SECTION II

TYPICAL PROCESS

INTRODUCTION

This section provides information relating to the setup of a typical 903e etching process.

These process parameters are presented as useful starting points and not as optimized processes. The process applications presented include contact/via, spacer, and nitride passivation etch. Process applications are followed by typical process performances for each application.

A typical process uses combinations of Sulfur Hexafluoride (SF_6), Freon 23 (CHF_3), and Helium (He). Process trend charts (refer to table 1) should be used to optimize the process for any specific application.

TYPICAL PROCESS (continued)

CONTACT/VIA

Typical Wafer Structure (903e)

Patterned Photoresist Mask (typically 8% exposed area)
>3000 Å of dielectric SiO_2 (typically 8000 Å)
Silicon and/or polysilicon (contact)/silicon or aluminum (via)

Process Specifications (903e)

Profile	85-90°
CD loss	<0.1 µm
Non-uniformity	< ±10% (3σ)
Selectivity to silicon/polysilicon	≥10:1
Cleaning frequency	250-500 wafers

Process Parameters

***Step 1** (nonselective etch step)*

	Starting Point	Range
CHF_3 (sccm)	30	20-35
SF_6 (sccm)	5	4-10
He (sccm)	80	60-100
Pressure (torr)	1.8	1.6-2.0
Power (watts)	variable*	450-650

* i.e., size dependent: 450W for 4"
550W for 5"
650W for 6"

***Step 2** (selective etch step)*

	Starting Point	Range
CHF_3 (sccm)	45	45-50
SF_6 (sccm)	2.5	1.5-2.5
He (sccm)	80	60-100
Pressure (torr)	1.8	1.6-1.8
Power (watts)	variable*	5,6,700

* i.e., size dependent 500W for 4"
600W for 5"
700W for 6"

TYPICAL PROCESS (continued)

CONTACT/VIA (continued)

Step 1 should be run in a timed mode terminating 1000 Å before the first exposed polysilicon/silicon or aluminum. Step 2 will then selectively etch the remaining oxide, optically endpointing on the substrate, and the appropriate overetch time will be processed using the step 2 chemistry.

Typical Process Performance (903e)

ETCH RATES		
Film	Step 1 Å/min	Step 2 Å/min
PSG	8000	6000
CVD oxide (undoped)	6000	4500
Thermal	5000	4000

SELECTIVITIES		
Film	Step 1	Step 2 Å/min
Selectivity to PR	>3:1	>5:1
Selectivity to polysilicon	>3:1	≥10:1
Selectivity to aluminum	>100:1	>100:1

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TYPICAL PROCESS (continued)

NITRIDE PASSIVATION

Typical Wafer Structure (903e)

Patterned Photoresist Mask (typically 8% exposed area)	
PECVD Si_3N_4	8000 Å
PSG	8000 Å
Silicon and/or aluminum substrate	

Process Specifications (903e)

Profile	85-90°
CD loss	<0.1 µm
Non-uniformity	≤±10% (3σ)
Selectivity to silicon	≥5:1
Cleaning frequency	250-500 wafers

Process Parameters

	Starting Point	Range
CHF_3 (sccm)	35	25-45
SF_6 (sccm)	5	3-10
He (sccm)	80	60-100
Pressure (torr)	1.8	1.6-2.0
Power (watts)	variable*	450-650

* i.e., size dependent 450W for 4"
550W for 5"
650W for 6"

Process Setup (903e)

This process can be run with one step and a timed overetch, but acceptable non-uniformity cannot be achieved on both oxide and nitride with the same one-step parameters. Therefore, Tegal recommends running a two-step process to optimize non-uniformity for each film (nitride/oxide). The first step will uniformly etch the nitride, endpointing on oxide, and the second step will uniformly etch the PSG, optically endpointing on the substrate.

TYPICAL PROCESS (continued)

NITRIDE PASSIVATION (continued)

Typical Process Performance (903e)

ETCH RATES	
Film	Step 1 Å/min
Silicon Nitride PSG	6000 8000

SELECTIVITIES	
Film	Step 1
Selectivity to PR Selectivity to silicon Selectivity to aluminum	≥3:1 ≥5:1 ≥100:1

TYPICAL PROCESS (continued)

LDD (Lightly Doped Drain) SPACER

Typical Wafer Structure (903e)

CVD SiO_2 or TEOS	3000 Å
Patterned Poly	3500 Å
Thermal SiO_2 gate	250 Å
Substrate	Silicon

