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Plasma Etching Monitor by Electric Probe

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Plasma etching with the barrel type reaction chamber is now widely used for LSI fabrication. The plasma etching in such an apparatus is isotropic, because material removal is due mostly to chemical reactions. Moreover, the etch rate increases as the surface area of the etched material decreases. Thus, severe undercutting is caused by over-etching. This can result in significant dimensional changes in the etched images during over-etching. It is, therefore, necessary to have some means of accurate mechanical end point detection, i.e., a method of determining the time when the subject layer is etched through.

This paper describes a novel method of end point detection using a conventional electric probe.1),2) Data are presented for plasma etching in a CF_4-O_2 plasma.

The schematic diagram of the plasma etching apparatus and the electric probe circuit are shown in Fig. 1. The reaction chamber is made of quartz and the rf plasma is generated by capacitive electrodes. The probe is inserted into the chamber through the front door. In the figure, measurements are carried out using the double probe method.2)

The I-V characteristics of the electric probe were measured for various etching conditions. One example of the double probe I-V characteristics with the etch tun-

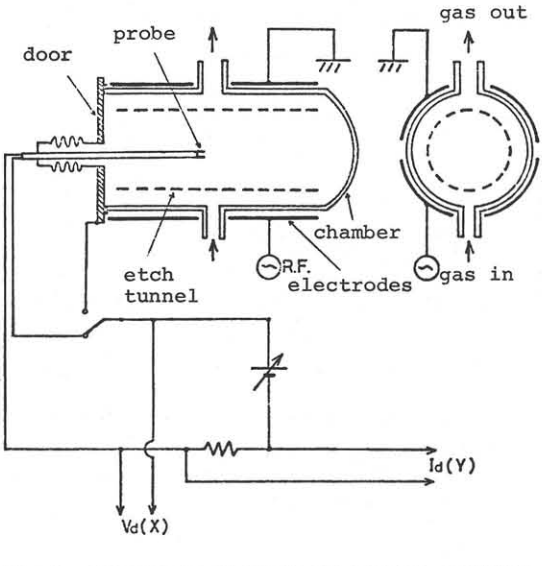

Fig.1 Schematic diagram of plasma etching apparatus and electric probe circuit.

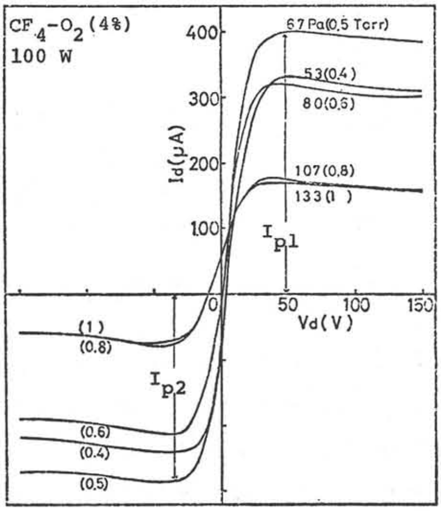

Fig.2 Double probe current-voltage characteristics with etch tunnel in operation for various pressures.

nel in operation for various pressures is shown in Fig. 2. In this figure, ion saturation current (ISC) is dependent on pressure. ISC is also dependent on rf power and etching gas composition. Furthermore, it was found that ISC changes with different etched materials. An example, where ISC depends on the etched material (Si or SiO_2), and on the distance between the probe and the wafer, is indicated in Fig. 3. It is thought that the dependence of ISC on etched material is due to the resulting change in the contents by volume of the gas, because Si etch rate is more than ten times higher than that of SiO_2.3) From these results, it is possible to detect what material is being etched during etching process.

Practical application of the electric probe to end point detection permits monitoring of the ISC for a given probe bias. The changes in ISC at a probe bias of 150 V during plasma etching of a poly-Si layer on SiO_2 are shown in Fig. 4. At time a,the rf power was turned on, and at time c, turned off. At time b, a drastic change in ISC was obserbed as the poly-Si layer was etched away. Similar results were obtained for etching Si_3N_4 on SiO_2, and photoresist removal in an O_2 plasma.

This application of the electric probe to end point measurement should permit more accurate control of etching processes to be realized.

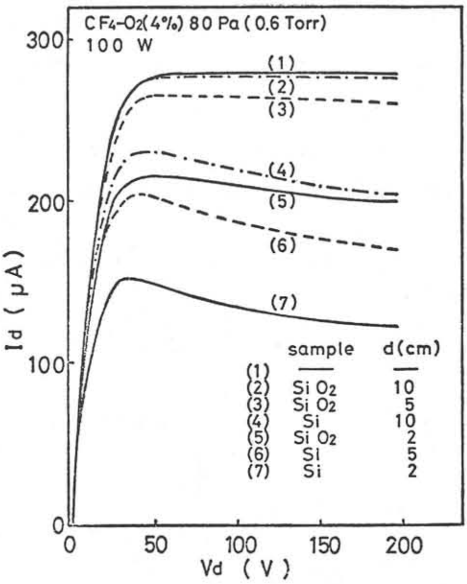

Fig.3 Double probe I-V characteristics with etch tunnel in operation. A 3-in. Si or SiO_2 wafer is set in the etch tunnel, d cm from the probe.

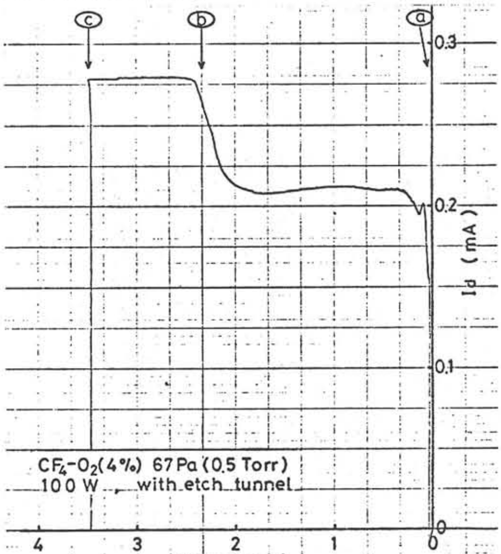

Fig.4 Chart recorder trace of ion saturation current at a probe bias of 150 V during plasma etching of poly-Si on SiO_2.

References

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3) R. L. Bersin, Solid State Technol. 19-5, 31 (1976)