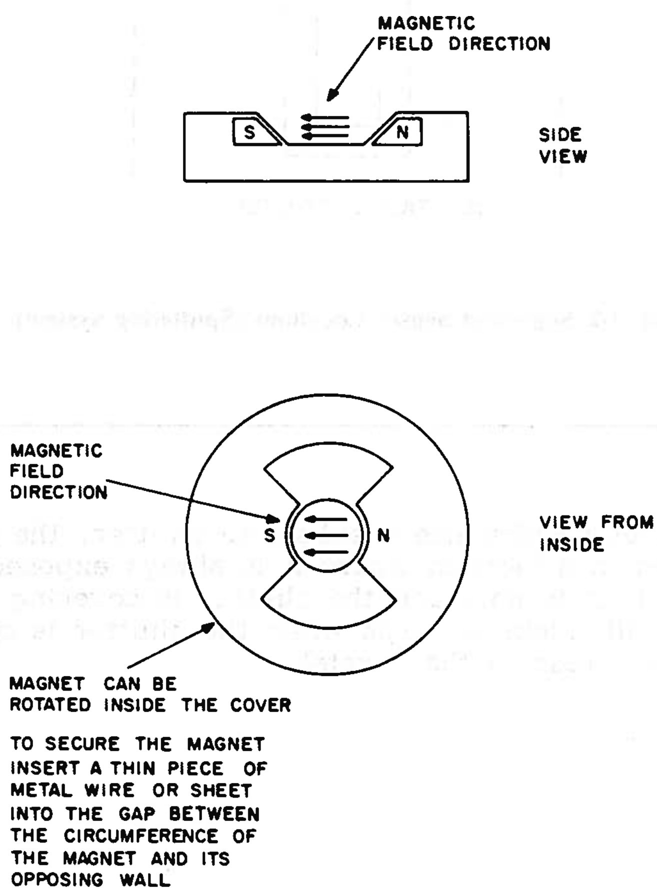


Fig. 3-3 Sensor Magnet & Field Configuration

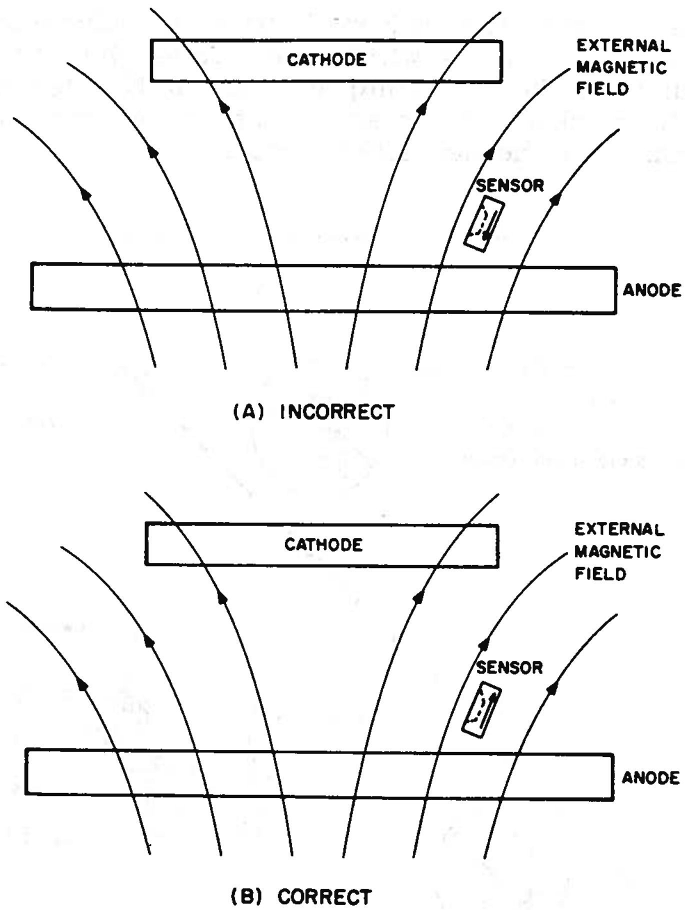


Fig. 3-4 Orientation of Sensor Magnetic Field

Operation of the Sputtering Sensor

At the start and the termination of the glow discharge, it is normal to observe a sudden but small shift of the thickness display on the control unit. The shift is negative at the start and positive at the termination of the glow discharge. This is due to the thermal stress generated in the crystal when one surface is exposed to the glow discharge. The magnitude of this thickness shift depends on the sputtering power and other parameters. The shift at the termination of the glow discharge is about the same magnitude as the shift at the start of the glow discharge, but in the opposite direction. It is independent of the total deposition time, and thus it is completely predictable. If you want to stop the deposition by using the Thickness Limit Relay on the control unit to turn off the power or to close a shutter you should zero the thickness reading after the establishment of the glow discharge. This will eliminate the effect of the initial thickness shift due to thermal stress.

Typical Performance

An actual performance curve of the Inficon Sputtering Thickness Sensor is shown in Figure 3-5. The curves within the circles show the details of the performance curve at the beginning and end of the deposition. The numbers within the circles indicate scale factors for time and thickness and particular points in the deposition cycle.

