New Fluorinated Resins for 157 nm Lithography Application

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As part of a new generation of more transparent 157 nm resist platforms we are developing, a novel resist system is described that has higher transparency and contrast than AZ®FX™ 1000P. Using a new protecting group strategy, encouraging results have been obtained with both poly(α,α-bis(trifluoromethyl)bicyclo[2.2.1]hept-5-ene-2-ethyl) and a more transparent perfluorinated resin (TFR). These new resist systems show absorbance values as low as 1 μm⁻¹ at 157 nm, have twice the contrast (i.e., 12 instead of 7) of AZ®FX™ 1000P, and have neither significant dark erosion nor do they switch to negative tone behavior within the dose range studied. The dry etch resistance of the TFR platform is found to be superior to a Standard DUV resist for polysilicon but somewhat lower for oxide etches. Features as small as 50 nm lines and spaces were resolved for slightly relaxed pitches (1:1.5 micron). By adjusting the base level it is possible to improve the photospeed by a factor of more than 10 while still maintaining a resolution of 70 nm L/S features.

Keywords: 157 nm, resist, high transparency

Introduction
The development of sufficiently transparent resin systems is one of the key elements required for a successful and timely introduction for 157 nm lithography. Two basic classes of photoresists sensitive at 157nm, and based on fluorinated polymers with pendant fluoroalcohol groups, are known to be substantially transparent at that wavelength.

One class of 157 nm fluoroalcohol photoresists is derived from polymers containing groups such as fluorinated norbornenes, and is homopolymerized by metal organic catalysts or copolymerized in a free radical reaction with other transparent monomers such as tetrafluoroethylene[1]. Generally, these materials give higher absorbencies (i.e. > 1.2 AU/micron) but have good plasma etch resistance due to their high alicyclic content.

More recently, a new class of 157 nm fluoroalcohol polymers was described in which the polymer backbone is derived from the cycopolymerization of an asymmetrical diene such as 4-(trifluoromethyl)-5,5,6,7,7-pentafluorohepta-1,6-diene-4-ol.[2] These materials give lower absorbance at 157 nm (i.e. < 1 AU/micron) but, due to their lower alicyclic content as compared to the fluoro-norbornene polymer, have lower plasma etch resistance. Even more recently, it has been shown that these two classes of polymers can often be blended to allow imaging at blend compositions which are a good compromise between the high etch resistance of the first type of material and the high transparency at 157 nm of the latter[3].

However, an important limitation to any of these approaches is the availability of a suitable
protecting group for fluoroalcohols. In almost all of these approaches, the acid labile protecting groups for the fluoroalcohol moiety has been limited in scope to either acetal type (e.g. MOM (methoxymethyl)), or tertiary alkylkoxycarbonyl (e.g. T-BOC (tert-butyloxycarbonyl)) or tertiary alkyl protecting groups. These protecting groups on the perfluoroalcohol moiety are relatively unstable and often undergo partial or complete deprotection during polymerization or processing. Table 1 illustrates thermal stability trends found for different protecting groups by thermogravimetric analysis (TGA) in two representative fluoroalcohol resins, poly[3-(bicyclo[2.2.1]hept-5-en-2-yl)-1,1,1-trifluoro-2-(trifluoromethyl)propan-2-ol] (F1) and a transparent fluorinated resin (TFR) (Fig. 1, Structure I and II, respectively).

Table 1 Onset of deprotection of polymers I and II with different protecting groups

<table>
<thead>
<tr>
<th>Protecting group</th>
<th>Polymer</th>
<th>Onset of Deprotection (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOCME</td>
<td>II</td>
<td>174</td>
</tr>
<tr>
<td>BOCME</td>
<td>I</td>
<td>206</td>
</tr>
<tr>
<td>T-BOC</td>
<td>I</td>
<td>120</td>
</tr>
<tr>
<td>MOM</td>
<td>II</td>
<td>&lt;100**</td>
</tr>
</tbody>
</table>

* Data gathered at 20°C/min heating rate
** Estimate, group is decomposed upon initial isotherm heating at 50°C. Moreover, a massive exotherm for decomposition was detected at ~50°C at a heating rate of 10°C/min.

