Plasma Etch Characteristics

of Advanced Hardmask Materials

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Introduction

The 45-nm node and beyond will require the use of thinner photoresists as the critical dimension shrinks and the aspect ratio limitations remain. Thickness available for pattern transfer is further reduced in immersion applications, as resist is lost during topcoat removal. These thin resists necessitate multilayer pattern transfer schemes.

One common multilayer approach is the use of a silicon-rich layer below the resist with a carbon-rich layer below that. This approach could use CVD (SiN or SiON on alpha-Carbon) or spin-on films (Si ARC® with a spin-on carbon, or SOC) or combinations of CVD and spin-on. The hardmask/carbon-layer combination provides a route to etch substrates due to the alternating plasma etch selectivities of the organic resist, inorganic hardmask, and carbon underlayer.

In general, the higher the plasma etch selectivity between adjacent layers, the larger the process window and higher the quality of the transferred pattern. With spin-on hardmask materials (Si ARC®), higher selectivity can be achieved by increasing Si content. Yet at the limit, a higher Si content represents a trade off between etch selectivity and photo resist compatibility.

The incorporation of elements other than Si may help to break this cycle and provide increased etch selectivity, or equivalent selectivity with improved imaging. Advanced materials are being developed using metal such as Ti to accomplish this.

Experimental

The materials tested include a commercially available Si ARC® as a reference, and several other hardmasks that incorporate varying quantities of metals and/or Si.

The materials will all be tested for blanket etch rate in straight oxygen and in straight CF_4 to demonstrate fundamental etch resistance. Other blanket etch data will include some more complex etch recipes designed to enhance selectivity.

In addition to blanket etch data we will also show litho profiles at 65nm and 45nm to evaluate resist compatibility.

Results and discussion

Figures 1 and 2 show the blanket etch data we have to date. More materials and etch recipes will be added and included in the final abstract for the July deadline.

Conclusions

Expected conclusions:

By varying the weight percent of metals and by incorporating various relative levels of Si, a wide range of oxygen plasma etch selectivity can achieved. In addition, by varying the density of the film, the fluorinated rate can be controlled to some extent. The “knobs” can be use to produce spin-on films with etch properties tailored to a given application within a reasonable range.

References

[1] J. H. Hah *et al*., Proc. Of SPIE Vol. 6153 (2006)

Figures

See following page:

Figure 1: Blanket CF4 Etch of Various Spin-on Hardmasks

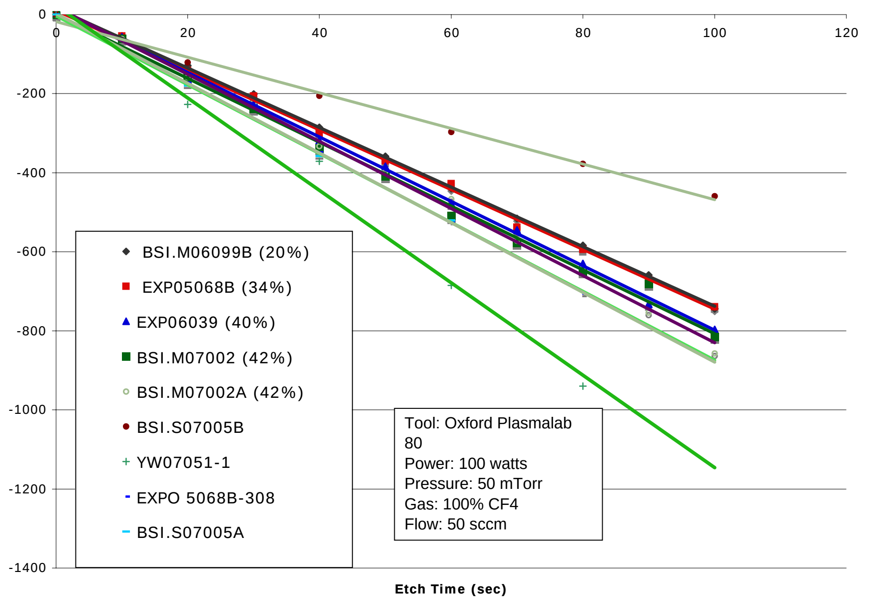

Figure 2: Blanket Oxygen Etch of Various Spin-on Hardmasks