SAES Packaging service

making innovation happen, together
Agenda

- MEMS Packaging service description
- Facility and operations
- Capabilities and future prospective

Choose your type of service:
- Fast prototyping
- Process developments
- Packaging foundry service

Add-on services
- RGA (Residual Gas Analysis)
- Outgassing
- Leak rate measurements

Conclusions
SAES Packaging Service description

- MEMS discrete (die-level) vacuum packaging
  - Ceramic packaging
  - Metal packaging

- Getter integration
  - Getter film deposition and patterning

- Sealing methods
  - Au/Sn eutectic
  - Glass frit soldering
Facilities and operations

Equipment
- Independent outgassing/forming gas system
- High vacuum sealing furnace
- Independent heating systems
- Rapid thermal annealing

Operations
- Class 100 clean room
- High Throughput
- Flexible sealing recipes

Testing
- Ultrasonic microscope bonding line integrity test
- Leak rate measurements

Temperature: up to 1100°C
- Heated plates, up to 450 x 450 mm
- Fast ramping of plate
  - Ramp up at > 3.5°C/second
  - Ramp down at > 2°C/second
- 100 steps per program
- Ultimate Vacuum: ~ 7 x 10⁻⁷mbar
- High pressure atmosphere: up to 3 bar (abs)
Capabilities and future prospective

Current achievements:
- Final packaging pressure down to $10^{-3} - 10^{-4}$ mbar range with getter integration
- Hermeticity level < $10^{-16}$ mbar l/s
- Fast sealing process
- Die attach materials selections

Future available services:
- Die attach
- Wire bonding

Example of residual gas of MEMS samples packaged by SAES

<table>
<thead>
<tr>
<th>Gases</th>
<th>Internal Pressure (mbar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H\textsubscript{2}</td>
<td>-</td>
</tr>
<tr>
<td>He</td>
<td>-</td>
</tr>
<tr>
<td>CO</td>
<td>-</td>
</tr>
<tr>
<td>N\textsubscript{2}</td>
<td>1.96E-3</td>
</tr>
<tr>
<td>CH\textsubscript{4}</td>
<td>-</td>
</tr>
<tr>
<td>H\textsubscript{2}O</td>
<td>-</td>
</tr>
<tr>
<td>Ne</td>
<td>-</td>
</tr>
<tr>
<td>O\textsubscript{2}</td>
<td>-</td>
</tr>
<tr>
<td>C\textsubscript{2}H\textsubscript{6}</td>
<td>-</td>
</tr>
<tr>
<td>C\textsubscript{3}H\textsubscript{8}</td>
<td>-</td>
</tr>
<tr>
<td>Ar</td>
<td>1.62E-5</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>-</td>
</tr>
<tr>
<td>Kr</td>
<td>3.38E-6</td>
</tr>
<tr>
<td>TOT.</td>
<td>1.98E-3</td>
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</tbody>
</table>
Choose your type of service

SAES is offering:

- Fast prototyping
- Process developments
- Packaging foundry service
Fast prototyping

- Need prototypes quickly?
- Here are the steps SAES follows:
  - Review packaging drawings and requirements
  - Develop tools
  - Perform bonding trials on empty packages
  - Perform bonding on first prototypes
  - Complete tests and characterizations

- In a reasonably short time we can make your first prototypes a thing of reality
- Need more fast? We can do that!
- We can provide effective and robust solutions
Process developments

- Step by step process development
  - Discussion and definition of the project goals
  - Material selections and analysis
  - Getter integration
  - Preliminary packaging experiments
  - Recipe definition and testing
  - Recipe improvements
  - Tests on repeatability
  - CpK definition and key control parameters

- Process installation
- Tests and fine tuning
Packaging foundry service

- High throughput capability
- Competitive costs
- Fast delivery

Packaging components provided by customer:
- Ceramic container with die attached and wire bonded MEMS
- Au plated Kovar lid
- Au-Sn Bonding preform
Add-on services

SAES also offers:

- RGA (Residual Gas Analysis)
- Outgassing tests
- Leak rate measurements
MEMS samples with internal volume down to nano liter range
- Analysis sensitivity $10^{-6}$ cc mbar
- Total pressure and gas composition
- Service capability:
  - Two samples per day
  - Standard lead time 4 weeks
  - Fast lead time: 1 week

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### Without getter

<table>
<thead>
<tr>
<th>Sample 1</th>
<th>Sample 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q Factor</strong> (measured)</td>
<td><strong>Q Factor</strong> (calculated)</td>
</tr>
<tr>
<td>3000</td>
<td>3220</td>
</tr>
<tr>
<td><strong>Q Factor</strong> (measured)</td>
<td><strong>Q Factor</strong> (calculated)</td>
</tr>
<tr>
<td>35000</td>
<td>1.40E+07</td>
</tr>
</tbody>
</table>

