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MITSUBISHI GAS CHEMICAL COMPANY, INC.

"Development of EUV Resists Based on Non-polymeric Macromolecules with Polyphenol Derivatives"

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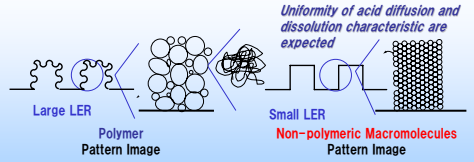
INTRODUCTION

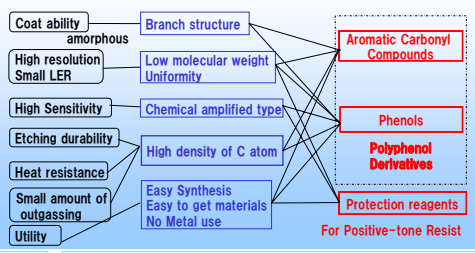
Approach from Resist Base Materials for LER Reduction



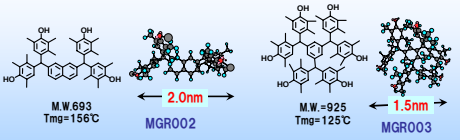
To be smaller the size of molecular and to form a uniform matrix are regarded as one of the method for the resist materials development of high resolution and small LER

MGC's Development of Non-polymeric Macromolecules with Polyphenol Derivatives for EUV Resists Base

Molecular Design Concept for Resist Base Materials



MGC's Development of Non-polymeric Macromolecules with Polyphenol Derivatives for EUV Resists Base

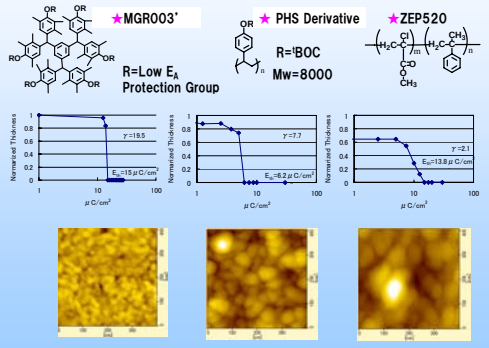


Fundamental Performance
- Amorphous
- High Heat Resistance (High Tg)
- Good Solubility for PGMEA and TMAH2.38wt%aq.
- High Etching Durability (Etching rate are 0.7-0.8 relative to PHS)

POSSIBILITY OF ACHIEVING SMALL LER WITH NON-POLYMERIC MACROMOLECULES WITH POLYPHENOL DERIVATIVES

Contrast Curve and Evaluation of Surface Roughness of MGR003' and Polymers by EB Exposure

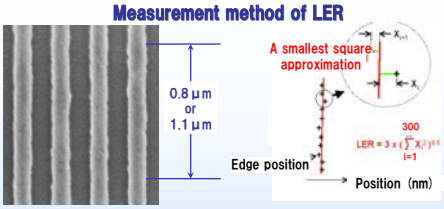
Non-polymeric Macromolecule | Polymers



The size of aggregation of Non-polymeric macromolecule, MGR003' was much smaller than those of polymers, PHS Derivative and ZEP520. It's expected to the non-polymeric macromolecules, MGR003' could provide small LER pattern.

EXPERIMENTAL CONDITIONS

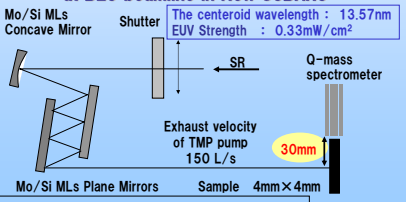
Measurement method of LER



We evaluated the mean of eight 3σ and the minimum arbitrary 3σ.

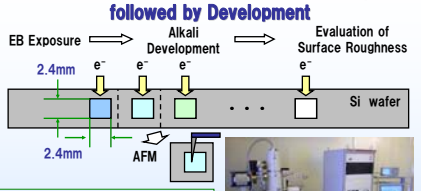
The evaluations of Surface Roughness, Sensitivity, Resolution and LER after EB Exposure were carried out at the Mitsubishi Gas Chemical Company, Inc.: Hiratsuka Research Lab. in Kanagawa Prefecture, Japan.

Experiment setup for resists experiments at BL3 beamline in New SUBARU



The evaluations of outgassing from their resist films during EUV Exposure were carried out at the NewSUBARU synchrotron radiation facility in Hyogo Prefecture, Japan.

Evaluation of Surface Roughness after EB Exposure followed by Development



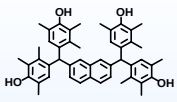
Evaluation Condition
Exposure : EB Tool
Acceleration voltage : 50keV
Film thickness : 100nm
Measurement Area : 0.4×0.4μm□

High-NA (NA=0.3) Small Field Exposure Tool (HiNA)

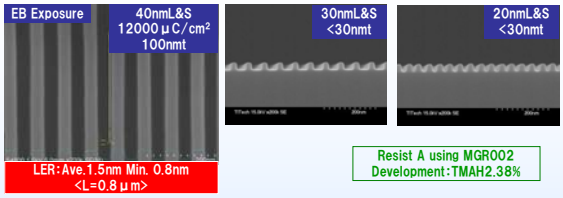
The evaluations of sensitivity and resolution after EUV Exposure were carried out by HiNA at ASET EUV process technology research lab. in Kanagawa Prefecture, Japan.

