Impedans PLASMA MEASUREMENT

End-point detection of polymer etching using Langmuir Probes*

STUDY:

Determining accurately the end point of a plasma-etching process is extremely important for integrated circuit fabrication, as overetching can result in the removal of part of the film, or substrate lying under the film to be etched, and/or in extra undercut of the film. End-point detection is traditionally performed using several different techniques including the four most common techniques: measurement of the DC self-bias voltage, mass spectrometry, emission spectrometry, and interferometry.

The authors of this study used a Langmuir probe in order to determine the end point of a polymer etching, by measuring the floating potential V_f which changes at the end of an etching process.

METHOD:

The authors used a single-wafer RIE system, with a 6-inch diameter, aluminum lower electrode, powered at 13.56MHz, and with automatic pressure control. All the etching tests were performed using an oxygen flow of 25sccm, a pressure of 100mTorr (13.3Pa) and a power level of 100W.

The samples used for etching were 3 inches in diameter, test-wafer quality, silicon wafers, which were spun coated with Tokyo Ohka ONPR 800 Positive Resist, at 4000rpm, during 20s, after which they were pre-baked on a hot plate at 105°C, during 90s, resulting in a resist thickness of approximately 1.2pm. In order to obtain wafers with a 25% or 50% partial coverage, the resist was exposed, using a mechanical mask, which covered 25% or 50% of the wafer. The emission spectrometer used was a Princeton Instruments, Inc., OSMA Detector Controller - STS 120.

The Langmuir probe used is a single probe, with a tungsten tip, 4mm long and 0.2mm in diameter. Preliminary tests with a bare Langmuir probe (without RF compensation) showed a high-noise level, which made it impossible to measure accurately the floating potential, and so the authors added standard RF compensation at 13.56MHz. To determine the electron temperature and the ion density of the plasmas, a double Langmuir probe was used. The Langmuir probes were inserted into the plasma through a side window.

FINDINGS:

The experiment showed that it was necessary to apply an intermittent sputter clean process to the probe tip to remove a film of impurities during the experiment, as the impurities corrupted the floating potential measurement. The authors compared three end-point detection methods: the floating potential, the DC bias voltage and the intensity of the 777-nm O-line. The results are shown in the table below:

	S_{bcf}	S_{aft}	ΔS	ΔS / S_{bcf} (%)	SF	ΔS / SF
V_{dc} 100%	-490.5V	-492.7	2.2	0.4	1.5V	1.5
I_o 100%	2560	3060	500	19.5	40	12.5
V_f 100%	18.92V	19.58	0.66	3.5	0.02V	33
V_{dc} 50%	-485.5V	-486	0.5	0.1	1V	0.5
I_o 50%	2975	3190	225	7.6	20	11
V_f 50%	19.17V	19.43	0.26	1.4	0.01V	26
V_{dc} 25%	-483V	-483	0	-	1V	-
I_o 25%	3100	3200	100	3.2	15	6.6
V_f 25%	19.13V	19.24	0.11	0.6	0.01V	11
V_{dc} 10%	-497V	-497	0	-	0.2V	-
I_o 10%	3340	3375	35	1.0	10	3.5
V_f 10%	19.07V	18.99	0.08	0.4	0.01	8

DC Self Bias Voltage V_{dc} Intensity of the 777nm oxygen line I_o and floating potential V_f. Signals before (S_{bcf}) and after (S_{aft}) end point, the absolute and relative changes of these signals, the signal fluctuations (SF) and the signal change to signal fluctuation ration for wafers with 100%, 50%, 25% and 10% resist coverage.

These results show that the DC self-bias voltage method yields the least reliable results, whereas the floating potential and the O-line intensity are both reliable signals for end-point detection. Several wafers were etched using the floating potential for end-point detection during the study, and analyses show that the polymer was removed completely from the wafers. This indicated that this relatively simple and cheap system is adequate as an end-point detector. Langmuir probe measurements also showed that the floating-potential variation is caused not only by the change of average ion mass, but also of plasma density, electron temperature, and electron energy distribution.

REFERENCES:

* “End-point detection of polymer etching using Langmuir probes”. Raul Murete de Castro, Patrick Verdonck, Marcelo B. Pisani, Ronaldo Domingues Mansano, Giuseppe Antonio Cirino, Homero Santiago Maciel and Marcos Massi. Plasma Science, IEEE Transactions on (Volume:28 , Issue: 3) Page(s): 1043 - 1049 DOI: 10.1109/27.887774. Date of Publication : Jun 2000. Publisher: IEEE

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