Process Specifications

Non-uniformity <10% 3 sigma
Selectivity to silicon >10:1
Minimal silicon damage process
No trenching of silicon along spacer sidewall
Cleaning frequency 500 to 700 wafers

Process Parameters

Steps 1 and 2 *(optical endpoint and timed overetch)*

	Starting Point	Range
CHF_3 (sccm)	45	40-50
SF_6 (sccm)	2.5	1.5-3.0
He (sccm)	80	60-100
Pressure (torr)	1.8	1.8-2.2
Power (watts)	variable*	500-700

* i.e., size dependent: 500W for 4"
600W for 5"
700W for 6"

Step 1 should be run to optical endpoint on the silicon. The endpoint will be very sharp because of the large amount of exposed area; therefore, endpoint after a 1-volt drop in endpoint signal. Step 2 is a very short timed overetch.

TYPICAL PROCESS (continued)

LDD (Lightly Doped Drain) SPACER (continued)

Typical Process Performance (903e)

ETCH RATES	
Film	Step 1 Å/min
CVD Thermal Oxide TEOS	4500 4500 4500

SELECTIVITY	
Film	Step 1
Selectivity to silicon/polysilicon	>10:1

TYPICAL PROCESS (continued)

SLOPED OXIDE ETCH

In this process, the resist is baked at a high temperature to flow and slope the resist pattern. The slope of the resist is dependent on the type of resist, the temperature, and the duration of the bake. A plasma containing SF_6 is then used to anisotropically etch the oxide. During the process, the sloped sides of the resist erode to progressively expose more oxide at the top to produce sloped sides (see figures 5 & 6). The slope profile is dependent on etch selectivity and pre-etch resist profile. A low selective etch, where resist and oxide etch at similar rates, produces more slope than a highly selective etch. Doped CVD oxide etches faster than thermal oxide and therefore CVD oxide produces a steeper, less sloped etch than thermal oxide in a given process.

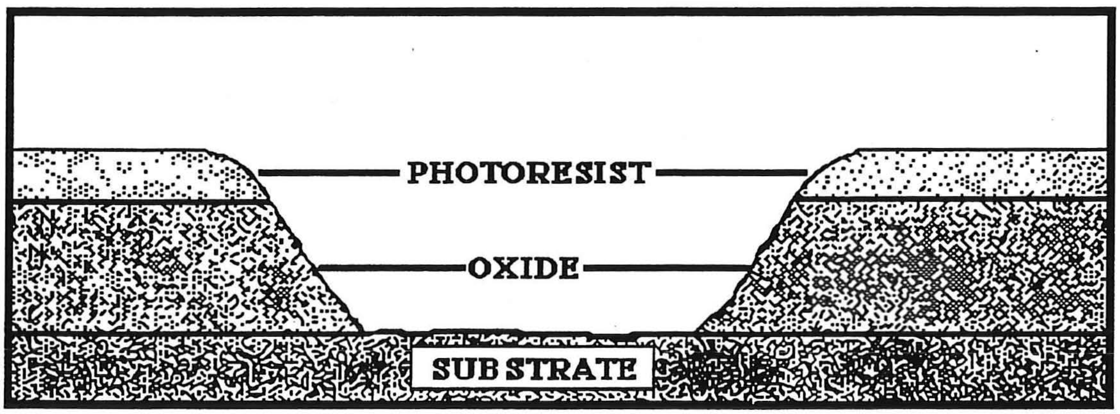

Figure 5. Low Selectivity-to-Slope Comparison

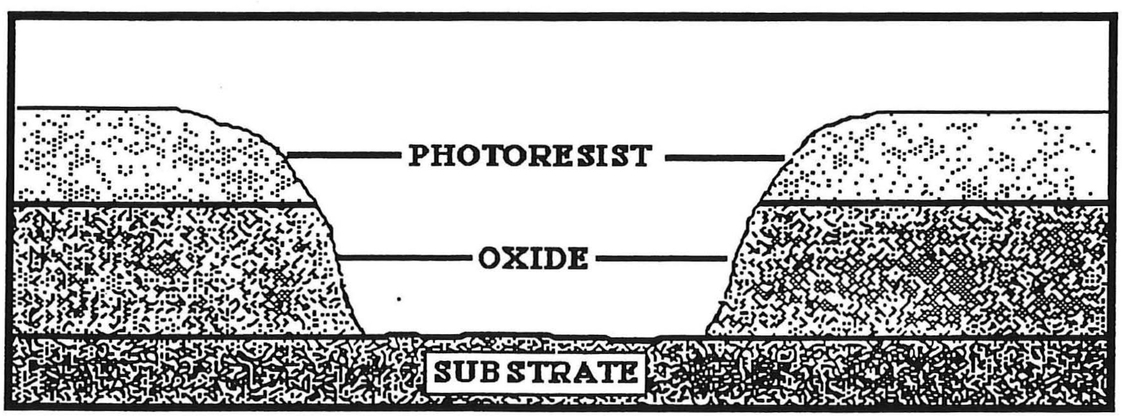

Figure 6. High Selectivity-to-Slope Comparison

TYPICAL PROCESS (continued)

