Section III

TYPICAL PROCESSES

INTRODUCTION

This section provides basic information on some of the processes which can be considered typical for the 901e system. It is intended as a guideline for etching various films in a 901e system. Typical processes are presented as a useful starting point for the user, and do not represent optimized processes. Process models and process trends are outlined, and variations on typical processes are shown for the most commonly encountered films.

Typical 901e processes use combinations of Freon 11* (CCl_3F) and Sulfur Hexafluoride (SF_6). Actual process conditions and general characteristics are given below. Process trend charts should be used to optimize the process for any specific application.

*Freon 11 must be used with a vacuum regulator. Freon 12 can be substituted if desired.

Table 4-2. Process A

PHOSPHORUS DOPED POLY/SiO_2

					ENDPOINT				
PROC. STEP	SEQ	GAS FLOW (sccm)	PRESS (Torr)	POWER (watts)	MODE	DIREC-TION	THRESH-OLD	SENSOR	TIME
1	C	SF_6 25	0.3 0.4	150 CW	ABS	DECR	7-8 DIV	Optical	
*2	D	SF_6 25	0.3 0.4	50 CW	Timed				12-36 sec.

*Step 2 is being used as an overetch.

General Characteristics: High selectivity, high etch rate, good uniformity, can be subject to loading effect.

Poly etch rate:	8000 Å/minute
Uniformity:	±5%
Loss of dimension:	0.4-0.6 microns
Selectivity to SiO_2:	20:1

Process A is most commonly used when some undercut can be afforded, and a very high etch rate is desired.

Table 4-3. Process B

PHOSPHORUS DOPED POLY/SiO_2

PROC. STEP	SEQ	GAS FLOW (sccm)		PRESS (Torr)	POWER (watts)	ENDPOINT MODE	ENDPOINT DIREC-TION	ENDPOINT THRESH-OLD	SENSOR	TIME
1	C	SF_6 25	CCl_3F 3	0.25	150 0.30	ABS CW	DECR	8 DIV	Optical	
2	D	SF_6 25	CCl_3F 3	0.25 0.30	75 CW	Timed				12-36 sec.

General Characteristics: High etch rate, good selectivity, with less loss of dimension (undercut). Good uniformity.

Poly etch rate:	8000 Å/minute
Uniformity:	±5%
Loss of dimension:	0.1-0.3 microns
Selectivity:	15-20:1

Process B is most commonly used with a more heavily doped poly than would be used in Process A. The loading effect for Process B is much less than that for Process A.

Table 4-4. Process C

PHOSPHORUS DOPED POLY/SiO_2, CONTROLLED CD

PROC. STEP	SEQ	GAS FLOW (sccm)		PRESS (Torr)	POWER (watts)	ENDPOINT MODE	ENDPOINT DIREC-TION	ENDPOINT THRESH-OLD	SENSOR	TIME
1	C	SF_6 25	CCl_3F 3	0.25	150 0.30	ABS CW	DECR	7-8 DIV	Optical	
*2	D		CCl_3F 10	0.25 0.30	75 CW	Timed				12-36 sec.

*Step 2 is being used as an overetch.

General Characteristics: High etch rate, only slightly less selective than Process A, with less undercut due to the overetch with straight CCl_3F.

Poly etch rate:	8000 Å/minute
Uniformity:	±5%
Loss of dimension:	0.1 ±0.3 microns
Selectivity:	15-20:1

The overetch must be kept as short as possible to prevent polymer buildup. Adding Ar (3 sccm) decreases the formation of polymer. The chamber should be cleaned with straight SF_6.

Table 4-5. Process D

NITRIDE/SiO_2, PASSIVATION or THICK NITRIDE (LOCOS)

PROC. STEP	SEQ	GAS FLOW (sccm)	PRESS (Torr)	POWER (watts)	ENDPOINT MODE	DIREC-TION	THRESH-OLD	SENSOR	TIME
1	C	SF_6 20	0.2-0.3	150 CW	ABS	DECR	7-8 DIV	Optical	
*2	D	SF_6 20	0.2-0.3	50 CW	Timed				6-12 sec.

*Step 2 is being used as an overetch.

