Sensirion SGP30 Gas Sensor

Multi-Pixel Gas Sensor

MEMS report by LE BLEIS Clément
February 2018 – Version 1
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Executive Summary

• This full reverse costing study has been conducted to provide insight on technology data, manufacturing, cost and selling price of the SGP30 Gas Sensor made by Sensirion.

• Sensirion has released a complete sensor system SGP integrated into a small 2.45 x 2.45 x 0.9 mm DFN package. With these dimensions, it can be embedded in any smartphone, smart-home and appliance applications to measure indoor air environment (CO₂), consumer product (Siloxane) and volatile organic compound (VOCs) in real-time.

• Sensirion has developed “Pixel” technology which consist to detect different gases like CO₂, VOCs and particulate matter on the common membrane including multiple metal-oxide in the same component. To reduce the component size, Sensirion placed the gas sensor above the ASIC and packaged it with the same mold compound, gaining certain advantages like a reduced number of bonds, and an increased signal-to-noise ratio. With specific material and layout choices, the SGP30 embeds the heater and electrodes within the ASIC. Despite the high current and temperature generated, signal measurement is preserved from these disturbances. The electrode and heater are managed by the ASIC, which includes a temperature sensor for measuring the membrane’s temperature, along with flash memory for data calibration. In order to preserve the gas sensing cell in time, a white membrane with a special material is pasted to the top of the package allowing gases to pass through.

• With this low cost gas sensor, Sensirion SGP multi-pixel are suitable for several environmental applications in order to improve comfort and well-being, as well as energy efficiency. With one biggest advantage to have a small size under 5.5 mm³ these can be embedded in any low power portable system.
The reverse costing analysis is conducted in 3 phases:

**Teardown analysis**
- Package is analyzed and measured
- The dies are extracted in order to get overall data: dimensions, main blocks, pad number and pin out, die marking
- Setup of the manufacturing process.

**Costing analysis**
- Setup of the manufacturing environment
- Cost simulation of the process steps

**Selling price analysis**
- Supply chain analysis
- Analysis of the selling price
Summary of the Physical Analysis

Package:
- Dimensions: 2.45 x 2.45 x 0.9 mm
- Number of Pins: 6-pins
- Type: holed-DFN
- Electrical Connection: Wire Bonding

ASIC:
- Substrate: Silicon Wafer
- Process Type: [details]
- Metal Layer: [details]
- Polysilicon layers: [details]
- Estimated Process: [details]
- Lithography steps: [details]

MEMS:
- Sensing Principle: Resistive
- Process:
  - Sensor: [details]
Packaging : Views & Dimensions

- Package : 6-pin DFN
- Dimensions : 2.45 x 2.45 x 0.9 mm
- Pin Pitch : 0.8 mm
Package Opening

- Wire bonding number:
  - Bonding nb between Package & MEMS:
- Material:
- Diameter:

Membrane removed during the analysis
Package Cross-Section

Gas Sensing – SEM View
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Gas Sensing – SEM View
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Gas Sensing Cross-Section – Optical View
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Sensor Die: Membrane Composition

Gas Sensor – Optical View
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EDX Analysis– SEM View
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EDX Analysis– SEM View
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Sensor Die: Cross-Section

Physical Analysis
- Summary
- Physical Analysis
- Operating Principle
- Packaging
  - Sensor Die
- Working Assumption
- ASIC Die
- ASIC Process Characteristics

Manufacturing Process Flow

Cost Analysis

Selling Price Analysis

Feedbacks

About System Plus
ASIC Die: Dimensions

- Dimensions:
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  o Summary
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physical comparison
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ASIC Die Cross-Section

Package Cross-Section – SEM View
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Comparison with SGP30, AMS AS-MLV-P2 and Bosch BME680

<table>
<thead>
<tr>
<th></th>
<th>BME680</th>
<th>SGP30</th>
<th>AMS MLV-P2</th>
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</thead>
<tbody>
<tr>
<td>Sensor Diameter</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sensor material</td>
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<tr>
<td>Electrode</td>
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<td></td>
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<tr>
<td>Heater</td>
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</table>
Global Overview

Manufacturing Process Flow
- Global Overview
- ASIC Front-End Process
- ASIC Wafer Fabrication Unit
- MEMS Front-End Process
- MEMS Wafer Fabrication Unit
- MEMS Sensor Process Flow
- Package Assembly Unit
- Packaging Process Flow

Cost Analysis
- Selling Price Analysis

Feedbacks

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MEMS Front-End Process

- MEMS Wafer:
  - Substrate:
  - Process type:
  - Metal layers:
  - Special features:
  - Area:
  - Lithography Steps:
MEMS Sensor Process Flow

- Bonding opening
- Cavity

Cost Analysis
Selling Price Analysis
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Packaging Process Flow

- **Packaging (Patent JP2010-050452A)**

- **Molded Package**
  - **Injection Molding**
  - **Lead + Test**

- **Lead + Test**
  - **Lead Forming**
  - **Testing**

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**Manufacturing Process Flow**
- Global Overview
- ASIC Front-End Process
- ASIC Wafer Fabrication Unit
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- MEMS Wafer Fabrication Unit
- MEMS Sensor Process Flow
- Package Assembly Unit
- Packaging Process Flow

**Cost Analysis**
- Selling Price Analysis

**Feedbacks**

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### ASIC Unprobed Front-End Cost

<table>
<thead>
<tr>
<th></th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
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<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>Breakdown</td>
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<tr>
<td>Raw wafer Cost (Si)</td>
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<td>Clean Room Cost</td>
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<tr>
<td>Equipment Cost</td>
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<td>Consumable Cost</td>
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<td>Labor Cost</td>
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<tr>
<td>Yield losses Cost</td>
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<tr>
<td><strong>Unprobed Front-End Cost</strong></td>
<td><strong>Gross Profit</strong></td>
<td><strong>Unprobed Front-End Price</strong></td>
<td></td>
</tr>
</tbody>
</table>

The **Unprobed front-end cost** for the ASIC ranges from [blank] according to yield variation.

The largest portion of the manufacturing cost is due to the [blank].
MEMS Front-End Cost

<table>
<thead>
<tr>
<th></th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
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</thead>
<tbody>
<tr>
<td>Clean Room Cost</td>
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<tr>
<td>Yield losses Cost</td>
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</tbody>
</table>

The **MEMS front-end cost** ranges from \[\text{Cost}\] according to variation.

MEMS Front-End Cost Breakdown (Medium Yield)
### Component Cost

<table>
<thead>
<tr>
<th>Component Cost</th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEMS Die cost</td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
</tr>
<tr>
<td>Packaging cost</td>
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<tr>
<td>Final test, Calibration &amp; Burn-in cost</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Yield losses cost</td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
</tr>
</tbody>
</table>

The component cost ranges from [x] to [y] according to the yield variations:

- The **MEMS die** represents [x%] of the component cost.
- The **Packaging Cost** represents [y%] of the component cost.
- The **Final test and Yield losses** account for [z%] of the component cost.
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