CLEANING PROCEDURE (903e)

DISCUSSION

Factory recommended cleaning and preventive maintenance procedures should be followed to obtain optimum performance and productivity.

The user should determine a Chamber cleaning frequency that is best suited to the particular production load/applications involved.

A Chamber cleaning should, of course, be performed whenever a change of film types is involved.

EQUIPMENT REQUIRED

1. Standard Field Engineer's tool box.
2. Clean, lint-free, wipes.
3. Isopropyl Alcohol (IPA).
4. Dummy Wafer.
5. Gloves, Acid-proof (Medium 80-202-196 - Large 80-202-195)
6. Clean Conditioning wafers (10 minimum)

PRELIMINARY INSTRUCTIONS

1. Select and run the appropriate oxygen plasma clean recipe by pressing the **clean** option on the **RofR**, **clean**, **wfr qty** and **more** screen.. The recommended clean recipe is:

   O_2 Clean Channel:

Partial Pressure	500 mTorr	
CHF_3	20 sccm	
He	50 sccm	
Pressure	3000 - 4000 mTorr	
Power	300 Watts	4"
	400 Watts	5"
	500 Watts	6"
Time	1800 to 2400 Seconds (depends on Chamber cleanliness)	

   CAUTION

   This process must be run with a dummy wafer if the Lower Electrode has metal pins. The clean process should be run with no wafer if the Lower Electrode has quartz pins. This wafer/no wafer option is software selectable.

TYPICAL PROCESS (continued)

PROCEDURE

1. Open the Top-Plate.
2. Inspect the Upper Electrode, Chamber sidewalls, on ceramics for polymer. If polymer remains, repeat the O_2 cleaning procedure.
3. Enable the N_2 vent valve by placing the PURGE switch to the **ENABLE** position (see figure 7).
4. Switch to **QUICK** flow (see figure 7).

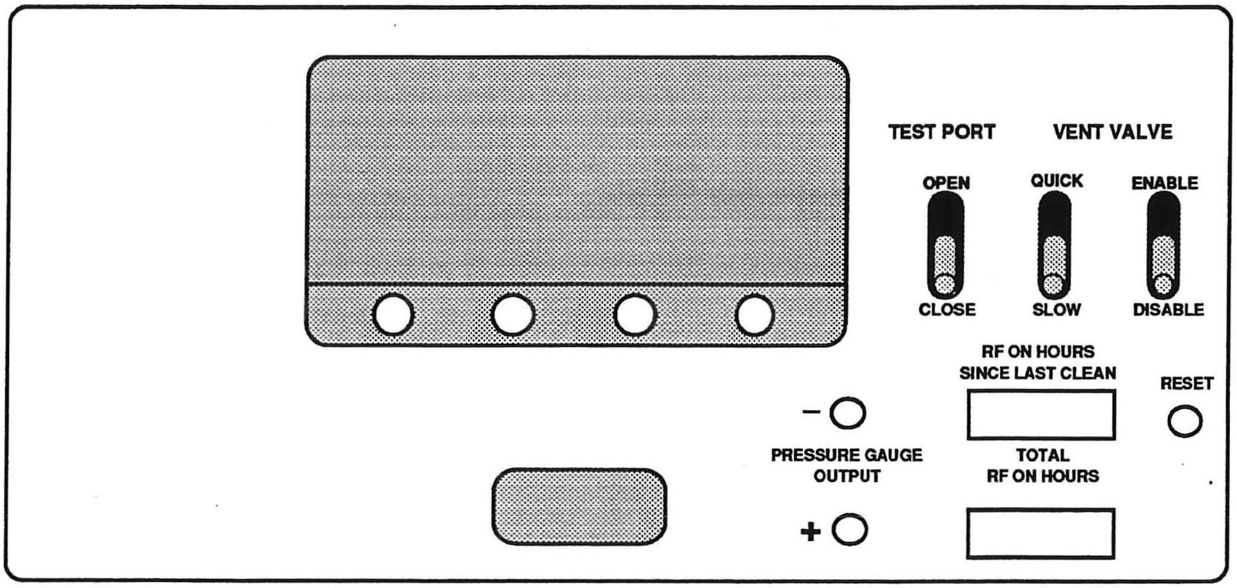

Figure 7. Front Panel Switch Locations

NOTE
Insure the Upper Electrode, Chamber, and ceramics are free of polymer prior to performing step 5.