The difficulty in protecting the fluoroalcohol functionality, and the resultant loss of the unexposed photoresist film, has meant that the acid labile functionality can often only be attached to either a methacrylate, acrylate, or norbornene carboxylic acid repeat unit, or to a dissolution inhibitor additive.1

This paper shows that fluoroalcohol moieties in either type of polymers shown in Fig. 1 can easily be functionalized with a tert-butyloxycarbonyl methyl group (BOCME) to provide resins which have good thermal stability, transparency and still allow for blending of polymers to gain access to resist formulation with better etch resistance. The specific resins to which we have applied this approach are (F1) and (TFR), whose BOCME derivatives will in this paper be referred to as BOCME-F1 and BOCME-TFR respectively.

Fig. 1 Examples of repeat unit in F1 (I) and TFR (II)

2. Experimental

2.1 Synthesis

The synthetic pathways to BOCME-F1 and BOCME-TFR are shown, respectively, in Fig.’s 3 and 4.

2.2 Thermogravimetric Analysis

The TGA and DSC data shown in Table 1 was obtained, respectively, with a Perkin Elmer TGA7 at a heating rate of 20°C per min and a TA instrument model number 2920 modulated DSC at a heating rate of 10°C/min.

2.3 Absorption Measurements

Optical spectra of polymers films with and without 10% DI were recorded on a VU-301 vacuum ultraviolet variable angle spectroscopic ellipsometer (VUV-VASE) instrument (J.A. Woollam Co.) at International SEMATECH or at Clarient Corporation. Samples for measurement of resist were prepared as described above and measured after the PAB. Preparation of samples for the measurement of polymer alone was done in a similar manner, simply excluding the PAG and base components before spinning the film.

2.4 Preparation of resist solution and imaging at 157 nm

The imaging work was done with an Exitech 157 nm small field (1.5 X 1.5 mm²) mini-
stepper (NA 0.6 or 0.85) using a phase-shift mask (s=0.3) at International SEMATECH in Austin, TX, unless otherwise noted. A JEOL JWS-7550 was used to obtain scanning electron micrographs, and a Hitachi 4500 CD-SEM was used to obtain cross-sectional data. An FSI Polaris 2000 track was used to coat, bake, and develop the resist films, and resist thickness was measured a Prometrix interferometer.

2.5 Etching Studies
Fig.’s 19 and 21, respectively, give details on the processing conditions for polysilicon and oxide etch. The relative etch measurements were evaluated based upon the absolute etch values for a 248 nm deep UV resist.

3. Results and Discussion
3.1 Synthesis BOCME-F1 and BOCME-TFR and discussion of general properties of BOCME as applied to capping fluoroalcohols

The approach of using a BOCME group as a capping moiety on fluoroalcohols has several advantages. As discussed in the introduction, many protecting group directly attached to fluoroalcohol functionalities have insufficient thermal stability (Table 1). The BOC group has a stability ~100°C lower than that of the BOCME while in the MOM group proved to be even more unstable (Table 1). This instability of the MOM group may be inherent in the fluoroalcohol matrix or possibly precipitated by a high sensitivity to a small level of acidic impurities; whatever the case, this may lead to limited shelf life for resist formulations. In contrast, the thermal stability of BOCME protected fluoro alcohols is comparable in thermal stability to the tert.-butyl ester of a norbornenecarboxylic acid repeat unit. Generally, from a resist standpoint, such an increase in the thermal stability of a protected fluoroalcohol as imparted by the use of BOCME is desirable as it may increase thermal processing latitude and shelf life. Finally, from a synthetic standpoint, such a chemical modification is desirable as it helps to boost the yield of protected fluoroalcohol polymers, whether they are made by protection of pre-formed fluoroalcohol polymers or through polymerization of monomers containing a fluoroalcohol moiety protected by BOCME groups.

Surprisingly, despite its high thermal stability, the BOCME capping group on a fluoroalcohol can easily undergo acidolysis with photoreleased acid. Consequently, resists formulated with it only need modest post-exposure bake temperatures to effect cleavage (110°C-130°C).

