Alternative Chemistries for Wafer Patterning

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The goal of this project is to identify possible alternatives for perfluorocompound chemistries for wafer patterning of dielectric films that do not pose long term environmental problems. The etch viability of a variety of alternatives have been determined, and the most promising candidates from the etch viability study will be further tested to define an alternative wafer patterning process. The effluents are identified with Fourier Transform Infrared Spectroscopy (FTIR) to assess their potential ESH impact. Beta testing of alternative processes are performed at the facilities of industrial collaborators.

Gases such as fully fluorinated alkanes - CF4, C2F6, C3F8 - as well as inorganic compounds like NF3 and SF6, collectively termed as perfluorocompounds (PFCs), are used heavily by the semiconductor industry for the etching of dielectric films in wafer patterning applications. Their use and emission is problematic, however, from an environmental standpoint because of the global warming nature of these substances coupled with their long atmospheric lifetimes.

This report highlights recent work accomplished in the development of etch processes with alternative chemistries, specifically C4F6, for etching OrganoSilicate Glass (OSG) low-k films. The experimental work has taken place on a magnetically enhanced reactive ion etcher at Motorola. Diagnostic tools include optical emission spectroscopy for plasma analysis and FTIR spectroscopy for effluent analysis.

The two OSG process conditions that are discussed on the eMax medium density etch chamber are listed in Table 1. The film stack had a thin AntiReflective Coating (ARC) layer on top of the OSG. A two-step etch process was required to etch these film stacks: ARC breakthrough and main etch.

Process Name	ARC BT Power (Watts)	ARC BT Gas Flows	ARC BT Time (s)	Main Etch Power (Watts)	Main Etch Gas Flows	Main Etch Time (s)
eMax-OSG-1	1800	27 sccm C_4F_8 16 sccm O_2 700 sccm Ar	20	700	10 sccm C_4F_8 20 sccm O_2 100 sccm Ar	60
eMax-OSG-2	1800	30 sccm C_4F_6 20 sccm O_2 700 sccm Ar	20	700	10 sccm C_4F_6 30 sccm O_2 100 sccm Ar	60

Table 1: OSG film etch conditions examined on the eMax etch chamber.

The eMax-OSG-1 condition is the conventional c-C4F8 reference process. The via cross sections from this process are shown as Figure 1. The etch rate was 2480 Å/min (center) and 2670 Å/min (edge). The resist remaining is 3870 Å and 3350 Å at the center and edge of the wafer, respectively. The global warming emissions from this process were 0.339 kgCE. The majority of the global warming emissions (59.7%) were due to unutilized c-C4F8 process gas.

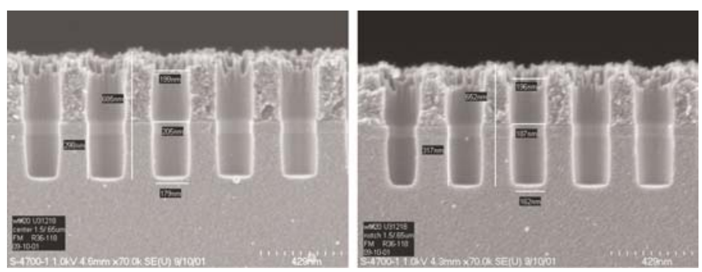

Fig. 1: 0.20 mm CD via cross sections at center (left) and edge (right) for the eMax C4F8 based process of comparison (eMax-OSG-1 process condition).

The via cross sections from eMax-OSG-2 process condition, using C4F6 as the etch gas for both the ARC breakthrough and the main etch step, is shown as Figure 2. This process shows lower photoresist erosion of 4010 Å (center) and 3740 Å (edge) and greater etch rate of 3140 Å/min (center) and 4180 Å/min (edge). The total global warming emissions from this process were 0.119 kgCE. This is a reduction of 65.1% compared to the c-C4F8 process.

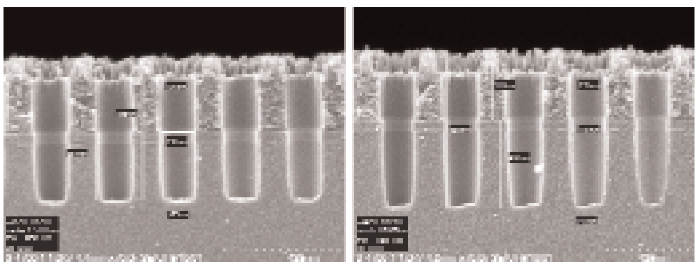

Figure 2: 0.20 mm CD via cross sections at center (left) and edge (right) for the eMax C4F6 based process condition eMax-OSG-2.

The novel C4F6 etch chemistry exhibits improved process performance, as well as, significant environmental benefits. Future work will focus on the applicability of this chemistry to ultra low-k films.