Reverse Costing analysis

Avago FBAR Filter
ACMD-7612: UMTS Band I Duplexer

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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 Avago ACMD-7612 component.

- The ACMD-7612 is a duplexer which uses Avago's FBAR and Microcap technologies.

- Film Bulk Acoustic Resonator (FBAR) is a silicon-based MEMS technology allowing to create structures with higher Q than Surface Acoustic Wave (Saw) structures for most cellular frequency bands.

- Microcap corresponds to the wafer level packaging process of the FBAR filters. The Microcap process uses gold plated Through Silicon Vias (TSV) in the cap to report electrical contacts and gold-gold thermo-compression wafer bonding to ensure an hermetic sealing.

- ACMD-7612 is targeted for handsets or data terminals operating in the UMTS Band I frequency range and features a Maximum RF Input Power to Tx Port of ±33 dBm.
Package Characteristics & Markings

- **Package type:** 3-pin LGA
- **Dimensions:** 3.0mm x 2.5mm x 1.2mm
- **Pin pitch:** 2.27mm
- **Marking:**
  - PFI1
  - 0105
  - 1714
Package X-ray: Top View

Package X-Ray Top view
Package opening reveals two dies connected to the substrate by wire bonding process.

Wire bonding material:
Wire bonding diameter:
Wire bonding number:

✓ Bonding nb between Tx die & Package:
✓ Bonding nb between Rx die & Package:
✓ Bonding nb between Package & Package:

Package Opening – Optical view

Notes: Pictures blurred in sample report
Package Cross-Section - Overview

- Package total thickness:
  - LGA PCB thickness:
  - Dies thickness:
  - Molding compound thickness on top of dies:

Cross-Sectional Plane

Pictures blurred in sample report

Cross-Section Overview (SEM Image)
Die Cross-Section - TSV

- The TSV are etched
- TSV depth:

Cross-Section Overview

Cap TSV Cross-Section – SEM view

Pictures blurred in sample report

Avago ACMD-7612: FBAR Duplexer
Die Cross-Section - Membrane

- Piezoelectric material for resonating layer: Aluminum Nitride (AlN)
- Electrodes material:
- TSV Cross-Section Overview
- PSG sacrificial layer is used to define the swimming pool
- AlN piezo layer thickness:
- ...
Main steps of economic analysis

- We perform the economic analysis of the component with the MEMS CoSim+ software.
### MEMS Front-End Cost

<table>
<thead>
<tr>
<th>MEMS Front-End</th>
<th>Tx Die</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Yield</td>
<td>Medium Yield</td>
</tr>
<tr>
<td></td>
<td>Cost</td>
<td>Breakdown</td>
</tr>
<tr>
<td>Raw wafers (High Resistivity Si)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FBAR Wafer</td>
<td></td>
<td></td>
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<tr>
<td>Cap Wafer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonding &amp; TSV</td>
<td></td>
<td></td>
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<tr>
<td>Yield losses</td>
<td></td>
<td></td>
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<tr>
<td>MEMS Front-End Cost</td>
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</tr>
</tbody>
</table>

#### MEMS Manufacturing Cost Breakdown (Tx - Middle Yield)

- **Semiconductor Technology:** Represents the main part of the manufacturing cost with **26%.**
MEMS Dies Cost (FE + BE 0)

<table>
<thead>
<tr>
<th></th>
<th>Tx Die</th>
<th>Rx Die</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low Yield</td>
<td>Medium Yield</td>
</tr>
<tr>
<td></td>
<td>Cost Breakdown</td>
<td>Cost Breakdown</td>
</tr>
<tr>
<td>Front-End Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE 0 : Probe Test Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE 0 : Dicing Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEMS Wafer Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nb of potential dies per wafer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nb of good dies per wafer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front-End Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BE 0 : Probe Test</td>
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<td></td>
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<tr>
<td>BE 0 : Dicing Cost</td>
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</tr>
<tr>
<td>BE 0 : Yield losses</td>
<td></td>
<td></td>
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<tr>
<td>MEMS Die Cost</td>
<td></td>
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</tr>
</tbody>
</table>

- The **Tx die cost** ranges from $ to $ according to yield variations.
- The **Rx die cost** ranges from $ to $ according to yield variations.
## ACMD-7612 Component Cost (FE+BE 0+BE 1)

<table>
<thead>
<tr>
<th>Component Cost</th>
<th>Low Yield</th>
<th>Medium Yield</th>
<th>High Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cost</td>
<td>Breakdown</td>
<td>Cost</td>
</tr>
<tr>
<td>FE + BE 0: Tx Die cost</td>
<td>$x$</td>
<td>$y$%</td>
<td>$z$</td>
</tr>
<tr>
<td>FE + BE 0: Rx Die Cost</td>
<td>$c$</td>
<td>$d$%</td>
<td>$e$</td>
</tr>
<tr>
<td>BE 1: Packaging cost</td>
<td>$i$</td>
<td>$j$%</td>
<td>$k$</td>
</tr>
<tr>
<td>BE 1: Final test &amp; Calibration cost</td>
<td>$o$</td>
<td>$p$%</td>
<td>$q$</td>
</tr>
<tr>
<td>BE 1: Yield losses</td>
<td>$u$</td>
<td>$v$%</td>
<td>$w$</td>
</tr>
</tbody>
</table>

### ACMD-7612 Component Cost Breakdown (Medium Yields)

- The component cost is between $x$ and $y$ according to yield variations.
- The Rx die represents $z$% of the total manufacturing cost.
- The Tx die represents $a$% of the total manufacturing cost.
- The packaging cost represents $b$% of the total manufacturing cost.
- Final test cost and yield losses (due to packaging and final test) represent $c$% of the total manufacturing cost.
### ACMD-7612 Estimated Selling Price (Medium Yield)

<table>
<thead>
<tr>
<th>ACMD-7612 - Medium Yield</th>
<th>Selling Price 100K units</th>
<th>Selling Price 1M units</th>
<th>Selling Price 10M units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final Component Cost</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturer Price</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- *life cycle factor*
- *quantity factor*

### ACMD-7612 Selling Price Variation according to Quantity

![ACMD-7612 Selling Price Variation](image-url)