TowerJazz High Performance
SiGe BiCMOS processes
The Global Specialty Foundry Leader

Total 8" Equivalent Capacity of ≈ 1.7M WPY

Santa Clara, CA, USA
Sales and Support Office

Austin, TX, USA
Sales Office

Newport Beach, CA, USA
8" Fab

290K WPY

Virginia, USA
Sales Office

UK & France
Sales Reps

Bangalore, India
Sales Office

720K WPY

Migdal Haemek, Israel
8" Fab and 6" Fab

Netanya, Israel
Worldwide Design Center

700K WPY

Tokyo, Japan
Sales Reps

Shanghai, China
Sales and Support Office

Hsinchu, Taiwan
Sales Office

Nishiwaki, Japan
8" Fab

Seoul, Korea
Sales and Support Office
<table>
<thead>
<tr>
<th>Technology Portfolio</th>
<th>0.50 µm</th>
<th>0.35 µm</th>
<th>0.25 µm</th>
<th>0.18/0.16/0.152 µm</th>
<th>0.13 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power/BCD</strong></td>
<td>BiCMOS, SiGe</td>
<td>SiGe</td>
<td>SiGe</td>
<td>SiGe</td>
<td>SiGe</td>
</tr>
<tr>
<td><strong>RFCMOS</strong></td>
<td>RFCMOS and SOI CMOS</td>
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<td>RFCMOS and SOI CMOS</td>
</tr>
</tbody>
</table>

**Comprehensive Technology Portfolio**

- 0.50 µm
- 0.35 µm
- 0.25 µm
- 0.18/0.16/0.152 µm
- 0.13 µm

- Power/BCD
- BCD
- RFCMOS
- RFCMOS and SOI CMOS
- Mixed-Signal Digital CMOS
- SiGe
- SiGe
- SiGe
- SiGe
- SiGe

**Image Sensor (X-Ray & Visible)**

**eNVM**
RF and HPA Applications and Technology

**RF and Tuners**

**RF CMOS and SiGe BiCMOS**
- Cell Phone, WiFi TxRx
- Basestation, Specialty Wireless
- TV, Satellite, STB Tuners

**mmWave**

**High Performance SiGe**
- Optical Fiber Networks
- Automotive Radar
- 60 GHz WiFi, 24GHz Backhaul
- Light Peak and Thunderbolt
- GPS LNA

**Front-End Modules**

**SOI Switch and SiGe Power Amplifiers**
- Power Amplifiers
- Antenna Switch
- PA Controllers

**High Performance Analog**

**Complementary BiCMOS**
- Line Drivers DSL, HomePlug, ATE
- HDD PreAmp
- DAC, ADC

*Best-in-class SiGe, RF CMOS, RF models and Design Enablement*
### Front-End Module Technology

#### Controller

**RF CMOS Controller Platform**
- 5V, 0.18um optimized CMOS
- Up to 50% die size shrink vs. 0.25um
- 1.8V Logic, Bipolar, LDMOS options

#### Power Amplifier

**SiGe PA, through-silicon-via (TSV), IPD**
- SiGe PA cells for WiFi and Cellular
- TSV for low-inductance ground
- 1.8/3.3/5V CMOS, high res options
- IPD (5um dual-Cu in development)

#### SOI Switch

**Platform for integration of FEM**
- Thin-Film SOI (best in class Ron-Coff)
- Thick-Film SOI for ease of integration
- 5V control, LNA, PA/Driver options

#### Design Services and IP

**Models, design tools and IP**
- Example: PA Design Library (PADL)
- Example: 4T, 6T, 9T SOI Switch IP
- Analog / RF Design Services

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**Best-in-class SiGe, RF CMOS, RF models and Design Enablement**
The SiGe HBJTs are embedded into complimentary BiCMOS platforms offering high performance RF, analog and digital performances.
The high-performance bipolar transistors are built “vertically” meaning that the n-p-n structure is created perpendicularly from the top of the wafer down.
# TowerJazz High Speed SiGe Processes

