Introduction

- Mass spectrometer is an instrument which can measure the masses and relative concentrations of atoms and molecules.
- Mass spectrometer comprises three physically important sub-systems: the ion source, separation system and ion trap. The ions must be able to travel along the path from the ion source and through the separation system to the ion trap, to the greatest possible extent without colliding with gas molecules.
- Inficon-Leybold quadrupole mass spectrometer (QMS) is used to provide real-time measurement of species concentration of gas phase above wafer surface and predict the thin film thickness deposited in programmable CVD process.

System Response Time Simulation 1

In order to reach the real-time in-situ process monitor, mass spectrometry response time should be as short as possible.

1. Install orifice at the bottom of sampling tube for chamber contamination monitor and fault detection.

\[ t_R = \frac{(V/Q) \cdot (P_1 + P_2)}{2} \]

Where:
- \( t_R \): response time
- \( V \): sampling tube volume
- \( Q \): gas flow rate
- \( P_1 \): CVD reactor pressure
- \( P_2 \): inside orifice pressure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Orifice hole diameter</td>
<td>0.04 inch</td>
</tr>
<tr>
<td>Sampling tube length</td>
<td>40 inch</td>
</tr>
<tr>
<td>Mass spec pumping speed</td>
<td>300 L/sec</td>
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<tr>
<td>P1 (CVD reactor pressure)</td>
<td>10-6 torr</td>
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<tr>
<td>P2 (Mass spec chamber pressure)</td>
<td>0.5 torr</td>
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Results: Based on the simulation results, orifice sampling system design will be used, and the response time will be around 3 sec.

System Response Time Simulation 2

2. Apply capillary to control the gas flow into mass spec chamber.

Results: Based on the simulation results, capillary inside diameter is 0.04 inch, capillary length is 40 inch and the response time will be around 3 sec.

Initial Experiment Result with Capillary Sampling

Open valve
Close valve

Response time
Open valve: 1-2 sec
Close valve: 30 sec

Mass Spectrometry Multi-sampling System Design

Mass Spectrometry Sampling System

Mass Spectrometry System and Programmable CVD system

Conclusion and Future Work

1. Mass spectrometer multi-sampling system has been designed and developed to measure the species concentration of gas phase above wafer surface in programmable CVD process.
2. Simulation results evaluate time sharing of mass spectrometer monitoring.
3. In addition to monitor the gas concentration from the different segment, mass spectrometer sampling system is also designed for the fault detection and monitoring chamber contamination.
4. Initial mass spectrometer monitor experiments have been performed and further system optimization is being conducted to achieve shorter response time.