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GRAVITY PROBE-B GYRO HOUSING LITHOGRAPHY PROCESS

Document Revision Record

Rev	Date	ECO No.	Pages Affected	Description

1. PHOTORESIST APPLICATION

EQUIPMENT AND MATERIALS:

- ZEISS AXIOSKOP FLUORESCENCE MICROSCOPE
- A.C.E. PHOTORESIST SPINNER (CUSTOM MADE FOR GP-B)
- SHIPLEY 1400-27 POSITIVE PHOTORESIST
- ACETONE
- ~2-¾" SQUARE CUT FROM Z-FOAM CLEAN WIPE
- 3.5" DIAMETER PETRI DISH
- LARGE AND SMALL POLYURETHANE FOAM SWABS (TEXSWAB TX710 & TX709)
- CREW CLEAN WIPES
- HOUSING PATTERNING RECORD SHEET

REFERENCE

- *ZEISS AXIOSKOP OPERATING INSTRUCTIONS*

SAFETY CONSIDERATIONS:

- WEAR EYE PROTECTION e.g. AGAINST FLYING QUARTZ IN THE EVENT A CRACKED HOUSING SHOULD BREAK WHILE SPINNING.
- PHOTORESIST AND ACETONE FUMES ARE TOXIC AND FLAMMABLE. THESE MATERIALS SHOULD ONLY BE USED IN AN EXHAUSTED FUME HOOD IN THE PRESENCE OF A FIRE EXTINGUISHER.

Note: This is an ESD sensitive part. Take appropriate precautions.

PROCEDURE

1. Place aluminum foil liner around perimeter of bowel to prevent resist from splattering onto the polycarbonate exhaust hood (this greatly simplifies cleanup).

2. To clean , place the gyro housing, cavity side up, with a piece of Crew clean wipe ~1" square underneath, on the adapter chuck on the spinner. Push the start button twice to initiate spin cycle, then begin dispensing acetone from a small wash bottle onto the parting plane of the housing. After spinning at 900 rpm for 5 seconds the spin speed will increase to 4000 rpm. When the high speed spin cycle begins, stop dispensing acetone and allow the housing to spin dry.

3. Inspect the parting plane of the housing with the fluorescence microscope. With halogen lamp illumination, use light and dark field modes to search for particles on the surface and defects such as scratches and blisters in the Nb film. The microscope should then be put in the fluorescence mode with U.V. illumination from the mercury lamp to search for traces of organics.

   Proceed to step 4 only after assuring that the Nb surface is clean and free of defects.

4. Place the Z-foam pad in the petri dish and pour 25 ml of photoresist onto the pad. After fully saturating the Z-foam pad with resist, pour the excess resist off into the solvent drain.

   The resist saturated Z-foam pad should only be used for coating parts within 30 minutes of dispensing the resist onto the pad.

5. Remove the gyro housing from the spinner and press the parting plane gently against the resist saturated Z-foam pad. (The resist may alternatively be applied with a polyurethane foam swab which results in much less wasted resist, however one must take extra care to insure complete coverage.)

6. Replace the gyro housing , cavity side up, with a piece of clean wipe ~1" square underneath, on the adapter chuck on the spinner and push the start button twice to initiate the spin cycle.

7. After spinning stops inspect the resist film for defects such as bare spots, thick globs of resist or pieces of foreign matter in the area to be patterned. The unaided eye is sufficient for this inspection. If any defects are apparent in the coating strip resist and reapply as per steps 2 - 5.

8. When an acceptable coating of resist has been achieved on the parting plane of the gyro housing, coat the entire inside of the central cavity with resist using polyurethane foam swabs. Use the large swab to coat the bulk of the area up to ~1/8 - 1/4" from the parting plane and the small swab for the remaining area adjoining the parting plane. The resist coating on the parting plane should extend ~1/16 - 1/8" into the cavity making it possible to achieve complete coating of the cavity without disturbing the coating on the parting plane. Uniformity of the resist coating in not important in the cavity, as it only serves to protect the quartz surface from plasma etch. Re-inspect the pattern to insure that no resist splattered onto the area to be patterned during the cavity coating process and that no pinholes are present in the resist within the area to be patterned or in the resist in the cavity.

9. Record date, time and number of repeats for good coating on housing patterning record sheet.

CLEANUP

Discard the resist soaked Z-foam pad and foam swab. Rinse the petri dish with acetone.