5. Insure a sufficient amount of N_2 is purging through the Upper Electrode. If little or no N_2 is flowing, consult the maintenance manual.

CAUTION
Never use abrasive pads on anodized surfaces.

6. Using a lint-free cloth & IPA, wipe the Upper Electrode, Chamber sidewall, and the ceramic.

TYPICAL PROCESS (continued)

7. Wipe the entire surface of the Lower Electrode and the ceramic.

NOTE
The Chamber should now be thoroughly clean.

8. Switch the N_2 vent valve to **SLOW** flow and disable the vent valve.
9. Close the top plate.
10. Using the **RofR** test, pump the Chamber to base pressure.

NOTE
Purging the Chamber with Helium assists in the outgassing and shortens the pumpdown time. TEGAL recommends the He flow be 80 sccm for 5-10 minutes.

11. Once the Chamber has reached base pressure and an acceptable leak rate, quit the R of R test. The Chamber should be 'seasoned' for the next film by cycling at least 10 conditioning wafers with the following seasoning recipe:

SF_6	CHF_3	He	Press.	Power	Time
3	45	80	1.75	450W 4" 550W 5" 650W 6"	2 min/wafer

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TYPICAL PROCESS (continued)

PROCESS TRENDS

The etching process is affected by changes in any of the various parameters.

The relationships between the various parameters and process trends are indicated in Table 1.

NOTE

SELECTIVITY & POLYMERIZATION are adjusted by:

Primarily .... Ratio of SF_6 to CHF_3.

Secondarily .... RF Power.

NON-UNIFORMITY is adjusted by:

Primarily .... Pressure (Coarse adjustment).

Secondarily .... Helium (Fine adjustment).

Table 1. Process Optimization (903e)

PARAMETER	ETCH RATE		SELECTIVITY		POLYMERIZATION		NON-UNIFORMITY	
	CORRECT FOR		CORRECT FOR		CORRECT FOR		CORRECT FOR	
	SLOW	FAST	LOW	HIGH	HIGH(3)	LOW(3)	EDGE-TO-CTR	CTR-TO EDGE
SF_6/CHF_3 RATIO	↑ (1)	↓	↓	↑	↑	↓	↓	↑
POWER	↑	↓	↓ (2)	↑	↑	↓	↑	↓
PRESSURE	–	–	↑	↓	↓	↑	↓	↑ (4)
HELIUM		↓				↑	↓ (4)	

EXAMPLE

If the etch rate is low and selectivity is not a major concern, increase power and/or increase the SF_6:CHF_3 ratio to increase the etch rate.

Increasing power may affect uniformity, ie, cause center-to-edge clearing. An increase in pressure may also be necessary to maintain uniformity.

NOTE

Center-to-edge clearing is defined as etching faster at the center than the edges. Edge-to-center clearing is the opposite.

TYPICAL PROCESS (continued)

(1) This is true only for low ratios (<1:1) of SF_6/CHF_3.

(2) Reducing RF power mproves the selectivity but slows the etch rate and may induce polymer formation.
High selectivity is desirable for a second step & overetch step process. During this step, higher polymerization ($SF_6:CHF_3$ ratio reduction) is required to attain the desirable selectivity values.

(3) The amount of CHF_3 influences the deposition of polymers in the Chamber, ie, more CHF_3, more polymers. SF_6 aids in removing these polymers. Of course, an increase of polymers can increase the selectivity.

(4) Center-to-edge clearing that cannot be remedied by reducing the percentage of Helium and increasing the pressure may be due to 'loading effect'. Loading of the plasma can be caused by the amount of oxide exposed or the amount of oxygen in the etch. Greater than 15% exposed oxide will load a 50 sccm total flow plasma. Depending on the type of photoresist, solvents present, etc., the type of photoresist may also load the process.
To correct for center-to-edge clearing due to 'loading', increase the total flow of the process by increasing the flow of CHF_3 and SF_6, but keep these two gases in the same ratio. Increase the total fluorocarbon flow in 15% increments until the center-to-edge clearing pattern is remedied.

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