Measurement of Device Charging Damage in a Dielectric Etch 300mm Chamber with a Bias Voltage Diagnostic Cathode

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In order to maintain high device yields, plasma-induced device charging damage must be minimized, yet this damage is process, chemistry, hardware, and wafer-structure dependent. A novel diagnostic cathode has been developed in order to quickly monitor potentially damaging charge during dry etching without using any production or diagnostic wafers. This tool maps bias voltage (V_{DC}) across the entire cathode surface, is shown in Figure 1, and the calculated ΔV_{DC} has been successfully correlated to real production yield data as shown in Figure 2. In this paper, process (magnetic field, pressure, and power) and plasma chemistry results generated in a Dielectric Etch eMAX™ 300mm chamber (shown in Figure 3) are presented.

Magnetic fields are generated with four independently controlled electromagnets and are configured to generate a magnetic, and consequently, an electric field gradient across the wafer surface depending on the wire-pair current ratio. As expected, ΔV_{DC} increases with magnetic field strength and CMF ratio for $CHF_3/CF_4/Ar$ chemistry and is shown visually in Figure 4. These results corroborate that plasma damage can be avoided with field strengths and CMF ratios less than 60 G and 0.4, respectively.

ΔV_{DC} is also sensitive to the process chemistry, but to a lesser degree, and is presented in Figure 5 for $CHF_3/CF_4/Ar$ and $C_4F_6/O_2/Ar$. Both chemistries have large process windows that are below the damage threshold voltage. ΔV_{DC} is essentially insensitive to power and is below the threshold value over a similarly wide process window.

In summary, the V_{DC} diagnostic cathode can identify process windows and chemistries that will reduce the likelihood of plasma-induced device charging damage. The eMAX 300mm dielectric etcher has wide pressure, wide power, and relatively wide magnetic field strength process windows and shows low ΔV_{DC} with $CHF_3/CF_4/Ar$ and $C_4F_6/O_2/Ar$ chemistries. With this tool, experimental data can be quickly generated in order to identify safe operating conditions and reduce development time, the need for test wafers, and the frequency of damaged production wafers.

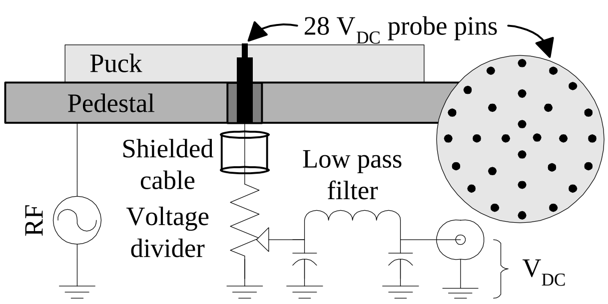
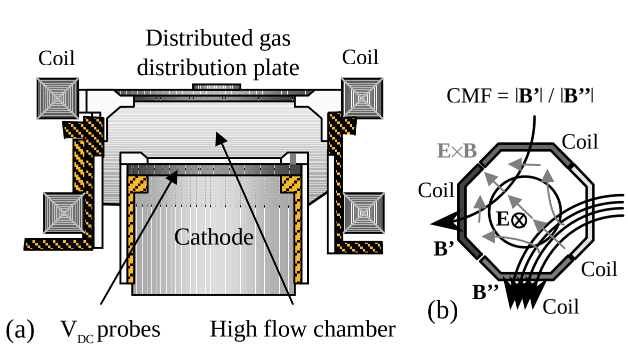


Figure 1. Electrical schematic and V_{DC} probe pin layout for the 300mm V_{DC} diagnostic cathode.



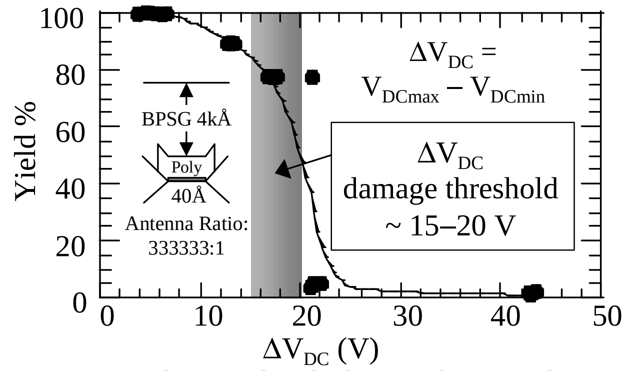


Figure 2. Plasma-induced device charging damage exhibits a dependence on ΔV_{DC}.

Figure 3. Schematic diagram of (a) Dielectric Etch eMAX™ 300mm chamber and (b) four-coil configurable magnetic field (CMF).

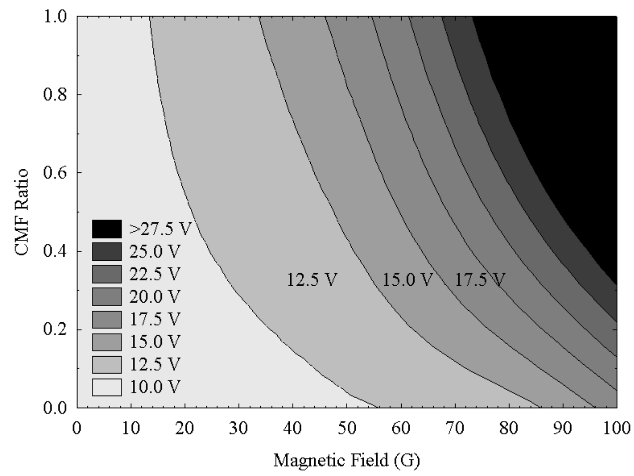


Figure 4. ΔV_{DC} contour plot as a function of magnetic field strength and CMF ratio for $CHF_3/CF_4/Ar/2000$ W at 30 G.

Figure 5. ΔV_{DC} contour plot as a function of pressure and CMF ratio for a) $CHF_3/CF_4/Ar/2000$ W and b) $C_4F_6/O_2/Ar/3000$ W at 30 G.