Spin-on-carbon hard masks utilising fullerene derivatives

Conference Item

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Spin-on-Carbon Hard Masks utilising Fullerene Derivatives

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Introduction
The advance of lithographic resolution requires extremely thin photoresist films for the fabrication of 1x nm structures, to mitigate resist collapse during development. But the use of such thin films will limit achievable etch depths.

Key hard mask properties
Key attributes for hard mask materials include:
- Spin coating from standard solvents
- High thermal stability
- Low etch rate in halogen plasmas
- High etch rate in oxygen plasmas
- High resolution patterning (20 nm or better)
- Low "wiggle" at sub-30 nm

The etch resistance of the irresistible Materials’ fullerene based material allows high aspect ratio plasma etching from a very thin film and at high-resolution.

New HM340 Hard Mask
Combining the increased thermal stability and etch resistance of the HM100 series, with increased fullerene to crosslinker ratio.

Etch Performance
From the etch performance data, the HM300 series was shown to give better etch performance than the HM100 series, and the HM340 is predicted to have a significantly better etch performance than the HM140.

Summary and Outlook
The use of multilayer etch stacks incorporating carbon hard masks is now essential to the semiconductor industry to produce devices at ever shrinking dimensions, particularly given recent developments in three dimensional device architectures, such as FinFET and trigate devices.

Acknowledgements
With the further increased carbon content (from 88.4% to 95.3%), the etch resistance of the HM340-383-010 is expected to be very good. This will be verified in upcoming etch trials.

HM100 series fullerene hard mask
Previously reported good results for the HM100 series:
- Cyclohexanone casting solvent.
- Material available from MicroChem.

HM140-350-100 performance
The HM140-350 series formulations use a low cost to produce mixed fullerene multi-adduct derivative, which gives no degradation in the performance as a result of the cost reduction measures.

Improved thermal stability
TGA (manually spread film to increase mass for analysis)

The new HM340-383-010, with a higher content of the more thermally stable fullerene derivative and a slightly higher crosslinking bake temperature, has shown improved thermal stability, both in terms of thickness loss with temperature and mass loss with temperature.

Roughness Characterization
Measurements of surface roughness performed by AFM

Spin thickness v. concentration for HM340-383-010 at 1500rpm

The very high carbon content of the 383 formulation (>95%) should give high etch resistance.

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These Irresistible Materials’ fullerene based hard mask formulations outperform existing state of the art materials across several critical performance metrics, whilst maintaining the advantages of spin-on materials over CVD deposited carbon.

The new HM340-383-010 has a high thermal stability and a very high carbon content, offering high etch resistance.

IM hard mask materials are available from MicroChem, a supplier of specialist chemicals for micro/nanofabrication applications (via a non-exclusive license agreement).

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