Typically, fluoroalcohol moieties have a pKa ~ 7-9; this fact coupled with the hydrophobic nature of the fluorinated substituents entails that such resins have modest dissolution rates. On the other hand, carboxylic acids as functional groups have a much higher pKa’s (4-5), and are know to give rise to materials with higher rates of dissolution. The deprotected fluoro-BOCME (e.g. -C(CF3)2-O-CH2CO2H) is also expected to be much more acidic than typical moieties employed as repeat units in 157 nm resins (Fig. 2). Moreover, Fig. 3 shows that the BOCME derivative of a fluoroalcohol has a higher hydrophobicity than a t-butyl ester of a carboxylic acid, or a fluoro alcohol group protected with a BOC or MOM moiety, without sharing the low thermal stability of the latter two. This higher hydrophobicity coupled with the higher acidity of the deprotected fluoro-BOCME gives rise to the expectation of high contrast and resolution in resins protected with fluoro-BOCME moieties. Indeed, in practice we have found that resist formulated with BOCME-containing repeat units invariably lead to higher contrasts (12-25 vs 6-7)[4] compared to systems such as AZ™FX1000P that are formulated with tert-butyl norbornenecarboxylate (i.e. poly(tet-Butyl Bicyclo[2.2.1]hept-5-ene-2-carboxylato-co-1,1,1-trifluoro-2-(trifluoromethyl)pent-4-en-2-3-(bicyclo [2.2.1]hept-5-ene-2-yl)-1,1,1-trifluoro-2-(trifluoro- methyl)propan-2-ol) and poly(tet-Butyl-3- (trifluoromethyl)tricyclo[4.2.1.02,5]non-7-ene-3- carboxylato-co-carbon monoxide). A study of dissolution rates is currently underway.

Of course, to gain higher dissolution rates one can always copolymerize into a 157 nm resins acrylic acid or norbornenecarboxylic acid or their fluorinated analogs. In practice it is not always
possible to copolymerize such moieties into a specific fluoroalcohol bearing resins because of differing reactivity ratios for monomers. The use of a BOCME capping group on a fluoroalcohol inherently has much wider applicability. For instance, Fig.’s 3 and 4 shows how one can prepare such materials either by using a polymer modification or a polymer synthesis approach.

Fig. 2 Comparison of pKa of repeat units with perfluoroalcohol, alkylcarboxylic acid or perfluoroalkyloxymethylacrylic acid moieties (calculated using ACD/pKa DB version 4.0 for Microsoft Windows™).

Fig. 3 Comparison of hydrophobicity of pendant protected moieties.

Fig. 4 Synthesis Pathways for BOCME-F1

Fig. 5 Synthesis Pathways for BOCME-TFR functionalized with a BOCME group

3.2 Absorption Studies

The BOCME capping group provides for lower absorbencies at 157 nm in resist resins than are possible by with simple alicyclic moieties such a tert-butyl 5-norbornenecarboxylate (BNC, tert-Butyl Bicyclo[2.2.1]hept-5-ene-2-carboxylate)). As an example, while poly(tert-butyl 5-norbornenecarboxylate) has an absorbance at 157 nm of 3.8. F-1 functionalized with 27% BOCME group has an absorbance of only 2.21 AU/micron. Moreover, the TFR platform capped with similar levels of BOCME has an even lower absorbance of 0.94 AU/micron.

These low absorbencies are possible because the use of the BOCME group is not tied to also introducing a norbornene repeat unit. Instead, the BOCME group is introduced directly onto a fluoroalcohol bearing-repeat unit which typically has lower absorbance at 157 nm than norbornenecarboxylic acid-derived repeat units. Fig.’s 6 and 7 show plots of the absorbance of these two fluoro-alcohol polymer matrices as a function of protection level with the BOCME group. As can be seen from these plots, experimental values conform closely to the predicted absorbance based upon the “STUPID model”[5] (Fig.’s 6 and 7). Although, as expected, the contribution of the BOCME functionality to absorption is significant, the level of BOCME needed to suppress dark erosion in the F1 or TFR fluoro-alcohol bearing resins is low.
3.3.1 Imaging of BOCME-F1

Figure 8 shows imaging with a F1-BOCMEm based resist in which resolution down to 100 nm 1-1.5 line and spaces (L/S) was achieved using a 0.6 NA lens with a Levenson-type strong phase shift mask. As can be seen from this Figure, 100 nm L/S are patterned close to their coded size at a dose of 51 mJ/cm². The resolution of this system is still strongly limited by its high absorbance (ca. 2 μm⁻¹).