Remove the aluminum foil liner from around the spinner bowel and wipe the bowel clean with acetone and clean wipes. Wipe up any resist spills on the bench with acetone and clean wipes.

2. SOFT BAKE

EQUIPMENT AND MATERIALS:

- BLUE-M CLEANROOM OVEN CATALOG NO. 146

SAFETY CONSIDERATIONS:

- AVOID BREATHING PHOTORESIST FUMES
- EXERCISE CAUTION IN HANDLING HOT PARTS
- HOUSING PATTERNING RECORD SHEET

PROCEDURE

1. Turn on the small Blue M oven and allow at least 20 minutes to warm up. The atmosphere in the oven should be ambient air

2. Place photoresist coated gyro housing in oven at 90 ±5 ° C.

3. Remove and allow to cool after baking for 45 ±5 minutes. The housing may be handled in this step with latex gloves, avoiding contact with the parting plane.

4. Record date and time on the housing patterning record sheet.

CLEANUP

Turn off oven.

3. EXPOSURE

EQUIPMENT AND MATERIALS:

- QUINTEL ALIGNER/EXPOSURE SYSTEM IN GP-B LITHOGRAPHY AREA, MODEL Q-2001CT WITH ADVANCED RADIATION CORP. 200 WATT SHORT ARC LAMP
- PHOTOMASK 4LOOP2BM[1].
- HOUSING PATTERNING RECORD SHEET
- BRASS CENTERING RING
- OPTICAL ASSOCIATES MODEL 306 POWER METER
- 4"X4"X.06" GLASS PLATE

SAFETY CONSIDERATIONS

- AVOID LOOKING AT STAGE AREA OF ALIGNER WHEN SHUTTER IS OPEN
- WEAR UV RESISTANT SAFETY GLASSES

REFERENCES

- *Q-2001CT MANUAL TRAY LOAD MASK ALIGNER OPERATIONAL INSTRUCTION MANUAL* From Quintel corporation

PROCEDURE

Turn on house vacuum to the aligner via the valve on wall under the aligner table. Turn on the power switch on the exposure lamp power supply and press the **START LAMP** button. Set power to 150 watts. Allow exposure lamp at least 15 minutes to warm up before using.

Place the intensity meter probe on the wafer chuck and Press **WAFER LOAD** to bring the chuck into the expose position. Turn on the intensity meter and press the **SHUTTER** switch on the aligner. Record the intensity reading on the housing patterning record sheet.

The exposure time should be set to give an energy dose of 390 millijoules/cm^2 at a wavelength of 400 nanometers. (Divide 390 by the uv intensity in milliwatts/cm^2 to get the exposure time in seconds. At the time this document was written a 30 second exposure was used with an intensity of 13 milliwatts/ cm^2)

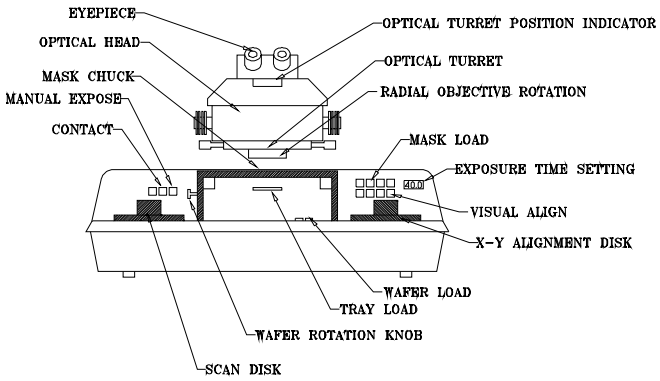
Inspect the photomask for dirt and defects. Loose particles may be blown off with a filtered air gun. Resist residue and adherent particles should be cleaned off with R-10 resist stripper, after which the mask should be thoroughly rinsed in DI, blown dry with filtered air, then oven dried at 50 - 90°C. If scratches or voids are found in the chrome pattern the mask should be discarded and replaced.

Press **VISUAL ALIGN** to raise the optical head. Press **MASK LOAD** (this will turn off vacuum to the mask chuck). Place the photomask on the chuck, chrome side down with the contact pads on the left or right side (This facilitates viewing the pads using split field viewing). See figure 2. Press **MASK LOAD** again to secure the mask to the vacuum hold down.

