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Growth rates and Pinholes of ALD SiO2, Al2O3, TiO2, and HfO2 films

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Growth rates and Pinholes of ALD SiO2, Al2O3, TiO2, and HfO2 films (Graduate Student Fellow Program)

Prepared by Zisong Nie (3/4/2015)

- See the default recipes on the following web page:
  https://www.seas.upenn.edu/~nanosop/ALD_Recipes.htm

## Growth Rates

### Growth rates of SiO2, Al2O3, TiO2, and HfO2 films prepared by ALD

<table>
<thead>
<tr>
<th></th>
<th>Temperature (°C)</th>
<th>Precursor</th>
<th>Growth Rate (A/cycle)</th>
<th>Default Growth rate (A/cycle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO2</td>
<td>150</td>
<td>TDMAS, O3</td>
<td>0.48</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>TDMAS, O3</td>
<td>0.84</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>TDMAS, O3</td>
<td>1.04</td>
<td>1.10</td>
</tr>
<tr>
<td>Al2O3</td>
<td>150</td>
<td>TMA, H2O</td>
<td>1.34</td>
<td>0.91</td>
</tr>
<tr>
<td>TiO2</td>
<td>200</td>
<td>TDMAT, H2O</td>
<td>0.44</td>
<td>0.40</td>
</tr>
<tr>
<td>HfO2</td>
<td>200</td>
<td>HFDMA, H2O</td>
<td>1.20</td>
<td>1.01</td>
</tr>
</tbody>
</table>

* TDMAS: Tris(dimethylamino)silane
* TMA: Trimethylaluminum (TMA)
* TDMAT: Tetrakis(dimethylamido)titanium
* HFDMA: Tetrakis(dimethylamino)hafnium
Pinholes

- XeF₂ Etcher
  - The number of cycles: 30
  - Etch time: 60 sec
  - The pressure of XeF₂: 3.0 Torr.
  - The pressure of N₂: 2.0 Torr

SiO₂: Thickness = 10 nm
- Pinholes were confirmed.

Photo of ALD 10 nm thick SiO₂ film after XeF₂ etching. The original mirror surface was changed to the dull surface.

Optical microscope image (x500) of ALD 10 nm thick SiO₂ film after XeF₂ etching
Al2O3: Thickness = 13 nm
• Pinholes were NOT confirmed.

Photo of ALD 13 nm thick Al2O3 film after XeF2 etching. The original mirror surface was kept even after XeF2 etching.

TiO2: Thickness = 13 nm
• Pinholes were confirmed, but the number of pinholes on TiO2 film was much smaller than that of SiO2 film.

Photo of ALD 13 nm thick TiO2 film after XeF2 etching. The original mirror surface was still remained in the middle, but the edge of the film was eroded by XeF2.

Optical microscope image (x500) of ALD 13 nm thick TiO2 film after XeF2 etching
HfO2: Thickness = 12 nm
- Pinholes were confirmed.

Photo of ALD 12 nm thick HfO2 film after XeF2 etching. The original mirror surface was changed to the dull surface.

Optical microscope image (x500) of ALD 12 nm thick HfO2 film after XeF2 etching