### Gas Pressure (mbar) and Composition

<table>
<thead>
<tr>
<th>Gas</th>
<th>Pressure</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>H$_2$</td>
<td>7.92E-01</td>
<td>81.7%</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>8.52E-02</td>
<td>9.2%</td>
</tr>
<tr>
<td>H$_2$O</td>
<td>9.70E-04</td>
<td>0.1%</td>
</tr>
<tr>
<td>CO</td>
<td>5.53E-02</td>
<td>5.7%</td>
</tr>
<tr>
<td>N$_2$</td>
<td>1.55E-02</td>
<td>1.6%</td>
</tr>
<tr>
<td>C$_2$H$_6$</td>
<td>5.82E-03</td>
<td>0.6%</td>
</tr>
<tr>
<td>C$_2$H$_4$</td>
<td>7.56E-03</td>
<td>0.8%</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>1.94E-03</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

**Total** 9.70E-01 100.0%

**Mean Viscosity** ($10^{-5}$ Pa s) 0.984

### With getter

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<td><strong>Q Factor</strong> (calculated)</td>
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<tr>
<td>50000</td>
<td>1.40E+07</td>
</tr>
<tr>
<td><strong>Q Factor</strong> (measured)</td>
<td><strong>Q Factor</strong> (calculated)</td>
</tr>
<tr>
<td>75000</td>
<td>1.40E+07</td>
</tr>
</tbody>
</table>

### Gas Pressure (mbar) and Composition

<table>
<thead>
<tr>
<th>Gas</th>
<th>Pressure</th>
<th>Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>H$_2$</td>
<td>3.92E-05</td>
<td>9.8%</td>
</tr>
<tr>
<td>CH$_4$</td>
<td>2.28E-05</td>
<td>5.7%</td>
</tr>
<tr>
<td>H$_2$O</td>
<td>1.52E-05</td>
<td>3.8%</td>
</tr>
<tr>
<td>CO</td>
<td>3.36E-05</td>
<td>8.4%</td>
</tr>
<tr>
<td>N$_2$</td>
<td>2.89E-04</td>
<td>72.3%</td>
</tr>
</tbody>
</table>

**Total** 4.00E-04 100.0%

**Mean Viscosity** ($10^{-5}$ Pa s) 1.911
Outgassing tests

- Material studies on outgassing properties
- Material vacuum compatibility assessments
- Material selections
- Material comparisons

Service capability:
- Max sample size of 1”
- Max temperature treatment is 800°C

<table>
<thead>
<tr>
<th></th>
<th>Sample 1</th>
<th>Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Outgassing</td>
<td>Composition</td>
</tr>
<tr>
<td></td>
<td>load [ccmbar/cm³]</td>
<td>%</td>
</tr>
<tr>
<td>Active gases</td>
<td>2.49E-04</td>
<td>43.7%</td>
</tr>
<tr>
<td>H₂ and H₂O</td>
<td>1.64E-04</td>
<td>28.9%</td>
</tr>
<tr>
<td>CO₂, O₂, CO₂</td>
<td>8.45E-05</td>
<td>14.8%</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>3.20E-04</td>
<td>56.2%</td>
</tr>
<tr>
<td>N₂</td>
<td>-</td>
<td>0.0%</td>
</tr>
<tr>
<td>Noble gases</td>
<td>1.04E-07</td>
<td>0.0%</td>
</tr>
<tr>
<td>Total</td>
<td>5.69E-04</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Methods:

- **Static outgassing**
  - to measure the outgassing rate from metals, glasses, ceramics, and other materials which release a relatively low amount of gas

- **Dynamic outgassing**
  - is very useful to make measurements on plastics, foams and other materials which show a high amount of gas evolved and mainly outgas water vapor
Leak rate measurements

The detection and measurement of very small leaks is a key factor for the assessment of device lifetime.

The method is able to:
- establish whether the device is affected by a leak or not
- quantitatively measure the leak rate

Service capabilities:
- **Sensitivity**: the minimum detectable air leak rate is about $1 \times 10^{-16}$ mbar l/s. Whenever the leak rate is close to the system sensitivity an upper limit will be provided
- Standard lead time: 4 weeks
- Fast service lead time: 2 weeks

Example
- Tests performed on inertial sensors
- The producer observed Q-factor degradation with time for some devices
Conclusions

- Competitive advantages of SAES’ MEMS die packaging service

- High vacuum encapsulation
- Getter integration for long term stability
- Flexibility
- Fast response
- Competitive costs
- Engineering capabilities
Thanks for your attention