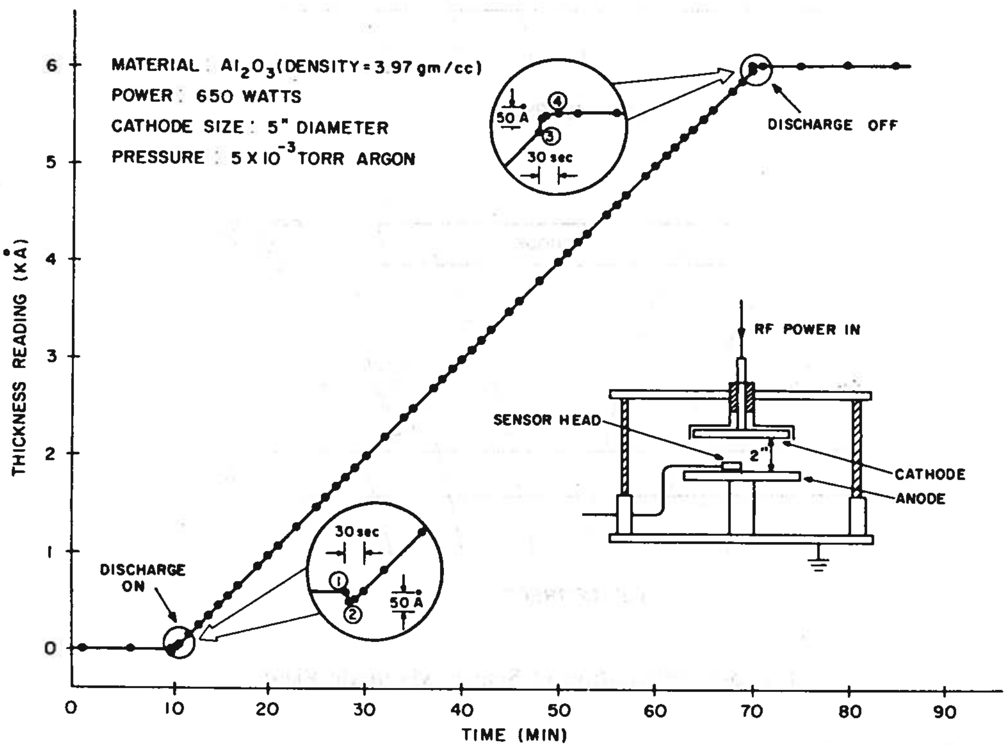


Fig. 3-5 Typical Performance Curve of Sputtering Sensor

Note that the thickness shift due to thermal stress is very small and is established within 30 seconds after the start or termination of the glow discharge. The thickness shift at the termination of the glow discharge is about the same, but in the opposite direction, (as compared to that at the start of the glow discharge), even after one hour of sputtering. The actual thickness being deposited on the crystal, with density setting at 4.00 gm/cc, is indicated by the Reading 4 (6.034 kÅ), because the thickness reading was zeroed before the deposition (Reading 1 = 0.000 kÅ). If you zero the thickness indication at Reading 2 (actual reading: 9.973 kÅ or -0.027 kÅ), Reading 3 (actual reading: 5.982 kÅ) will become 6.009 kÅ - only 0.4% less than Reading 4. The stability of the thickness reading after the termination of the glow discharge also indicates the lack of any accumulative heating effect on the sensing crystal during sputtering. This demonstrates the excellent stability and accuracy of the Inficon Sputtering Thickness Sensor when used in the sputtering environment.

REAR PANEL CONNECTIONS

I/O Connector (J2)

All control inputs and outputs are accessible at this connector. Use the mating connector and pins supplied and make the connections with 20 gauge (or smaller) wire. Be careful when soldering the pins so that the solder does not flow to the contact portion of the pins. Fig.3-6 shows pin locations; descriptions of inputs and outputs are listed below.

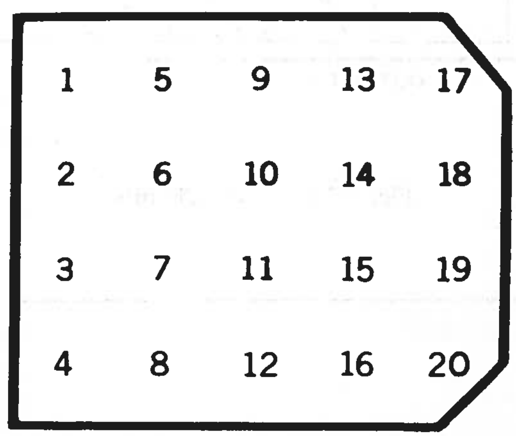


Fig. 3-6 J2 Pin Locations

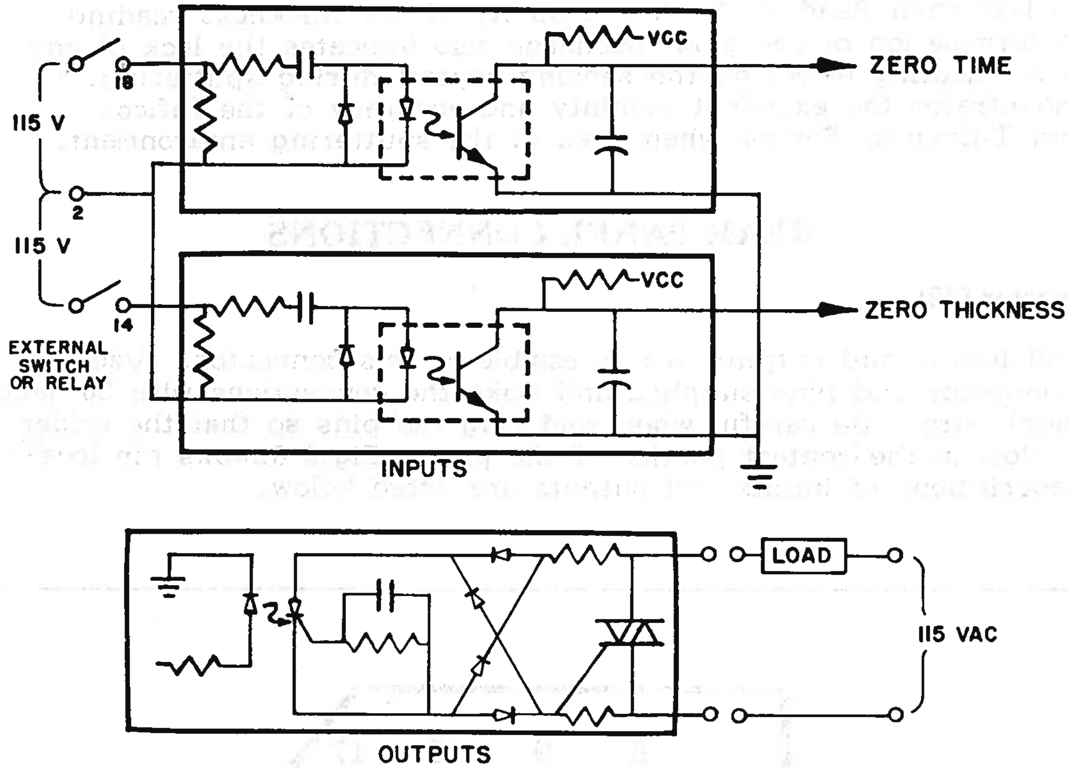


Fig. 3-7 Interface Circuits

Inputs

All inputs are optically isolated from the internal circuitry and require a 60 - 135 Vac signal between the common input (2) and the function input. A simple contact closure (Fig. 3-7), supplying a 50-60 Hz signal activates the inputs. Current requirements are less than 10 MA rms when using 135 volt input.