[1] A copy to the AutoCad drawing **4Loop2bm.dwg** is on file with the document center. The master photoplate is held by HTA Photomask.

FIGURE 2

QUINTEL ALIGNER



Place the gyro housing parting plane down on the glass plate. Open the brass ring just enough to allow it to slide easily over the gyro housing using the opening screw. Slip the ring over the housing with the lapped surface down. With both the parting plane of the housing and the lapped surface of the ring in contact with the glass plate tighten the ring gently around the housing after backing off on the opening screw.

Pull out the tray load and set the gyro housing onto the chuck top surface with the contact holes in approximately the same position as the contact pads on the photomask, then push the tray load back in. Double check that the housing is centered within the mask opening so it doesn't hit and crack when raised.

Press **WAFER LOAD** to bring the substrate into close proximity of the mask. Perform a rough alignment of the mask to substrate by translating with the X-Y Alignment (right hand) Disk and rotating with the Wafer Rotation Adjustment Knob.

Press **VISUAL ALIGN** to lower optical head. With the optical turret in the "Row and Column" microscope position find the inside edge of the brass ring. Use the Scan (left hand) disk to center the mask under the radial viewing objective. Center the centering marks on the mask with the inside edge of the brass ring while scanning radially using the radial objective rotation. The entire inside edge of the brass ring may be viewed by rotating the radial objective once the radial objective is concentric with loop and the viewing radius is properly set. To do this rotate the radial viewing objective to the 6 o'clock position (closest to the operator). Position the photomask with the disk scan so the 6'oclock area of the centering pattern is in view. Now rotate the radial viewing objective to the 12 o'clock position. With minor adjustment of the mask position with the disk scan the entire loop should be visible by rotating the radial viewing objective. If not, the viewing radius may need to be adjusted with the knob on the objective. Once the viewing radius is set there should be no need of readjustment for subsequent alignment/exposure runs. When the centering marks appear concentric brass ring, bring the contact pad area into view with the scanning disk. Align the contact pads on the mask with the contact holes in the gyro housing using the X-Y Alignment Disk for translation and the Wafer Rotation Adjustment Knob for rotation, then repeat the centering procedure.

When the photomask and gyro housing are aligned press **CONTACT**. Do not touch the X-Y Alignment Disk when the substrate and mask are in contact or damage to the instrument may result. Recheck alignment and centering over the entire loop area again after contact has been established, then return the Scan Control Disk to the approximate center.

Rotate the optical turret to the **EXPOSE** position. Press **MANUAL EXPOSE**.

The substrate should automatically drop to the position it was in before **WAFER LOAD** was pressed after completion of exposure. Check to see that this has indeed happened then pull the tray out and remove the gyro housing.

Record the date, time and other information, including mask drawing number, as indicated on the housing patterning record sheet.

CLEANUP

Press **VISUAL ALIGN** to raise the optical head. Press **MASK LOAD** to turn off vacuum to the mask chuck. Remove the photomask and return it to its box. Press **VISUAL ALIGN** again to lower the optical head.

Turn off power to the aligner and the UV lamp power supply and turn off the valve to the house vacuum.

• 4. DEVELOP

EQUIPMENT AND MATERIALS:

- SHIPLEY MICROPOSIT POSITIVE PHOTORESIST DEVELOPER 351 CONCENTRATE
- DE IONIZED WATER
- 2 - 400 ml BEAKERS
- TEFLON IMMERSION HANDLE
- TIMER
- PHOTORESIST SPINNER
- HOUSING PATTERNING RECORD SHEET

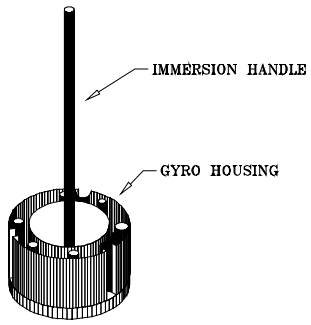
SAFETY CONSIDERATIONS:

- WEAR SAFETY GLASSES. PHOTORESIST DEVELOPER CONTAINS SODIUM HYDROXIDE WHICH CAN CAUSE SERIOUS DAMAGE TO THE EYES.

PROCEDURE

Place the gyro housing on the Teflon immersion handle with the parting plane facing up - see figure 3. Put 200 ml of deionized water in the beaker and add 50 ml of developer (dilute 4:1).