Fig. 8 Imaging of BOCME-F1 resist: 100 nm L/S. PAB: 130C/60s, PEB: 115C/90s, DEV.30s LDD26, 1609 A, 51.0 mJ/cm². Alternating phase shift mask, σ= 0.3, NA=0.6.

3.3.2 Imaging Studies for Resists Based upon BOCME-TFR.

Table 2 summarizes the absorbance and lithographic properties of resists formulated with BOCME-TFR. Such resists are capable of absorbencies as low as 0.93 AU/micron with lower levels of protection. However, this also degrades the dissolution contrast and has some impact on dark erosion. This said, the dark erosion does not increase significantly until quite low protection levels are achieved (Table 2). Although the contrast does degrade with decreasing protection and increasing dark erosion, resists formulated with a 0.46 protection level resin (Table 2) are still capable of high resolution. For instance, if one compares the lithographic performance of a resist formulated with the nominal resin protection level (Fig. 8) to that with 0.46 times the nominal level (Fig. 9), it can be seen that the lithographic performance is not strongly degraded.
The resist with lower protection level does show some improvement in ultimate resolution but at the cost of top rounding. Indeed, the 0.46x nominal resin based resist is capable of resolving 60 nm and 50 nm L/S features at slightly relaxed pitch (1-1.5 L/S, Fig. 11-13).

Table 2 Summary of Absorbance and Lithographic Properties for BOCME-TFR Resists

<table>
<thead>
<tr>
<th>Protection Level x nominal</th>
<th>Base Level x nominal</th>
<th>Abs 157 nm [μm/μm²]</th>
<th>Clearing Dose [mJ/cm²]</th>
<th>Contrast</th>
<th>Dark Erosion Post/Pre exposure thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.27</td>
<td>0.75</td>
<td>0.93</td>
<td>10.4</td>
<td>3.2</td>
<td>0.775</td>
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<tr>
<td>0.46</td>
<td>0.75</td>
<td>1.07</td>
<td>13.0</td>
<td>4.8</td>
<td>0.964</td>
</tr>
<tr>
<td>0.57</td>
<td>0.75</td>
<td>1.12</td>
<td>13.6</td>
<td>6.57</td>
<td>0.987</td>
</tr>
<tr>
<td>0.69</td>
<td>0.75</td>
<td>1.20</td>
<td>13.9</td>
<td>8.3</td>
<td>1.000</td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>1.34</td>
<td>16.5</td>
<td>8.2</td>
<td>0.999</td>
</tr>
<tr>
<td>0.46</td>
<td>0.25</td>
<td>1.07</td>
<td>2.4</td>
<td>6.0</td>
<td>0.93</td>
</tr>
<tr>
<td>0.46</td>
<td>0.25</td>
<td>1.07</td>
<td>5.4</td>
<td>6.2</td>
<td>0.96</td>
</tr>
</tbody>
</table>

The other resist formulations with 0.57 and 0.69 times the nominal protection level have resolution behavior intermediate between the nominal level and the 0.45 protection level (Fig.’s 14, 15).

Fig. 9 Resist formulated with BOCME-TFR with nominal protection level (1.0x) and nominal base content. 70 nm L/S 115 ml/cm², 1350 A ~900 A Organic BARC nominal protection level and nominal base content, Alt. PSM, σ=0.3, PAB 135°C/60s, Develop 30s 0.26 N TMAH.

Fig. 10 Resist formulated with BOCME-TFR with 0.46 x nominal protection level 70 nm L/S, 91 ml/cm², 1350 A ~900 A Organic BARC Alt. PSM, σ=0.3, PAB 135°C/60s, Develop 30s 0.26 N TMAH.

The clearing dose and resolution dose can be brought down considerably by lowering the base content (Table 2), while still maintaining resolution power, albeit at the cost of a large increase in top rounding and loss of square line profiles. However, this indicates that the resist can achieve high resolution at much lower dose. The ideal amount of base for formulation in order to achieve a good compromise between high sensitivity without undue loss of image quality and post-exposure bake delay latitude is presently under investigation.

