Usage of Fomblin Y to Improve Water Repellence of Surface Coatings

Shawn Kirby, Jeffrey Alston, Andrew Guenthner

Background

• Hydrophobic coatings have a multitude of potential uses, from repelling ice and removing chemical agents

• Fluoro Decyl Poss (FDP) is under testing for use as a hydrophobic coating additive to PMMA

• POSS stands for Polyhedral oligomeric silsesquioxane

Background

- Fluoro Decyl POSS is extremely hydrophobic because of its high amount of fluorination.
- Even if the surface is made of a hydrophobic material, but it is rough, it may take a high amount of energy to remove the water droplets from the surface.
Background

Background

- PMMA stands for Poly(methyl methacrylate), which is more commonly known commercially as plexiglass
Background

- Fomblin Y is a solvent that impedes FDP from crystalizing.
Objective

• Our goal was to test the feasibility of using Fomblin Y to reduce the crystal formation of the PMMA-FDP mixture. Theoretically, reducing crystal structure could decrease the energy needed to remove a drop.

<table>
<thead>
<tr>
<th>Old Mixture</th>
<th>New Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK225 PMMA POSS</td>
<td>AK225 PMMA POSS</td>
</tr>
<tr>
<td></td>
<td><strong>Fomblin Y</strong></td>
</tr>
</tbody>
</table>

Procedures

• First, Dynamic Light Scattering (DLS) was used to determine the solubility of POSS in Fomblin Y
Procedures

- A coating solution was developed with the desired components for comparison.

<table>
<thead>
<tr>
<th>Solution:</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contents:</td>
<td>80% AK225</td>
<td>78% AK225</td>
<td>67.5% AK225</td>
<td>70% AK225</td>
</tr>
<tr>
<td></td>
<td>10% PMMA</td>
<td>9% PMMA</td>
<td>27.5% PMMA</td>
<td>30% PMMA</td>
</tr>
<tr>
<td></td>
<td>10% FDP</td>
<td>9% FDP</td>
<td>9% FDP</td>
<td>5% Fomblin Y</td>
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</table>

Procedures

• Silicon Wafers were dip coated into the solutions. Three wafers were dipped in each solution.
Contact Angle

- The more attracted the water is to the surface, the lower the contact angle
- The more repelled, the higher the contact angle
Procedure

- Contact angle measurements were taken to measure the relative hydrophobicity of the surfaces.
Procedure

• Contact Angle Measurements were taken to measure the relative hydrophobicity of the surfaces
Data and Observations

- Unannealed samples
- The surfaces treated with FDP and Fomblin Y had the highest contact angle

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<td>70% AK225 30% PMMA</td>
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<tr>
<td></td>
<td>10% FDP</td>
<td>9% FDP 4% Fomblin</td>
<td>67.5% AK225 27.5% PMMA 5% Fomblin</td>
<td>70% AK225 30% PMMA</td>
</tr>
<tr>
<td>Average</td>
<td>74.9⁰</td>
<td>88.0⁰</td>
<td>70.0⁰</td>
<td>70.1⁰</td>
</tr>
<tr>
<td>Advancing Contact Angle:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Procedure

• Most of the wafers, (two of each solution) were annealed in an oven at 100°C for 24 hours to investigate the effects of boiling off the Fomblin.
Procedure

• We wanted to attempt to remove the Fomblin

• Fomblin has an extremely low vapor pressure. Thus, the samples were heated in an oven at 100 degrees Celsius overnight in an attempt to remove the Fomblin

• If we increased the temperature too much, we would have caused the FDP to sublime

• Thus, we needed to use a relatively low temperature at standard pressure for an extended period of time
Data and Observations

- Annealed samples at 100°C
- Annealing improved the hydrophobicity and stability of all surfaces

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<tr>
<td>Average Advancing Contact Angle:</td>
<td>93.9°</td>
<td>96.7°</td>
<td>79.0°</td>
<td>80.5°</td>
</tr>
</tbody>
</table>

Data and Observations

• What would further heating do?
• Further remove solvents, improving the surface?
• Or damage the surface?
Data and Observations

- Annealed at 180°C
- May have caused some slight damage to the coatings

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<td></td>
</tr>
<tr>
<td>10% FDP</td>
<td>9% FDP</td>
<td>5% Fomblin</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4% Fomblin</td>
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</tbody>
</table>

| Average Advancing Contact Angle: | 92.9° | 93.8° | 75.0° | 80.2° |

Conclusions

• Again, the surfaces treated with FDP and FomblinY had the highest contact angle.

• Additionally, the annealed samples were more stable when exposed to water, which indicates that the Fomblin was removed at 100 Celsius. The FDP was not removed at this temperature.
Further Work

• Further work will need to be done to ensure that the PMMA and FDP are indeed forming a smooth surface. SEM and EDX would be examples of experiments to run to confirm this.

• Additionally, the surface coatings can be improved by dip coating in a clean room. This would minimize dust and other impurities landing in the solution or on the silicon wafers.

• Additionally, spin coating provides a higher quality sample for future research.

• Need to figure out why advancing contact angles were not 120 degrees.
Special thanks to:
- Jeffrey Alston
- Andrew Guenthner
- Patrick Rice
- Yvonne Campos
- CSU STAR Program
Questions?