> **CAUTION:** Because of the common input (2), it is necessary to maintain ac line identity when using 135 volt input.

If the XTM was purchased with an 01 option, input ratings are 15 to 60 volts rms. Under no circumstances should the input exceed 60 volts rms.

Pin connection	Function
14	Zero Thickness (momentary input zeros thickness reading when signal is applied)
18	Zero Time (momentary input zeros elapsed time when signal is applied)
15	Shutter Open (momentary input activates the external output Shutter Open of the XTM)
20	Shutter Close (momentary input activates the external output Shutter Close of the XTM)
2	Common (circuit common to above inputs)

NOTE: Momentary inputs should be a minimum of one second duration.

Outputs

The outputs are also optically isolated and each circuit is independent (Fig. 3-7). The Triacs providing circuit closure are rated at 135 volts, 3 amps. To insure reliability, this rating should never be exceeded.

Pin connection	Function
1, 5	Thickness Limit 2 (Triac closes when displayed thickness equals or exceeds the programmed Thickness 2 value, and Thickness 1 limit has been active for at least one second.)
6, 9	Thickness Limit 1 (Triac closes when displayed thickness equals or exceeds the programmed Thickness 1 value.)
13, 17	Time Limit (Triac closes when elapsed time equals or exceeds programmed time.)
16, 19	Crystal Fail (Triac closes when the XTM determines that the sensing crystal has stopped oscillating.)
12, 8	Shutter Open (Triac closes when Shutter Open signal is activated.)
3, 4	Shutter Close (Triac closes when Shutter Close signal is activated.)

NOTE: Shutter Open and Shutter Close can be converted into momentary Triac closures by clipping shutter jumpers between 2, 2A and 3, 3A.

Recorder (D/A) Output Option (J3)

If the XTM is equipped with this option, the signal is available on pins 1 and 2 of connector J3. Pin 1 is the reference (ground) for this output. The output can represent either rate or thickness by the positioning of the selector switch (S1) on the rear panel.

The XTM may also be retrofitted with this option in the field. Fig. 2-3 (on p. 2-8) shows the six integrated circuits involved and their physical location on the XTM-300 board. These packages are shipped with designations A through F, and should be installed A to A, B to B, etc.

For output characteristics and calibration, refer to p. 4-5.

> **CAUTION:** Observe correct polarity when you install these integrated circuits, or they may be damaged.

XTM TIME DISPLAY

The XTM's time display can be used to show either elapsed time or deposition time. The unit is shipped from Inficon operating in the "Elapsed Time" mode; however, a simple adjustment will change the mode to "Deposition Time."

Elapsed Time

In the Elapsed Time Mode, the XTM's internal clock runs continuously, updating the time display every 0.1 minute. (To read the elapsed time, press the button labled T/X.) To reset the elapsed time to zero, and begin a new time accumulation, press the front panel "Zero" switch or activate an external time zero input.

Deposition Time

In the Deposition Time mode, pressing the front panel Zero button or activating an external time zero resets the displayed time to zero (press T/X to read) and starts a new time accumulation. The displayed time will continue to update (0.1 min. increments) until the displayed thickness is equal to the programmed value for Thickness 2. At that point, the internal clock is stopped and the time display will store deposition time, until the XTM is rezeroed.

To use this feature, install a jumper between terminal lugs labeled B & A on the main printed circuit board (Fig.2-3).

Section 4 of the XTM Manual provides instructions for determining several of the XTM program values, as well as for calibrating the analog output. It also contains a section on measurement theory for those interested in the evolution of quartz crystal monitors. The following topics are covered:

- Determining Density
- Determining Z-Ratio
- Determining Tooling
- Calibrating the Analog Output
- Measurement Theory

Please refer to Section 5 for troubleshooting procedures.

DETERMINING DENSITY

Note: Bulk density values are sufficiently accurate for most applications (see p. 4-4).

Follow the steps below to determine density value:

1. Place a substrate (with proper masking for film thickness measurement) adjacent to the sensor, so that the same thickness will be accumulated on the crystal and this substrate.
2. Set density to the bulk value of the film material or to an approximate value.
3. Set Z-ratio to 1.000 and tooling to 100%.
4. Place a new crystal in the sensor and make a short deposition (1000-5000 Å), using the manual control.
5. After deposition, remove the test substrate and measure the film thickness with either a multiple beam interferometer or a stylus-type profilometer.

074-013S4 830301

6. Determine new density value with the following equation:

$$\text{Density } (g/cm^3) = D_1 \frac{T_x}{T_{M_x}}$$

where D_1 = Initial density setting

T_x = Thickness reading on XTM

T_{M_x} = Measured thickness

7. A quick check of the calculated density may be made by programming the instrument with the new density value and observing that the displayed thickness is equal to the measured thickness, provided that the instrument has not been zeroed between the test deposition and the entering of calculated density.

Note: Slight adjustment of density may be necessary in order to achieve $T_x = T_{M_x}$.

DETERMINING Z-RATIO

A list of Z-values for materials commonly used is given in Table 4-1 . For other materials, Z can be calculated from the following formula:

$$Z = (d_q \mu_q / d_f \mu_f)^{\frac{1}{2}}$$

$$= 8.834 \times 10^5 \, (d_f \mu_f)^{-\frac{1}{2}}$$

where: d_f = density (g/cm^3) of deposited film

μ_f = shear modulus ($dynes/cm^2$) of deposited film

d_q = density of quartz (crystal)

μ_q = shear modulus of quartz (crystal)

(The densities and shear moduli of many materials can be found in a number of handbooks.)