Fig. 11 Resist formulated with BOCME-TFR with 0.46 nominal protection level and 0.75 nominal base content. 60 nm L/S, 91 ml/cm², 1350 A ~900 A organic BARC, Alt. PSM, σ=0.3, PAB 135°C/60s, PEB 115°C/90s, Develop 30s 0.26 N TMAH.

Fig. 12 Resist formulated with BOCME-TFR with 0.46 nominal protection level and 0.75 nominal base content. 60 nm L/S, 83 ml/cm², 1350 A ~900 A organic BARC, Alt. PSM σ=0.3 PAB 135°C/60s, PEB 115°C/90s, Develop 30s 0.26 N TMAH.
change in the feature appearance after even 20 minutes of delay in the FSI track.

Fig. 16 Resist formulated with BOCME-TFR with 0.46x nominal protection level and zero base content. 70 nm L/S, 8.5 mJ/cm², 1350 A, ~900 A organic BARC, Alt. PSM s=0.3 PAB 135°C/60s, PEB 115°C/90s, Develop 30s, 0.26 N TMAH

Fig. 17 Resist formulated with BOCME-TFR with 0.46x nominal protection level and 0.75x nominal base content. 70 nm L/S, 65.8 mJ/cm², 1350 A, ~900 A organic BARC, Alt. PSM s=0.3 PAB 135°C/60s, PEB 115°C/90s, Develop 30s, 0.26 N TMAH

3.33 Imaging Studies for Resists Based upon Blends of BOCME-F1 and BOCME-TFR

As was discussed in the introduction, there have been reports that polymers based upon fluoroalcohol moieties have good blending ability. It was of interest for us to explore whether such a blend approach would work to blend BOCME-F1 with BOCME-TFR to obtain a good compromise between the properties of these two materials. The simplistic rationale was as follows: BOCME-F1 has a higher absorbance at 157 nm than BOCME-TFR, but the former was expected to be more etch resistant and a blend could conceivably achieve a good compromise between these two properties. Table 3 summarizes the optical properties of the two blends that were studied: A blend containing a low amount of BOCME-TFR blended with
BOCME-F1 an another blend containing a high amount of BOCME-TFR. As expected, the blend with the higher content of BOCME-F1 had the highest absorbance.

The clearing doses for the blends were lower than the resist formulated with the BOCME-F1 resin alone (Table 4) but this latter formulation has a somewhat better contrast.

Resists formulated from the blends were both able to resolve relaxed pitches for 70 nm features (Fig. 18), as well as 60 nm features for the more transparent high BOCME-TFR formulation (Fig. 19). Since these materials were formulated with nominal protection levels, it is expected that the use of lower protection levels should give rise to more transparency and better resolution. This is a matter currently under investigation.

Table 3 Optical Properties of BOCME-F1, BOCME-
TFR Blends

<table>
<thead>
<tr>
<th>Resist</th>
<th>Thickness [Å]</th>
<th>Clearing Dose (mJ/cm²)</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOCME-TFR/F1 (Low)</td>
<td>1350</td>
<td>12.7</td>
<td>16</td>
</tr>
<tr>
<td>BOCME-TFR/F1 (High)</td>
<td>1350</td>
<td>11.8</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 4 Lithographic properties of BOCME-F1, BOCME-TFR Blends

<table>
<thead>
<tr>
<th>Resist</th>
<th>Thickness [Å]</th>
<th>Clearing Dose (mJ/cm²)</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
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<td>12.7</td>
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</tr>
<tr>
<td>BOCME-TFR/F1 (High)</td>
<td>1350</td>
<td>11.8</td>
<td>13</td>
</tr>
</tbody>
</table>

3.3.4 Etch Studies for Resists Based upon BOCME-TFR and blends with BOCME-F1.

Theetch performance using SEMATECH’s standard oxide etch conditions follows the expected trends with the materials containing the highest BOCME-TFR level giving the highest etch rates (Fig. 20) and least etch selectivity (Fig. 21). The 50/50 blend gives an etch performance almost as good as that of a standard deep UV resist. Even the BOCME-TFR resin itself and its high BOCME-TFR content blend with BOCME-F1 give reasonably good etch performance under these conditions.