FIGURE 3



While supporting the gyro housing by the immersion handle, immerse it in the developer solution. After one minute remove the gyro housing from the developer and place in the second beaker filled with DI water. Place the beaker under gently running water from the DI spigot. After rinsing for 5 minutes, remove the housing from the immersion handle and place it on the spinner chuck. Press the start button twice to initiate the spin only cycle which will spin the housing dry.

Record the date, time and develop time on the housing patterning record sheet.
CLEANUP

Pour the photoresist developer into a properly labeled container for waste developer and rinse the beaker in DI water.

5. HARD BAKE

EQUIPMENT AND MATERIALS:

- BLUE-M CLEANROOM OVEN CATALOG NO. 146
- CREW CLEAN WIPES

SAFETY CONSIDERATIONS:

- AVOID BREATHING PHOTORESIST FUMES
- EXERCISE CAUTION IN HANDLING HOT PARTS
- HOUSING PATTERNING RECORD SHEET

PROCEDURE

1. Turn on the oven and allow at least 20 minutes to warm up. The atmosphere in the oven is ambient air.

2. Place gyro housing in oven at 120 ±5 ° C.

3. Remove the housing with a clean wipe, avoiding contact with the parting plane, and allow to cool after baking for 45 ±5 minutes.

4. Record the date and time on the housing patterning record sheet.

CLEANUP

Turn off oven.

6. INSPECT RESIST AND MEASURE ECCENTRICITY OF PATTERN RELATIVE HOUSING

EQUIPMENT AND MATERIALS

- ZEISS AXIOSKOP MICROSCOPE FITTED WITH V-BLOCK ON STATIONARY STAGE
- HOUSING PATTERNING RECORD SHEET

PROCEDURE

Turn on the microscope light and place the gyro housing on the stage.
Using the 10X objective inspect the resist pattern, noting any defects on the housing patterning record sheet.

The maximum tolerable size for resist voids on the lines is 1/3 of the line width. The maximum tolerable size for stray resist spots between the lines is 1/3 of the space between lines. There shall be no stray resist spots in the field larger than 1 line width and no more than 5 stray resist spots larger than 1/2 the line width.

If the resist pattern does not meet the above criteria strip the resist in R-10 stripper, as per step 8 and repeat the patterning process starting with step 1.

Position the gyro housing against the v-block and select the 100X objective (1000X total magnification). Adjust the position of the v-block if necessary so that an edge of one of the pickup loop patterns appears in an intermediate position on the micrometer scale.

Rotate the gyro housing while keeping it positioned against the v-block. Note the total runout of the loop pattern as the housing is rotated. The eccentricity of the loop pattern relative to the outside edge of the housing is given by the maximum observed change in position of the loop divided by 2. (Each division on the micrometer scale represents 1μ). Record the eccentricity of the loop relative to housing on the Housing Patterning Record Sheet.

If the eccentricity exceeds 400 microinches (10.16μ) the centering is considered unacceptable and the resist should be stripped (Step 8) and the process repeated until acceptable centering is achieved.

CLEANUP

Turn off the microscope light.

7. PLASMA ETCH

EQUIPMENT AND MATERIALS:

- MARCH JUPITER II REACTIVE ION ETCHER
- OXYGEN (O_2), LINDE SPECIALTY GASES ULTRA HIGH PURITY 6
- SULFUR HEXAFLOURIDE (SF_6), LINDE SPECIALTY GASES ELECTRONIC GRADE
- ZEISS AXIOSKOP FLUORESCENCE MICROSCOPE
- HOUSING PATTERNING RECORD SHEET

SAFETY CONSIDERATIONS:

- SULFUR HEXIFLOURIDE, THOUGH NON TOXIC ITSELF, PRODUCES TOXIC PRODUCTS IN THE PLASMA REACTOR. BE SURE TO PURGE THE REACTOR OF VAPOR RESIDUES BEFORE UNLOADING.
- HIGH VOLTAGES ARE PRESENT. BE SURE PROTECTIVE PANELS ARE IN PLACE.

REFERENCES

- *JUPITER II OPERATION MANUAL,* March Instruments, Inc.
- *AXIOSKOP OPERATING INSTRUCTIONS*, Carl Zeiss, Inc

PROCEDURE

Open the cylinder and regulator valves for the O_2 and SF_6. Both regulators should be set for 15 ±5 PSI. Turn on the main power switch located on the back of the process control module. Turn on the power to the RF generator. Set the mode select switch to **AUTO** to backfill the chamber.