Laboratory results indicated that the Z-values of materials in thin-film form are very close to the bulk values. However, for high stress-producing materials, Z-values of thin films are slightly smaller than those of the bulk materials. For applications that require more precise calibration, the following direct method is suggested:

1. Using the calibrated density and 100 % tooling, make a deposition such that the percent crystal life display will read approximately 50%, or near the end of crystal life for the particular material, whichever is smaller.

2. Place a new substrate next to the sensor and make a second, short deposition (1000-5000Å).

3. Determine the actual thickness on the substrate (as suggested in density calibration).

4. Adjust Z-ratio value in the XTM to bring thickness reading in agreement with actual thickness.

For multiple layer deposition (for example, two layers), the Z-value used for second layer is determined by the relative thickness of the two layers. For most applications the following three rules will provide reasonable accuracies:

a. If the thickness of layer 1 is large compared to layer 2, use material 1 Z-value for layer 2.

b. If the thickness of layer 1 is thin compared to layer 2, use material 2 Z-value for layers 1 and 2.

c. If the thickness of both layers is similar, use a value for Z-ratio which is the weighted average of the two Z values for deposition of layer 2.

DETERMINING TOOLING

1. Place a test substrate in the system's substrate holder.

2. Make a short deposition and determine actual thickness.

3. Calculate tooling from the relationship:

$$\text{Tooling (\%)} = 100 \times \frac{T_{M_s}}{T_x}$$

where: T_{M_s} = Actual thickness at substrate holder

T_x = Thickness reading in the XTM

4. Round off perfect tooling to the nearest whole number.

5. When entering this new value for tooling into the program, T_{M_s} will equal T_x if calculations are done properly.

Table 4-1 Bulk Densities and Z-Values for Common Materials

MATERIAL	SYMBOL	BULK DENSITY (g/cm³)	Z-Ratio
Aluminum	Al	2.70	1.08
Antimony	Sb	6.62	0.768
Arsenic	As	5.73	0.966
Beryllium	Be	1.85	0.543
Boron	B	2.54	0.389
Cadmium	Cd	8.64	0.682
Cadmium sulfide	CdS	4.83	1.02
Cadmium telluride	CdTe	5.85	0.980
Calcium fluoride	CaF_2	3.18	0.775
Carbon (graphite)	C	2.25	3.26
Chromium	Cr	7.20	0.305
Cobalt	Co	8.71	0.343
Copper	Cu	8.93	0.437
Gallium	Ga	5.93	0.593
Gallium arsenide	GaAs	5.31	1.59
Germanium	Ge	5.35	0.516
Gold	Au	19.3	0.381
Indium	In	7.30	0.841
Indium antimonide	InSb	5.76	0.769
Iridium	Ir	22.4	0.129
Iron	Fe	7.86	0.349
Lead	Pb	11.3	1.13
Lead sulfide	PbS	7.50	0.566
Lithium fluoride	LiF	2.64	0.774
Magnesium	Mg	1.74	1.61
Magnesium oxide	MgO	3.58	0.411
Manganese	Mn	7.20	0.377
Molybdenum	Mo	10.2	0.257
Nickel	Ni	8.91	0.331
Niobium	Nb	8.57	0.493
Palladium	Pd	12.0	0.357
Platinum	Pt	21.4	0.245
Potassium chloride	KCl	1.98	2.05
Selenium	Se	4.82	0.864
Silicon	Si	2.32	0.712
Silicon dioxide (fused quartz)	SiO_2	2.20	1.07
Silver	Ag	10.5	0.529
Silver bromide	AgBr	6.47	1.18
Silver chloride	AgCl	5.56	1.32
Sodium chloride	NaCl	2.17	1.57
Tantalum	Ta	16.6	0.262
Tellurium	Te	6.25	0.900
Tin	Sn	7.30	0.724
Titanium	Ti	4.50	0.628
Titanium oxide	TiO	4.9	not available
Titanium dioxide	TiO_2	4.3	not available
Tungsten	W	19.3	0.163
Tungsten carbide	WC	15.6	0.151
Uranium	U	18.7	0.238
Vanadium	V	5.96	0.530
Yttrium	Y	4.34	0.835
Zinc	Zn	7.04	0.514
Zinc oxide	ZnO	5.61	0.556
Zinc selenide	ZnSe	5.26	0.722
Zinc sulfide	ZnS	4.09	0.775

CALIBRATING RATE AND THICKNESS ANALOG OUTPUT

Both rate and thickness analog output may be calibrated prior to actual deposition by using the internal test mode and the XTM memory.

The thickness output is proportional to the three least significant digits displayed on the front panel. Therefore, as the ranges change on the display, the full scale analog output (0-10 volts) representation also changes. These range changes affect the analog output in both resolution and full scale calibration.

Display Range	Output Resolution (10 mV)	Full Scale Output (10 V)
9.999 kÅ	1 Å	0.999 kÅ
99.99 kÅ	10 Å	9.99 kÅ
999.9 kÅ	100 Å	99.9 kÅ

As illustrated in Fig. 4-1, the first 10 peaks, starting at zero thickness, represent an accumulated thickness of 1000 kÅ each. At this point the front panel display would change range to 100 kÅ full scale, and the analog output would shift to 10 volts equal to 10 kÅ. A second range change would occur when 100 kÅ thickness is reached.