APPLICATION FOR NEGATIVE-TONE RESISTS

SEM Images of the Resist Patterns using MGR002 without additives

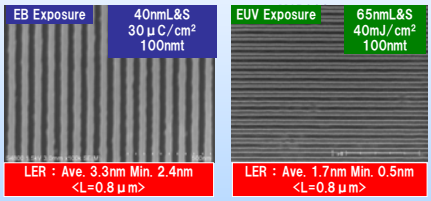


MGR002



Resist A using MGR002
Development:TMAH2.38%

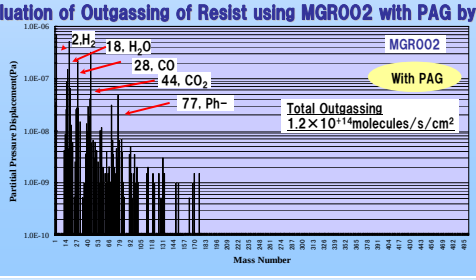
SEM Images of the Resist Patterns using MGR002 with PAG and additives



Resist B using MGR002
with PAG and additives
Development:TMAH2.38%

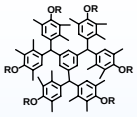
High Sensitivity, High Resolution and Small LER

Evaluation of Outgassing of Resist using MGR002 with PAG by EUV Lithography



Most of the outgassing was the solvent and PAG origin. We confirmed the amount of outgassing of MGR002 was small.

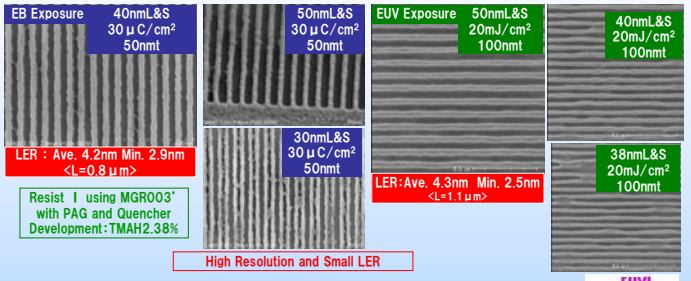
APPLICATION FOR POSITIVE-TONE RESISTS



R=Low E_A Protection Group

MGR003'

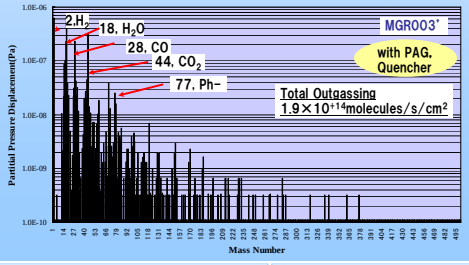
SEM Images of the Resist Patterns using MGR003' with PAG and Quencher



Resist I using MGR003'
with PAG and Quencher
Development:TMAH2.38%

High Resolution and Small LER

Evaluation of Outgassing of Resist using MGR003' with PAG and Quencher by EUV Lithography



Most of the outgassing was the solvent and PAG origin. We confirmed the amount of outgassing of MGR003' was small.

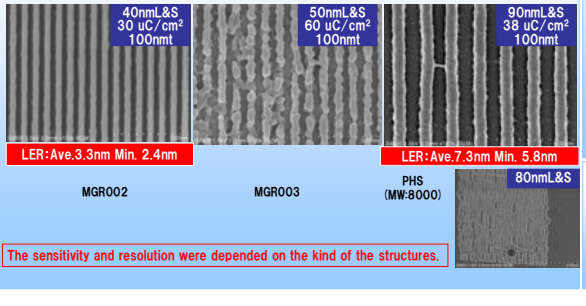
RESIST PERFORMANCE OF MGR002 COMPARED WITH THOSE OF OTHER RESISTS BASES

Resist Performance of the Negative-tone Resist Patterns using MGR002, MGR003, Other Resin and Polyphenol with PAG by EB Lithography

	MGR002		MGR003		PHS (MW:8000)		Trisphenol	
PAG	None	Used	None	Used	None	Used	None	Used
Dose (uC/cm²)	12000	120	4500	200	6000	200	20000	200
Resolution (nm)	30	30	30	No Pattern	80	No Pattern	No Pattern	No Pattern

As using MGR002 with PAG, the sensitivity improved remarkably.

SEM Images of the Negative-tone Resist Patterns using MGR002, MGR003 and Other Resin with PAG and additives by EB Lithography



The sensitivity and resolution were depended on the kind of the structures.

SUMMARY

We Developed the Non-polymeric Macromolecules with Polyphenol Derivatives for of EUV Resists Base.

Application for Positive-tone Resist (MGR003')

Resolution=38nm, Sensitivity=20mJ/cm², LER (3σ)=4.3nm, Small amount of outgassing

Application for Negative-tone Resists (MGR002)

Resolution=65nm, Sensitivity=40mJ/cm², LER (3σ)=1.7nm, Small amount of outgassing

Future Work

We'll develop the resist materials for high sensitivity (≦10mJ/cm²), high resolution (≦32nm) and low LER (≦3nm).

ACKNOWLEDGMENT

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