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Conference Item

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http://dx.doi.org/doi:10.1117/12.2219212
http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=2508811

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Spin-on-Carbon Hard Masks utilising Fullerene Derivatives

A.G. Brown¹, A. Frommhold², T. Lada³, J. Bowen², Z. el Oteli⁴ and A.P.G. Robinson⁵

¹Irresistible Materials Ltd., Langdon House, Swansea Waterfront, Swansea, SA1 8QY, UK
²School of Chemical Engineering, The University of Birmingham, Birmingham, B15 2TT, UK
³Nano-C Inc., 33 Southwest Park, Westwood, MA 02090, USA
⁴Department of Engineering and Innovation, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK
⁵IMEC, Kapeldreef 75, 3001 Leuven, Belgium

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.

Multilayer hard mask stacks are a possible solution. We have developed a fullerene based spin-on carbon hard mask material, capable of high aspect ratio etching.

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 “wiggles” 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.

The materials have low levels of aliphatic hydrogen, which is proposed as a solution to the “wiggling” of features below 30nm, during the plasma etch step to transfer of the features to the underlying layer.
- Wiggling is not observed with HM hard mask materials.

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.

New HM340 Hard Mask
Combining the increased thermal stability and etch resistance of the new 300 series, with increased fullerene to crosslinker ratio.

The material spins from the more acceptable anisole casting solvent. High solubility, >350 g/l allows for a wide range of spun film thickness

Spin thickness v concentration for HM340-383-010 at 1050rpm

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

Improved thermal stability
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.

Etch Performance
From the etch performance data, the HM340 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 enable the semiconductor industry to produce devices at ever shrinking dimensions, particularly given recent developments in these three dimensional device architectures, such as FinFET and trigate devices.

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.

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