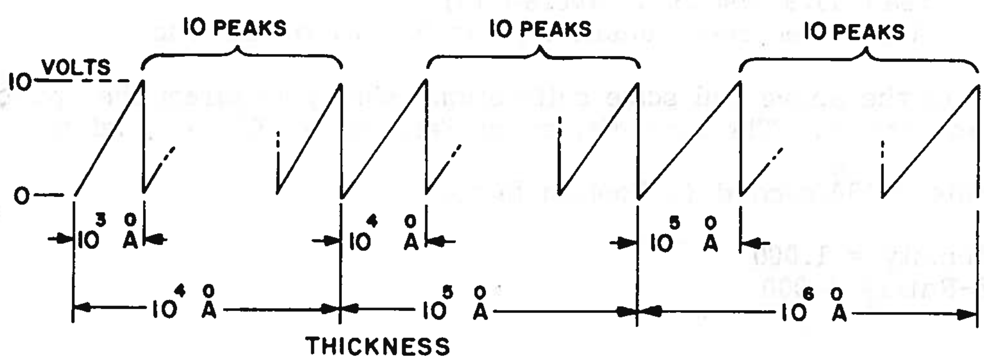


Fig. 4-1 D/A Option

Thickness output is calibrated using the programmable memory in the XTM. To calibrate, follow the procedure below:

1. Place the XTM in Program mode
2. Select Thickness 2 address
3. Program 0.000 into unit
4. Recall Thickness 2 (press yellow pushbutton)
5. Zero recorder to this output
6. Program 0.999 into unit
7. Recall Thickness 2 (press yellow button)
8. Adjust recorder sensitivity for full scale deflection

The rate analog output (rear panel switch in Rate position) is 0 to 10 volts equal to a display of 99.9 or 999. Calibration is accomplished using a combination of the XTM internal test mode and the programmable Tooling factor. For example, if a full scale recorder deflection equal to 99.9 was desired, calibration could be achieved as follows:

1. Place the XTM in normal mode of operation (Test switch off and program indicator off)
2. Rate displaying 000
3. Zero recorder to this output
4. Place the XTM in Test mode
5. Program the following:
   Tooling 999.0%
   Density 1.000 gm/cc
   Z-Ratio 1.000

   Place rate resolution switch in 0.1 Å position
6. Take the XTM out of Program mode (Rate display should read 99.9 Å/second (averaging)
7. Adjust recorder sensitivity for full scale deflection

For other than the above full scale calibration, simply program the appropriate tooling factors. The rate display in Test mode will be equal to

Rate = 10Å/second (% Tooling factor)

with Density = 1.000
Z-Ratio = 1.000

MEASUREMENT THEORY

Commercial quartz-crystal film thickness monitors have evolved in three distinct stages: (1) frequency measurement technique, (2) period measurement technique, and (3) z-match technique.

Sauerbrey[1] used the quartz-crystal resonator to measure deposited film thickness; this was later developed into a commercial unit. The thickness frequency used is given by

$$T_f = -(N_q d_q / d_f f_q^2)\ (f_c - f_q) \tag{1}$$

where

T_f = film thickness (cm)

d_q = density of quartz (g/cm³)

d_f = density of film (g/cm³)

$N_q = f_q l_q$ = frequency constant for AT-cut quartz crystal (Hz/cm)

l_q = thickness of quartz crystal (cm)

f_q = resonant frequency of unplated crystal (Hz)

f_c = resonant frequency of loaded crystal (Hz)

Experiments have shown that in order to keep the thickness measurement reasonably accurate, the maximum frequency shift allowable is limited to about 2% of f_q.

The period measurement technique was used by the second generation quartz-crystal thickness monitors, with the following equation used for thickness computation:

$$T_f = (N_q d_q / df)\ (t_c - t_q) \tag{2}$$

In this equation, $t_c = 1/f_c$ and $t_q = 1/f_q$ are the periods of oscillation for the loaded and original crystals, respectively. For a small frequency shift, Eq (1) becomes a good approximation of Eq (2).

Although experiments demonstrated that Eq (2) is reasonably accurate for selected materials with frequency shifts of up to 10% of f_q, the theoretical justification of using Eq (2) for thickness computation has been lacking. Tests on the validity of Eq (2) indicate that significant errors begin to appear for a majority of materials with crystal frequency shift as small as 5% of f_q. When the quartz crystal monitor is used to measure the rate of deposition, the errors in indicated time become even more serious, because the thickness error is a time-varying function, and rate is the derivative of thickness with respect to time.

Advances in crystal design and improved driving circuitry allow the quartz crystal to keep oscillating even with very large amounts of deposited material on it. In many cases it is possible to achieve frequency shifts of more than 20% of f_q. Also, complex and precise mathematical calculations can be easily performed with modern microcomputers.

Miller and Bolef[2] were the first to treat the quartz-film composite as a one-dimensional compound acoustical resonator. Their results indicated that the elastic properties of the deposited film should be related to the frequency shift. A further study on their original solution resulted in a simpler thickness frequency equation in the form of

$$T_f = (N_q d_q / \pi d_f f_c Z) \tan^{-1}(Z \tan [\pi(f_q - f_c)/f_q]) \quad (3)$$

where

$$Z = (d_q \mu_q / d_f \mu_f)^{\frac{1}{2}}$$

is the acoustic impedance ratio with μ_f and μ_q the shear moduli of deposited film and quartz crystal, respectively. Eq (3) shows that materials with different elastic properties will obey different thickness frequency relations. This phenomenon has been verified experimentally in our laboratory for a number of materials.[3] The experimental results demonstrated that if the density and Z-value of the deposited material are known, Eq (3) is remarkably accurate in determining film thickness.

Another significance of Eq (3) is that for the first time the validity of "period measurement" technique, or Eq (2), can be explained from a theoretical point of view. Through a simple algebraic exercise, one can easily show that Eq (2) is a special case of Eq (3) with Z = 1, or quartz-on-quartz.

The XTM uses the concept of a microcomputer, and incorporates an approximated form of Eq (3) for thickness computation. The acoustic impedance ratio Z can be entered into the instrument as a separate material constant. A reproducibility of better than 2% for both thickness and rate can thus be achieved with no restrictions on the allowable frequency shift of the crystal.

1 Sauerbrey, G.Z., Physik 155, 206 (1959).
2 Miller, J.G. and Bolef, D.I., J Applied Phys 39, 4589 and 5815 (1968).
3 Lu, Chih-Shun, J. Vac. Sci. Technology 12, (1975).

SECTION 5
MAINTENANCE AND REPAIR

Section 5 of the XTM Manual contains troubleshooting procedures for the unit and the sensors. The electrical schematics you may require are found in Section 6. Please note that any service attempted in the field should be done by qualified personnel. For any problems not covered in this section, contact Inficon directly. The following topics are covered:

- Troubleshooting the XTM
- Troubleshooting the Regular, Compact (Vertical), Dual, and Bakeable Sensors
- Troubleshooting the Sputtering Sensor
- Replacing the Crystals

TROUBLESHOOTING THE XTM

The XTM is designed to make service relatively easy. Problems can usually be isolated to specific boards by observing the front panel displays and indicators.

