Cryogenic Wideband MMIC-LNA development in SHAO

Ying Chen, Zhengkai Li, Bin Li
Shanghai Astronomical Observatory
Photographs and Measured Results

5-10GHz LNA
2300 × 900um (2 stages)

Average $T_N = 80K$
<table>
<thead>
<tr>
<th>Wire Bonder</th>
<th>Dual Head Epoxy Die Bonder</th>
<th>Single Head Eutectic Die Bonder</th>
</tr>
</thead>
</table>

Micro-Packaging Equipments
MMIC On-Wafer Measurement System

Cascade Probe Station

Agilent PNA-X VNA N5245A

Keithley Source Meter2400

Focus Tuner

Cascade Probe Station
Transistor Parameter Measurement

S-parameters (dB)

- Frequency (GHz)

- Solid line (measured in lab)
- Dotted line (provided by foundry)

NFmin (dB)

- Frequency (GHz)
Cryogenic Measurement System

Janis Cryogenic Probe Station

Testing cryostat
Cryogenic Noise Measurement System

![Cryogenic Noise Measurement System](image)

Frequency (GHz) vs. Cable Loss (dB)

- 17K
- 290K
- 154K

Room Temp.
Cold-Plate Temp.

From: noise source N4000A (6dB ENR)
To: noise figure analyzer

6dB Att.
Cryogenic $T_N$ and Gain of 5-10GHz LNA

Noise improvement factor $\approx 105/24 = 4.4$
<table>
<thead>
<tr>
<th>Freq (GHz)</th>
<th>Gain (dB)</th>
<th>Tn (K)</th>
<th>Bias (mA/V)</th>
<th>Area (mm²)</th>
<th>Process</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-8</td>
<td>23</td>
<td>65</td>
<td>40/2.0</td>
<td>2.3×0.9</td>
<td>150nm GaAs</td>
<td>Completed</td>
</tr>
<tr>
<td>5-10</td>
<td>23</td>
<td>80</td>
<td>40/2.5</td>
<td>2.3×0.9</td>
<td>150nm GaAs</td>
<td>Completed</td>
</tr>
<tr>
<td>8-20</td>
<td>23</td>
<td>150</td>
<td>40/2.5</td>
<td>2.3×0.9</td>
<td>150nm GaAs</td>
<td>Completed</td>
</tr>
<tr>
<td>5-10</td>
<td>26</td>
<td>70</td>
<td>70/2</td>
<td>2.4×0.8</td>
<td>100nm GaAs</td>
<td>Ready for Tape out</td>
</tr>
<tr>
<td>20-40</td>
<td>22</td>
<td>220</td>
<td>20/2</td>
<td>2.4×0.7</td>
<td>100nm GaAs</td>
<td>Ready for Tape out</td>
</tr>
<tr>
<td>18-26</td>
<td>17/26</td>
<td>140/150</td>
<td>120/2</td>
<td>2.4×0.8</td>
<td>100nm GaAs</td>
<td>Ready for Tape out</td>
</tr>
<tr>
<td>30-50</td>
<td>18</td>
<td>300</td>
<td>28/1.5</td>
<td>2.4×0.7</td>
<td>100nm GaAs</td>
<td>Ready for Tape out</td>
</tr>
<tr>
<td>1-10</td>
<td>30</td>
<td>63</td>
<td>100/2</td>
<td>2.4×0.8</td>
<td>100nm GaAs</td>
<td>Ready for Tape out</td>
</tr>
<tr>
<td>0.4-3</td>
<td>37</td>
<td>48</td>
<td>75/2</td>
<td>2.4×0.9</td>
<td>100nm GaAs</td>
<td>Ready for Tape out</td>
</tr>
<tr>
<td>DC-10</td>
<td>16</td>
<td>170-270</td>
<td>500/3.5</td>
<td>2.4×0.7</td>
<td>100nm GaAs</td>
<td>Ready for Tape out</td>
</tr>
</tbody>
</table>

GaAs pHEMT MMIC LNAs
Photographs and Measured Results

4-8GHz LNA
2300×900um (2 stages)

8-20GHz LNA
2300×900um (3 stages)

Average $T_N = 65K$

Average $T_N = 130K$
Layouts and Simulation Results

5-10GHz LNA
2400 × 820um (2 stages)

Gain ≈ 26dB and \( T_n \approx 70K \) with 70mA/2V

20-40GHz LNA
2400 × 683um (4 stages)

Gain ≈ 22dB and \( T_n \approx 220K \) with 20mA/2V
Layouts and Simulation Results

18-26GHz LNA
2400×800um (3 stages)

Gain ≈ 17dB and $T_n ≈ 140$K with 120mA/2V

18-26GHz LNA
2400×800um (4 stages)

Gain ≈ 26dB and $T_n ≈ 150$K with 160mA/1.5V
Layouts and Simulation Results

1-10GHz LNA
2400 × 760um (3 stages)

Gain ≈ 30dB and \( T_n \approx 63K \) with 100mA/2V

DC-10GHz DA
2400 × 760um (5 stages)

Gain ≈ 16dB and \( T_n \approx 170-270K \) with 500mA/3.5V
0.4-3GHz LNA
2400×900um (3 stages)

Gain ≈ 37dB and $T_n \approx 48K$ with 75mA/2V

30-50GHz LNA
2400×670um (4 stages)

Gain ≈ 18dB and $T_n \approx 300K$ with 50mA/1.5V
Thanks for your attention!