Open the chamber and set the gyro housing, cavity side up at the center of the RF electrode. Close the chamber and set the mode select switch to **MANUAL** which will cause the system to pump down to
10 - 20 mTorr ("001 -002")

Turn on the O_2 and set the flow to read 235. This flow should result in pressure reading of 025 (0.25 torr). Turn on the RF at 200 watts for 12 seconds to ash any photoresist scum remaining in the developed areas. After completion of the 12 second ash, turn off the O_2 and wait until the pressure reads 001-002.

Turn on the SF_6 and set the flow to read 184. This flow should result in a pressure reading of 015 (0.15 torr). Turn on the RF at 200 watts for 4.5 minutes to etch the exposed niobium. After completion of the etch turn off the SF_6 and wait until the pressure reads 001-002, then set the mode switch to **AUTO** to backfill.

After the chamber has backfilled, open and remove the gyro housing. Then close the chamber and set the mode switch to **MANUAL** to pump back down.

Inspect the etched niobium pattern under the microscope using the 5X objective. If any metal remains in the etched area replace the aluminum pins in the contact holes and repeat the above SF_6 etch for an additional 45 seconds.

Record the date, time and other information as indicated on the housing patterning record sheet.

CLEANUP:

Turn off the power switch on the RF generator and the main power switch. Shut off the O_2 and SF_6 cylinder and regulator valves.

Turn off the microscope light.

8. REMOVE STRAY METAL FROM PARTING PLANE

PROCESSING LOCATION: WET CHEMICAL BENCH IN GP-B PHOTOLITHOGRAPHY AREA

EQUIPMENT AND MATERIALS

- NIOBIUM ETCHANT:
  70 mL DI WATER
  120 mL Nitric Acid
  10 mL HYDROFLUORIC ACID
- POLYURETHANE FOAM SWAB
- DI WATER
- 20 X MICROSCOPE

PROCEDURE

Wet the tip of the swab with the etching solution. While observing through the microscope, wipe the all areas of stray metal on the parting plane of the gyro housing until the metal is gone.

Rinse the gyro housing in running DI water for at least 30 seconds. Blow dry.

9. STRIP PHOTORESIST

PROCESSING LOCATION: WET CHEMICAL BENCH IN GP-B PHOTOLITHOGRAPHY AREA

EQUIPMENT AND MATERIALS

- E400 POSITIVE PHOTORESIST STRIPPER FROM BRENT AMERICA, EMT DIVISION
- 2 - 400 ml BEAKERS
- PHOTORESIST SPINNER
- TEFLON IMMERSION HANDLE
- HOUSING PATTERNING RECORD SHEET
- HEATED WATER BATH IN CHEMICAL WET BENCH
- MERCURY THERMOMETER

SAFETY CONSIDERATIONS

- FUMES FROM R-10 STRIPPER ARE TOXIC AND FLAMMABLE. THIS CHEMICAL SHOULD ONLY BE USED IN AN EXHAUSTED FUME HOOD IN THE PRESENCE OF A FIRE EXTINGUISHER.
- WEAR CHEMICAL RESISTANT GLOVES SUCH AS NATURAL RUBBER OR NEOPRENE. R-10 STRIPPER IS CORROSIVE AND WILL DISSOLVE LATEX GLOVES.
- WEAR EYE PROTECTION

REFERENCE

- *WET ACID BENCH MANUAL* FROM WAFER PROCESS SYSTEMS

PROCEDURE

Fill the water bath in the wet bench with water and turn on the heater.

The water bath heater settings for 50°C are:
Process Setpoint (PS) 80
High Alarm Setpoint (HI) 90
Low Alarm Setpoint (LO) 60

Pour 200 ml of R-10 stripper into each of two beakers and place one of the beakers in one of the holes provided in the Teflon cover of the water bath. Place the thermometer in the bath through the other hole. Allow 30-60 minutes for the bath temperature to stabilize to 45 -55°C as indicated on the thermometer in the bath.

Place the gyro housing on the Teflon immersion handle with the parting plane facing up. While supporting the gyro housing by the immersion handle, immerse it in the stripper. After 5 minutes has elapsed remove the housing from the stripper.