Most of the internal circuits can be tested for proper operation by using the test procedure (p. 2-6).

> **CAUTION:** Always handle the XTM cards by their edges, so that static discharges do not destroy components on the card.

PROBLEM	REMEDY
No front panel lights turn on when power is applied to the unit.	1. Check fuse (rear of unit) and replace if necessary. 2. Check power supply outputs on XTM 401 test points. Replace power supply assembly if defective.
Unit can be turned on and off but status indicators are not working correctly (as described in test procedure, p. 2-6).	Replace XTM 401 power supply card. NOTE: Malfunctions will normally show up with the initial turn on. A more general indicator however, is severe abnormalities in instrument operation.
Unit initializes correctly, but is locked in initial condition. Programming is impossible.	Check for a stuck key or switch. If this is not the problem, check for a defective switch or key on XTM 201.
One of the various status indicators is not functioning.	Replace card XTM 201.
The numerical display is on, but some digits are missing.	Press TC/CHECK switch on front panel to verify faulty digits. Replace XTM 201, if necessary.
One digital display is not operating at all.	Replace XTM 201.
Unit will not respond when various keys are pressed.	Check to see if a switch or key is stuck. If all keys appear to be clear, replace XTM 201.
Unit operates normally in test mode, but there are gross errors in thickness reading as compared to actual thickness being deposited.	Check to be sure that the values for tooling, density, and Z-ratio are correct.

TROUBLESHOOTING THE SENSORS

Regular, Compact (Vertical), Dual and Bakeable Sensor and Crystals

SYMPTOM	CAUSE	REMEDY
1. large jumps of thickness reading during deposition	a. mode hopping due to defective crystal	a. replace crystal
	b. crystal near the end of its life	b. replace crystal
	c. scratches or foreign particles on the crystal holder seating surface	c. clean or polish the crystal seating surface on the crystal holder
2. crystal ceases to oscillate during deposition before it reaches its "normal" life Note: crystal life is highly dependent on process conditions of a. rate b. power radiated from source c. location d. material e. residual gas composition	a. crystal is being hit by small droplets of molten material from the evaporation source	a. use a shutter to shield the sensor during initial period of evaporation; move the sensor further away from the evaporation source
	b. defective crystal	b. change crystal
	c. built-up material on edge of crystal holder touching crystal	c. clean the crystal holder
	d. material on crystal holder partially masking full crystal area	d. clean crystal holder
3. crystal does not oscillate or oscillates intermittently (both in vacuum and in air)	a. defective or damaged crystal	a. replace crystal
	b. existence of electrical short or poor electrical contacts	b. check for electrical continuity and short in sensor cable, connector, contact springs, and the connecting wire inside the sensor; check

SYMPTOM	CAUSE	REMEDY
		for electrical continuity in feedthroughs
4. crystal oscillates in vacuum but stops oscillation after open to air	a. crystal was near the end of its life; opening to air causes film oxidation, which increases film stress	a. replace crystal
	b. excessive moisture accumulation on the crystal	b. turn off cooling water to sensor before opening it to air
5. thermal instability: large changes in thickness reading during source warm-up (usually causes thickness reading to decrease) and after the termination of deposition (usually causes thickness reading to increase)	a. crystal is not properly seated	a. check and clean crystal seating surface of the crystal holder
	b. excessive heat input to the crystal	b. if heat is due to radiation from the evaporation source, move sensor further away from source and use sputtering crystals for better thermal stability; if the crystal heating is due to secondary electron bombardment from the electron beam source, change regular sensor to a sputtering sensor
	c. no cooling water	c. check cooling water flow rate (0.2 gpm at 20°C)
	d. in older sensors (those without integral cooling passages), poor contact between water line and sensor	d. tighten waterline to body

SYMPTOM	CAUSE	REMEDY
6. poor thickness reproducibility	a. erratic source emission characteristics	a. move sensor to a different location; check the evaporation source for proper operating conditions; insure relatively constant pool height and avoid tunneling into the melt
	b. material does not adhere to the crystal	b. check the cleanliness of the crystal surface; evaporate a layer of proper material on the crystal to improve adhesion

Sputtering Sensor and Crystals

SYMPTOM	CAUSE	REMEDY
1. large jumps of thickness readings during sputtering	a. improper crystal seating	a. check and clean the crystal seating surface
	b. small pieces of material fell on the crystal (for crystal facing-up situation)	b. check the crystal surface and blow it with clean air
	c. small pieces of magnetic material being attracted by the sensor magnet and contacting the crystal	c. check the sensor opening hole and remove any foreign material
2. thickness reading jumps back and forth	a. RF interference from the sputtering power supply	a. check groundings; change location of instrument and oscillator; connect instrument to different power line

SYMPTOM	CAUSE	REMEDY
3. large drift of thickness reading (greater than 200 Å for density reading = 5.00 gm/cc) after termination of sputtering	a. crystal heating due to poor thermal contact	a. check and clean the crystal seating surface
	b. external magnetic field interferes with the sensor magnetic field	b. rotate the sensor magnet to a proper orientation with respect to the external magnetic field
	c. sensor magnet defective	c. check sensor magnet field strength; if a gaussmeter is available, the maximum field at the center of the opening hole should give a reading of 700 gauss or greater

Replacing the Crystal (Figs. 5-1, 5-2, 5-3, 5-4)

The procedure for replacing the crystal is basically the same with either the regular (including compact/vertical), dual or bakeable sensor. (Refer to page 5-8 for replacement of sputtering sensor.) Before you begin, please observe the following precautions:

- Always use clean nylon lab gloves and plastic tweezers for handling the crystal (to avoid contamination which may lead to poor adhesion of the film to the electrode).

- Do not rotate the ceramic retainer assembly after it is seated (as this will scratch the crystal electrode and cause poor contact).

In addition to the above precautions, please note the following:

- Certain materials, especially dielectrics, may not adhere strongly to the crystal surface and may cause erratic readings.