The results under etch conditions for polysilicon are a bit more unexpected. In this instance the etch rates (Fig. 20) and etch selectivity(Fig. 21) are somewhat better for the BOCME-TFR resin alone than for the blends or for the deep UV standard itself. It would appear that the fluorinated resin imparts an etch resistance at least comparable to the 248 nm deep UV standard under these conditions, and that there is little to be gained in going to a blend. A possible explanation could be that the fluorinated resin is more resistant to the Cl₂ plasma because of the higher bond strength of a C-F versus a C-Cl bond, which would prevent attack of the chlorine-containing plasma components on the main chain.
Fig. 20 Oxide etch rates of resists formulated with BOCME-TFR and blends this resin and BOCME-F1. Etch conditions 1500 W / 40 mT / 200 sccm Ar / 50 sccm CO / 10 sccm C4F8 / 5 sccm O2 / 40 C

Fig. 21 Relative Oxide etch rates of resists formulated with BOCME-TFR and blends this resin and BOCME-F1 compared to a STANDARD 248 NN DEEP UV RESIST E. Etch conditions, Tel DRM 1500 W / 40 mT / 200 sccm Ar / 50 sccm CO / 10 sccm C4F8 / 5 sccm O2 / 40 C

Fig. 22 Polysilicon etch rate compared to that of resists formulated with BOCME-TFR and blends this resin and BOCME-F1. Etch conditions LAM 9400 PTX main etch, 450 W / 45 W / 20 mT / 200 HBr / 75 Cl2 / 10 He O2 / 60 sccm. O2 / 60 sccm

Fig. 23 Relative etch rates of resists formulated with BOCME-TFR, blends this resin and BOCME-F1, a STANDARD 248 NN DEEP UV RESIST compared to polysilicon. Etch conditions LAM 9400 PTX main etch 450 W / 45 W / 20 mT / 200 HBr / 75 Cl2 / 10 He O2 / 60 sccm.

To our knowledge, such a stabilizing effect of main-chain fluorination has not been previously reported, and it would be of considerable importance for the design of future production-worthy 157 nm photoresists. However, it should be stressed that the above results are preliminary only, and need to be examined in more detail by patterned etches.

4. Conclusion
It has been shown that the BOCME group has a combination of properties that make it well-suited as a protective group for fluoroalcohol moieties. Among these are a higher thermal stability, the ability to impart high contrast, possibly due to the high hydrophobicity of fluoroalcohol moieties capped with BOCME, such as C(CF3)2-O-CH2-CO2t-Bu, and the ease to which such t-butyl esters undergo acidolysis to release capped fluoroalcohol moieties of high acidity, such as -C(CF3)2-O-CH2-CO2H.

Two types of BOCME substituted materials were described, BOCME-F1 and BOCME-TFR, both of which are accessible through direct polymerization and polymer modification. The BOCME-TFR polymers were found to give very transparent resins which upon formation with a PAG could give resins with absorbances as low as 1.07 AU/micron at 157 nm.

Both the BOCME-F1 and the BOCME-TFR platforms were able to resolve small features
upon exposure with 157 nm light. The BOCME-TFR resin with low nominal protection was able to achieve resolution of 70 nm for 1:1 and 50 nm 1:1.5 L/S features at dose of 91 mJ/cm² (alt. PSM, low sigma). By lowering the amount of base it is possible to increase lithographic sensitivity up to 8.9 mJ/cm² by reducing the base content. This is done at the cost of feature profiles and top rounding, but intermediate levels of base are expected to yield materials having a good compromise between the two. Indeed a PED latitude of at least 20 min in an FSI track can be easily achieved.

Blends of BOCME-F1 and BOCME-TFR give resins that have an intermediate absorption between the two types of resins. Using this blend approach, it was possible to resolve relaxed pitches down to 60 nm L/S. For oxide etch conditions, such blends can give improved plasma etch resistance, but it was found that the BOCME-TFR platform by itself is sufficiently etch resistant to give selectivity only slightly inferior to that of the 248 nm resist DEEP UV RESIST. For chlorine etches, the selectivity of the BOCME-TFR was unexpectedly found to exceed that of the DEEP UV RESIST standard. While these etch results are preliminary only and need to be confirmed by patterned etches, they are encouraging with respect to the production-worthiness of main chain fluorinated cycopolymer platforms.

5. Acknowledgments

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6. References


