INTRODUCTION AND PURPOSE

• Thin Al2O3 passivation layers reduce cost by increasing solar cell efficiency and enabling use of thinner wafers
• Al2O3 ALD entails 2 sequential, self-limiting reactions between gas-phase precursor molecules and a solid surface
• This study compares water vapor and ozone precursors for ALD used to grow a backside passivation layer on crystalline solar cells
• Ozone is efficient but costly, equipment intensive and hazardous
• Water from bubblers and vaporizers was unreliable
• New technology generates/delivers high flow rate ultra pure water vapor at consistent levels

WATER VAPOR GENERATING TECHNOLOGIES

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<thead>
<tr>
<th>Vaporizer</th>
<th>Bubbler</th>
<th>Membrane Technology</th>
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<tbody>
<tr>
<td>Initial Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating Cost</td>
<td></td>
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<tr>
<td>Scalability</td>
<td></td>
<td></td>
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<td>Water droplet prevention</td>
<td></td>
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<td>Particulates</td>
<td></td>
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<td>Flow Control</td>
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<td>Accuracy</td>
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APPROACH FOR COMPARING WATER VAPOR / OZONE

• 100 ALD cycles of TMA/Water and TMA/Ozone precursors for Al2O3 deposition were compared
• Technique requires presence of proper molecule and absence of competitive species (contaminants) that will disrupt lattice structure
• 300mm vacuum ALD process tool setup for deposition at 300°C and 0.5 Torr process pressure
• 10nm thickness expected after 100 ALD cycles or 1.0 ångstroms/cycle

OZONE TEST

• O3 saturation observed with a pulse time of 1000 milliseconds
• Growth rate of O3 is ~0.9 Å per cycle

WATER VAPOR TEST

• H2O saturation observed with a pulse time of 1000 milliseconds (like O3)
• Growth rate for H2O is ~1.0 Å per cycle
• Water vapor generation/delivery unit for humidifying process gas
  • Highly selective, non-porous membrane excludes particles, microdroplets, volatile gases, organic and metal contaminants
  • Allows safe use of gases that should be constrained from mixing with liquid water
  • Allows rapid transfer of water vapor into carrier gas
  • Temperature control adjusts humidification level and allows for controlled mass transfer
  • Operates in atmosphere and vacuum

RESULTS OF WATER VAPOR / OZONE COMPARISON TESTING

• Water pulse clearly visible on quadruple mass spectrometry
• Strong influence of water vapor rate vs. temperature observed
• Mean layer thickness was 10.27nm
• <40 particles added in random pattern during deposition
• Complete saturation between 500ms and 1000ms pulse time
• Growth rate of H2O process is slightly higher
• Water saturation is slightly faster due to higher doses delivered (normalized data)

CONCLUSIONS: WATER VAPOR OBTAINS SIMILAR RESULTS

• Study film characteristics with optimized water deliver system and cycle conditions
• Trace analysis for organic and metal contaminants in film
• Optimize for shorter cycle time, higher throughput stability/repeatability

NEXT STEPS: PROCESS OPTIMIZATION

• Process optimization for shorter cycle time, higher throughput stability/repeatability
• Optimization for water consumption
• No obvious particles due to water supply
• Expected layer thickness achieved and consistent with other reported water / Al2O3 ALD