- Thick deposits of some materials, such as SiO, Si, and Ni will normally peel off the crystal when it is exposed to air, as a result of changes in film stress caused by gas absorbtion.

Follow the procedure below to replace the crystal in the regular sensor head:

1. Gripping the crystal holder with your fingers, pull it straight out of the sensor body.

2. Gently pry the crystal retainer from the holder (or use crystal snatcher; see below).

3. Turn the retainer over and the crystal will drop out.

4. Install a new crystal, with the electrode face up.

5. Push the retainer back into the holder and replace the holder in the sensor body.

For the dual sensor, the procedure is identical for both crystals, except that you must flip up the shutter first, in order to remove the holder assemblies.

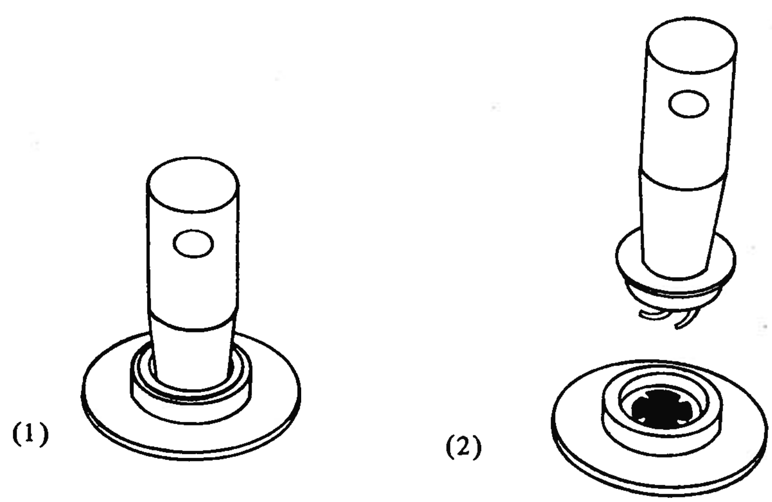
For the bakeable sensor, the procedure is the same as the regular crystal except that you must first unlock the cam assembly by flipping it up. Once the crystal has been replaced, place a flat edge of the holder flush with the cam mechanism and lock it in place with the cam.

To use the crystal snatcher supplied with the sensor follow the instructions below:

1. Insert crystal snatcher into ceramic retainer (1) and apply a small amount of pressure. This locks the retainer to the snatcher and allows the retainer to be pulled straight out (2).

2. Re-insert the retainer into the holder after the crystal has been changed.

3. Release the crystal snatcher with a slight side-to-side motion.



Crystal Replacement — Sputtering Sensor

1. Hold the back part of the sensor with your fingers and pull it straight out to separate it from the water-cooled front part. (In some installations, you may have to disconnect the sensor cable in order to separate the parts.)

2. Pull the crystal holder straight out from the back part of the sensor.

3. Use your fingers or tweezers to remove the ceramic retainer from the crystal holder (by pulling it straight out).

4. Turn the crystal holder upside down to let the old crystal drop out.

5. Place a new crystal in the holder with the patterned electrode facing the back, and contacting the leaf springs on the ceramic retainer.

   NOTE: Only special crystals for sputtering applications should be used (IPN 008-009).

6. Put the ceramic retainer back into the crystal holder, and put the holder into the back part of the sensor.

7. Align the position on the back part so that the connector matches with the notch on the front of the sensor, and snap the parts together. If the sensor cable has been disconnected, reconnect it

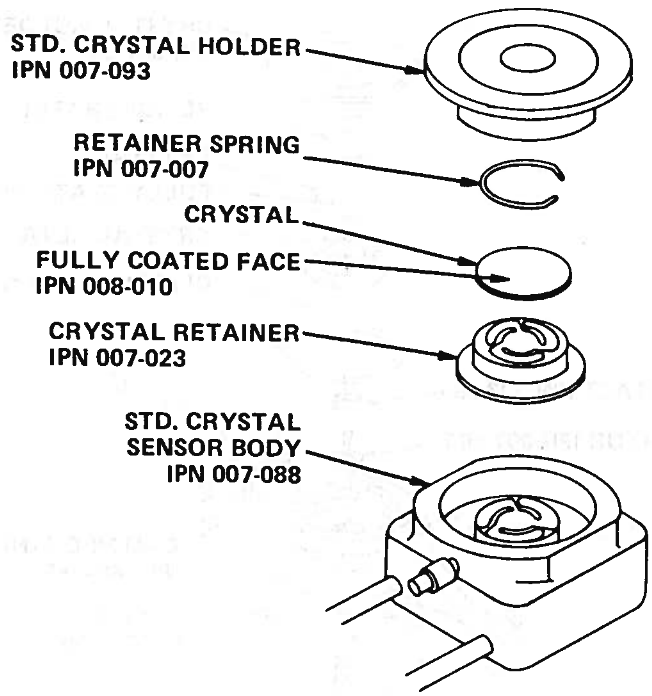


Fig. 5-1 Regular Crystal Sensor (Exploded View)