<table>
<thead>
<tr>
<th>Status</th>
<th>SBC18HA</th>
<th>SBC18H2</th>
<th>SBC18H3</th>
<th>SBC13HA</th>
<th>SBC13H3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMOS</td>
<td>Voltages</td>
<td>1.8/3.3V</td>
<td>1.8/3.3V</td>
<td>1.8/3.3V</td>
<td>1.2/3.3V</td>
</tr>
<tr>
<td>HS Bipolar</td>
<td>$F_T$ (GHz)</td>
<td>150</td>
<td>200</td>
<td>240</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>$F_{MAX}$ (GHz)</td>
<td>190</td>
<td>200</td>
<td>270</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>$BV_{CEO}$ (V)</td>
<td>2.2</td>
<td>1.9</td>
<td>1.6</td>
<td>1.9</td>
</tr>
<tr>
<td>Capacitor</td>
<td>fF/µm²</td>
<td>2.8/5.6</td>
<td>2/4</td>
<td>2.8/5.6</td>
<td>2.8/5.6</td>
</tr>
<tr>
<td>Varactor</td>
<td>Q at 20 GHz</td>
<td>10</td>
<td>NA</td>
<td>15</td>
<td>NA</td>
</tr>
<tr>
<td>LPNP</td>
<td>Beta</td>
<td>32</td>
<td>7</td>
<td>30</td>
<td>7</td>
</tr>
</tbody>
</table>

- There are numerous other SBC18 flavors in production with variations in back end configuration, selection of available devices etc.
- Presented data mainly from the SBC18H2/H3 flavors.
SiGe HBJT’s current and power gain

- 240 GHz $F_t$ / 270 GHz $F_{\text{max}}$ devices in mass production.
- High frequency performances sustained for wide collector current range.
SiGe HBJT’s gain vs DC power density

- TowerJazz Devices are optimized for low power consumption.
SiGe HBJT’s Noise

- SBC18H4 minimum noise figure at 20GHz is measured less than 1dB and at 40GHz at only 2dB.
- NFMIN is flat across various frequency ranges.
Circuit examples at ~100GHz: LNAs

- Broad band mm-wave LNAs fabricated in SBC18H2 and SBC18H3
- 4 identical LNAs built for a 4-channel W-band phased-array receiver
- Nearly 30dB of gain above noise floor at 85GHz
- Almost perfect matching between LNAs
RF Grounding: Deep Silicon Vias vs. Through Silicon Vias

- Deep Silicon Vias and Through Silicon Vias are available for enhanced RF grounding.
- next generation (SBC18H4) is in final development stage, \( F_{\text{max}} = 350 \text{Ghz} \), improved noise figure.
- SiGe NPN on thick film SOI under development.
Summary

- TowerJazz offer SiGe HBJT devices on 0.35µm, 0.18µm and 0.13µm technology nodes.
- TowerJazz SiGe HBJT offers Best in class SiGe Speed / Power and Best in class Noise.
- The SiGe HBJTs are embedded into complimentary BiCMOS platforms offering high performance RF, analog and digital performances.
www.towerjazz.com
# Complete SBC18H3 Device Roster

<table>
<thead>
<tr>
<th>Family</th>
<th>Device</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMOS</td>
<td>1.8V CMOS</td>
<td>Model-exact copy of all other TJ 0.18um CMOS</td>
</tr>
<tr>
<td></td>
<td>3.3V CMOS</td>
<td></td>
</tr>
<tr>
<td>Bipolar</td>
<td>HS NPN</td>
<td>240 GHz $F_T$ / 280 GHz $F_{MAX}$</td>
</tr>
<tr>
<td></td>
<td>STD NPN</td>
<td>55GHz $F_T$ / 3.2V $BV_{CEO}$</td>
</tr>
<tr>
<td></td>
<td>LPNP</td>
<td>$\beta=35$</td>
</tr>
<tr>
<td>Resistors</td>
<td>Poly</td>
<td>235 $\Omega$/sq and 1000 $\Omega$/sq</td>
</tr>
<tr>
<td></td>
<td>Metal</td>
<td>25 $\Omega$/sq TiN on M3</td>
</tr>
<tr>
<td>Capacitors</td>
<td>Single MIM</td>
<td>2 or 2.8 fF/$\mu$m²</td>
</tr>
<tr>
<td></td>
<td>Stacked MIM</td>
<td>4 or 5.6 fF/$\mu$m²</td>
</tr>
<tr>
<td>Varactors</td>
<td>1.8V MOS</td>
<td>$Q@20GHz = 20$</td>
</tr>
<tr>
<td></td>
<td>Hyper-abrupt junction</td>
<td>$Q@20GHz =15$, Tuning Ratio = 21%</td>
</tr>
<tr>
<td>RF Diodes</td>
<td>p-i-n</td>
<td>Isolation &lt;-15dB, Insertion loss &gt; -3.5dB at 50GHz</td>
</tr>
<tr>
<td></td>
<td>Schottky</td>
<td>$F_C &gt; 800$ GHz</td>
</tr>
</tbody>
</table>
SiGe HBJT basic layout-122 configuration