MEMS Development at Maxim Using STS VPX

Yaqiang Wang, Quanbo Zou, Dino Lei, Uppili Sridhar, and Tito Chowdhury

Dallas Semiconductor-Maxim
4401 S. Beltwood Parkway
Dallas, TX 75244
www.maxim-ic.com
Outline

• STS VPX Introduction
• MEMS Development Examples
• Summary
STS VPX Platform

• Released January 2006, up to three process chambers to share a common automated wafer transport platform
• Provide advanced high rate for silicon and compound semiconductor DRIE
• Well-suited for pilot production markets to transfer new device technology from R&D
General Principle – ASE™ Bosch Process

CFx polymer

ASE Anisotropic Etching schematic (Top)

Typical STS ICP system schematic (Bottom)
Maxim STS VPX System
## Process Development 1

<table>
<thead>
<tr>
<th>Etch Characteristics</th>
<th>Specification</th>
<th>STS UK Results</th>
<th>Dallas Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (μm)</td>
<td>200</td>
<td>227.3</td>
<td>188</td>
</tr>
<tr>
<td>Etch Rate (μm/min)</td>
<td>10</td>
<td>10.3</td>
<td>11.8</td>
</tr>
<tr>
<td>Uniformity (±%)</td>
<td>3</td>
<td>1.9</td>
<td>1.3</td>
</tr>
<tr>
<td>Repeatability (%)</td>
<td>3</td>
<td>0.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Selectivity to PR</td>
<td>80:1</td>
<td>90:1</td>
<td>&gt;90:1</td>
</tr>
<tr>
<td>Profile (°)</td>
<td>90±1</td>
<td>90.7</td>
<td>91</td>
</tr>
<tr>
<td>Initial Mask Undercut (μm/edge)</td>
<td>&lt;1</td>
<td>0.52</td>
<td>0.3</td>
</tr>
<tr>
<td>Scalloping (nm)</td>
<td>&lt;500</td>
<td>352.4</td>
<td>438.8</td>
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</table>
SEM micrograph for a 200-μm-deep trench with 382 nm scalloping
## Process Development 2

<table>
<thead>
<tr>
<th>Etch Characteristics</th>
<th>Specification</th>
<th>STS UK Results</th>
<th>Dallas Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (μm)</td>
<td>200</td>
<td>200</td>
<td>203</td>
</tr>
<tr>
<td>Etch Rate (μm/min)</td>
<td>&gt;7</td>
<td>9.1</td>
<td>9.3</td>
</tr>
<tr>
<td>Uniformity (±%)</td>
<td>3</td>
<td>1.3</td>
<td>1</td>
</tr>
<tr>
<td>Repeatability (%)</td>
<td>3</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>Selectivity to PR</td>
<td>60</td>
<td>72</td>
<td>&gt;61:1</td>
</tr>
<tr>
<td>Profile (°)</td>
<td>90±1</td>
<td>90.6</td>
<td>90.6</td>
</tr>
<tr>
<td>Initial Mask Undercut (μm/edge)</td>
<td>&lt;1</td>
<td>0.33</td>
<td>0.26</td>
</tr>
<tr>
<td>Scalloping (nm)</td>
<td>&lt;300</td>
<td>290.8</td>
<td>236.4</td>
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</tbody>
</table>
SEM Micrographs

(a) SEM micrograph for a 200-μm-deep trench with 242 nm scalloping
## Process Development 3

<table>
<thead>
<tr>
<th>Etch Characteristics</th>
<th>Specification</th>
<th>Dallas Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (µm)</td>
<td>100</td>
<td>101</td>
</tr>
<tr>
<td>Etch Rate (µm/min)</td>
<td>&gt;10</td>
<td>12</td>
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<tr>
<td>Uniformity (±%)</td>
<td>3</td>
<td>1.23</td>
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<tr>
<td>Selectivity to PR</td>
<td>70:1</td>
<td>&gt;78:1</td>
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<tr>
<td>Profile (°)</td>
<td>slightly positive</td>
<td>89.6</td>
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<tr>
<td>Initial Mask Undercut (µm/edge)</td>
<td>&lt;1.2</td>
<td>0.83</td>
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<tr>
<td>Scalloping (nm)</td>
<td>&lt;1000</td>
<td>800</td>
</tr>
</tbody>
</table>
SEM Micrographs

SEM micrograph for a 100-μm-deep trench with 600 nm scalloping
Process Development 4

• 80-100 μm silicon DRIE on SOI substrate without micro-grassing, good selectivity over oxide layer

• No notching issue at the interface of device silicon layer and buried oxide layer

• ARDE ratio should be less than 2:1
SEM Micrographs

SOI 100-μm-deep release with 210 nm scalloping
Other Development for Process 4

Positive slope

No notching at the silicon and oxide interface with ER 8 μm/min and selectivity to oxide over 200:1

No ARDE effect for 50 μm etch
Production Implement Example

• High throughput for Process 3 (100 μm trench): 5 wafer/hr, including loading, wafer transfer, and unloading.
• Lot manufacturing is stable and meets IOS target
Current Issue for the VPX Platform

- Wafer handling repeatability is not 100% guaranteed.

During a 1000-wafer handling test, the scheduler log showed an error for wafer transfer in either robot or aligner stage for the No. 764 wafer.
Summary

• High Etch Rate
• High selectivity over oxide and photoresist
• Good uniformity
• Versatile tunable parameters provide the flexibility for varied MEMS device structures realization
• Wafer handling repeatability is not so stable yet due to glitches in the operation software and Brooks Robot control

⇒ Powerful and convenient platform for MEMS production