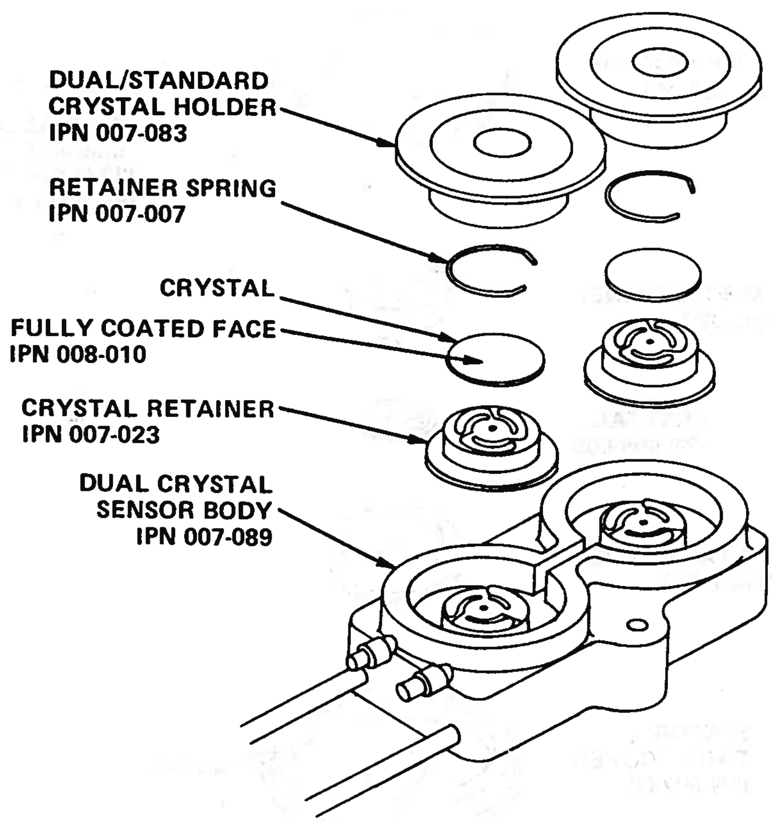


Fig. 5-2 Dual Crystal Sensor (Exploded View)

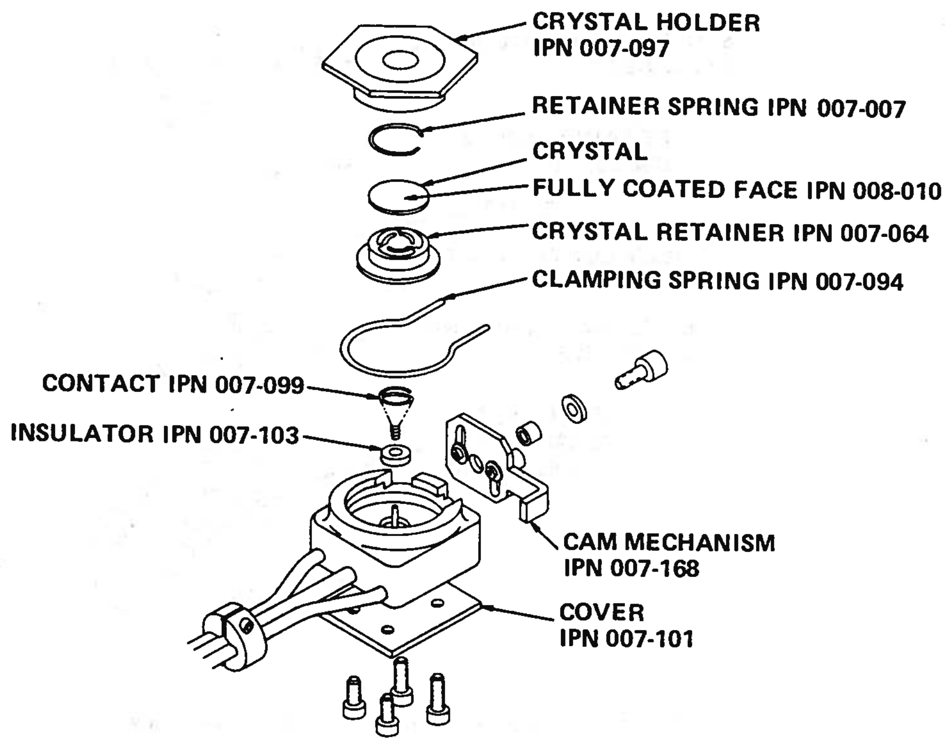


Fig. 5-3 Bakeable Crystal Sensor (Exploded View)

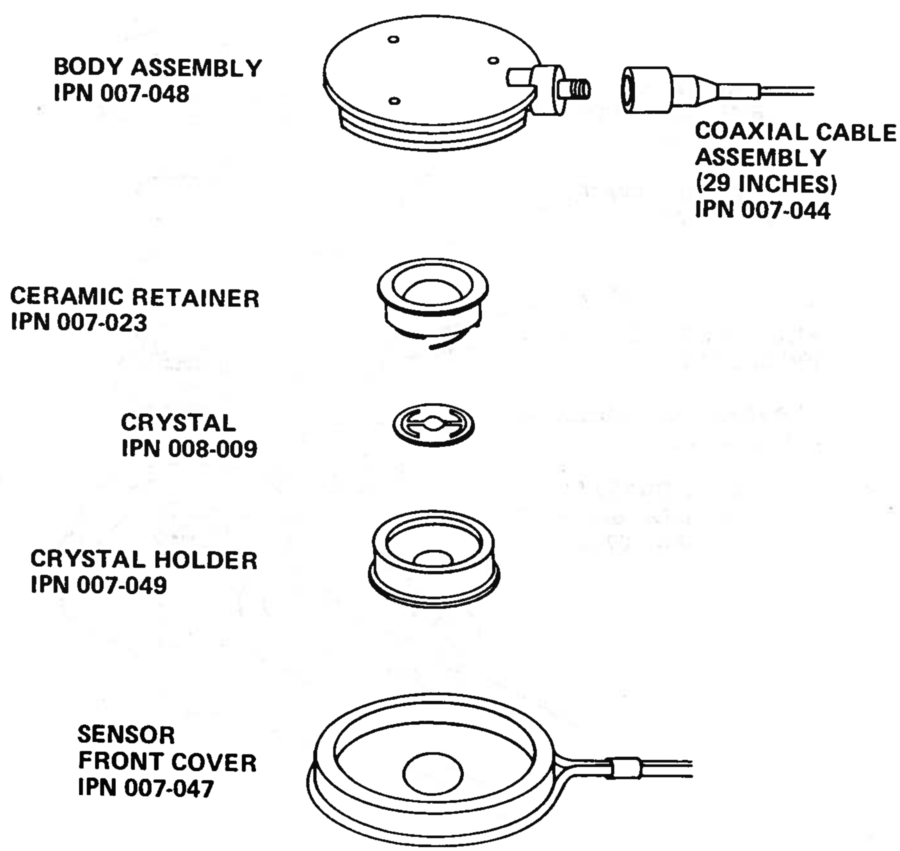


Fig. 5-4 Sputtering Crystal Sensor (Exploded View)