Rinse the housing in the second beaker of stripper at room temperature for 10 seconds then place it in the dump rinse tank. Press start on the rinser control panel. When the rinse cycle is completed remove the housing from the immersion handle and place it on the spinner chuck. Press the start button twice to initiate the spin only cycle which will spin the housing dry.

Record the date and time on the housing patterning record sheet.

CLEANUP

Remove the gyro housing from the adapter chuck and turn off power to the spinner. Pour used stripper in properly labeled waste container and rinse beakers with DI water.

10. FINAL INSPECTION AND ELECTRICAL TEST

EQUIPMENT AND MATERIALS

- ZEISS AXIOSKOP FLUORESCENCE MICROSCOPE
- FLUKE 77 SERIES II OHMMETER
- HOUSING PATTERNING RECORD SHEET

REFERENCE

- *ZEISS AXIOSKOP OPERATING INSTRUCTIONS*

PROCEDURE

The fluorescence microscope should be configured with u.v. illumination and the reflector slider in the #I position. Using the 10X objective, check to insure that all of the resist has been removed from the loops and contact pads (resist residue will fluoresce). This is important to insure good electrical contact to the cable. If there appears to be any resist residue remaining repeat the resist strip step. This may be followed by a five minute exposure to oxygen plasma in the plasma etcher as per step 7 (plasma etch).

Check pattern for defects and record any found on the housing patterning record sheet.

Measure room temperature resistance of the loop with the ohmmeter in the autorange mode. Verify that the resistance of the loop is consistent with the niobium film thickness, loop geometry, and niobium resistivity (~18μΩ-cm for the GP-B thin films). For the 4-turn readout loop the resistance should be approx. 6Ω as measured with the ohmmeter in the autorange mode. If the resistance is not within +100%,- 50% of this value notify supervisor.

The current/voltage specifications for the Fluke 77 Series II ohmmeter are as follows:

Resistance Range	Maximum Current
320Ω	0.6 mA
3.2kΩ	0.17 mA
32kΩ	20μA
320kΩ	2μA
3.2MΩ	0.2μA
32MΩ	32μA

Maximum open circuit voltage 3.1 V.D.C.
Full scale voltage <440mV up to 3.2 MΩ, < 1.4 volt in 32MΩ Scale

HOUSING PATTERNING RECORD SHEET

HOUSING #_____

PROCESSING SPECIFICATION REVISION DATE_____

1. SUBSTRATE CLEAN DATE:_____
   TIME:_____ _____

2. RESIST APPLICATION DATE:_____
   TIME:_____
   NUMBER OF REPEATS FOR GOOD COATING:_____

3. SOFTBAKE DATE:_____
   TIME:_____

4. EXPOSE: DATE:_____
   TIME:_____

   MASK DWG#_____
   REV:_____
   FAB DATE:_____
   DESCRIPTION:_____

   EXPOSURE INTENSITY mW/cm^2 @ 400nM_____
   EXPOSURE TIME SECONDS:_____

5. DEVELOP: TOTAL DEVELOP TIME: SEC_____ DATE:_____
   TIME:_____

6. HARD BAKE DATE:_____
   TIME:_____

7. INSPECT RESIST DATE:_____
   TIME:_____

   DEFECTS:_____

8. PLASMA ETCH: DATE:_____
TIME:_____

A) DESCUM
OXYGEN PRESSURE _____TORR
RF POWER _____WATTS
PROCESS TIME _____SECONDS

B) Nb ETCH
SF_6 PRESSURE _____TORR
RF POWER _____WATTS
PROCESS TIME _____SECONDS

RE-ETCH NEEDED ? ___YES ___NO

SF_6 PRESSURE _____TORR
RF POWER _____WATTS
RE-ETCH TIME _____SECONDS

9. . PHOTORESIST STRIP DATE:_____
TIME:_____

10. . FINAL INSPECTION & ELECTRICAL TEST DATE:_____
TIME:_____

INSPECT FOR RESIST RESIDUE WITH
FLUORESENCE MICROSCOPE.
RESIDUE OBSERVED: ___YES ___NO

DEFECTS NOTED: ___YES ___NO
(SEE INSPECTION RECORD SHEET)

LOOP RESISTANCE:	NOMINAL	MEASURED
INNER LOOP	_____	_____
OUTER LOOP	_____	_____
INNER TO OUTER	>20 MΩ	_____

ECCENTRICITY OF LOOP RELATIVE TO HOUSING _____

NOTE LOCATION OF ANY DEFECTS