General Characteristics: Good uniformity, fairly good etch rate.

Nitride etch rate:	1500-2000 for LPCVD nitride 3000-4000 for PECVD nitride
Uniformity:	±5%
Selectivity/oxide:	2-3:1

Table 4-6. Process E

UNDOPED POLY/SiO_2, ANISOTROPIC

PROC. STEP	SEQ	GAS FLOW (sccm)	PRESS (Torr)	POWER (watts)	ENDPOINT MODE	DIREC-TION	THRESH-OLD	SENSOR	TIME
1	C	CCl_3F 15 SF_6 3	0.2-0.3	100 0.2-0.3	ABS CW	DECR	8 DIV	Optical	
*2	D	CCl_3F 15 SF_6 3	0.2-0.3 0.2-0.3	100 CW	Timed				12 sec

*Step 2 is being used as an overetch.

General Characteristics: Low etch rate, minimal undercut.

Table 4-7. Process F

THIN NITRIDE, SELECTIVE TO OXIDE

PROC. STEP	SEQ	GAS FLOW (sccm)	PRESS (Torr)	POWER (watts)	ENDPOINT MODE	ENDPOINT DIREC-TION	ENDPOINT THRESH-OLD	ENDPOINT SENSOR	TIME
1	C	SF_6 20	0.2-0.3	150	ABS	DECR	8-9 DIV	Optical	
*2	D	SF_6 12, O_2 12	1.5	150	Timed				6-15 sec.

*Step 2 should not be used alone. Etch rate of step 2 is strongly influenced by the presence of a native or deposited oxide.

General Characteristics: Good etch rate (step 1), good selectivity (step 2)

Nitride etch rate (step 1):	LPCVD	1100-1500 A/min
	PECVD	2000-4000 A/min
(step 2):		600-1000 A/min
Uniformity (step 1):	$< \pm 5\%$	
Uniformity (step 2):	$< \pm 10\%$	
Selectivity (Nitride:Oxide)	$>9:1$	

PROCESS TRENDS

PRINCIPLES FOR PROCESS OPTIMIZATION

The 901e operates best with total process gas flows from 20 SCCM to 50 SCCM at pressures between 0.2 torr and 0.4 torr (for exception see selective nitride etch).

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

The relationship between the various parameters and process trends is indicated in the chart below.

Table 4-8. Process Optimization

PARAMETER	ETCH RATE		SELECTIVITY		UNDERCUT		UNIFORMITY*	
							Correct for:	
	Incr	Decr	Incr	Decr	Incr	Decr	Edge-to-Center	Center-to-Edge
SF_6/CCl_3F Ratio	↑	↓	↑	↓	↑	↓	—	—
Power	↑	↓	↓	↑	↓	↑	↓	↑
Pressure	↓	↑	↑	↓	↓	↑	↑	↓
Total Flow	↑	↓	—	—	↑	↓	—	

Example: If etch rate is low and selectivity is not a major concern, increase power and/or increase SF_6/CCl_3F ratio to increase the etch rate.

Reducing RF power improves the selectivity but slows down the etch rate and may induce polymer formation.

*Center-to-Edge means the etch is faster in the center of the wafer than on the edges.

*Edge-to-Center means the etch is fastest on the edges of the wafer.

CHAMBER CLEANING

Periodically, the reaction chamber needs to be cleaned of residue left behind from the etch process. The cleaning method used is depending on the etch process used.

Since all cleaning consists of timed processes, the D sequence should be used. At the end of each cleaning process, check the reaction chamber. If it is still not clean repeat the process until clean.

Processes using a combination of SF_6 and CCl_3F leave a chlorocarbon residue, which is cleaned with straight SF_6. Typical process A can be used, except the endpoint should be timed at 600 seconds.

Processes using straight SF_6 leave a sulfur residue. A 50 sccm O_2 plasma at 500 mTorr and 50 watts, CW, for 600 seconds is used for cleaning.

Processes using straight CCl_3F are cleaned with an SF_6 plasma, as outlined in typical process A. An acetone wipe followed by an isopropyl alcohol wipe also removes the polymer build-up. Use linen or other lint-free rags, only, and wear acid gloves when wiping out the chamber.