High aspect ratio deep etching in GaInAsSb/AlGaAsSb system by ICP-RIE plasma

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High aspect ratio deep etching in GaInAsSb/AlGaAsSb system by ICP-RIE plasma

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Context

Target

- Mid infrared tunable diode laser spectroscopy for trace gas detection in the 2-5 µm wavelength range.

Approach

- Array of 2nd-order DFB singlemode, all-photonic-crystal (PhC) lasers: We replace a laser which would be tunable over a wide range of wavelengths by an array of N lasers tunable over a range of wavelengths N times smaller. We call this method MTDLAS: multiplexed tunable diode laser absorption spectroscopy.

Issue

Towards the realization of laser diodes all PhC electrically pumped in GaSb system

- Heterostructure AlGaAsSb / InGaAsSb for an emission around 2.3µm

- Etching of submicron patterns with high aspect ratio in the heterostructure:
  - Characteristic dimensions: Ø - 375 nm, H - 3.5 µm
  - Aspect ratio: 1:9

- System tool: SPTS ICP-RIE: Trikon-Omega201

- Operating range:
  - Gas: SF6, O2, Cl2, Ar, N2
  - RF plasma powers (13.56 MHz): $P_{ICP} < 660$ W
  - $2$ mTorr < $P_r$ < 50 mTorr

Problem

Optimization of the process of chlorinated ICP-RIE etching III-V materials

- Influence of ICP power
- Influence of pressure

- Limit redeposition (verticality):
  - Adding Argon

Previous work

Masking strategy adopted

<table>
<thead>
<tr>
<th>Etching process by ICP-RIE</th>
<th>Mask</th>
</tr>
</thead>
<tbody>
<tr>
<td>P MMA</td>
<td>ZEP520A</td>
</tr>
<tr>
<td>GaAs by Cl$_2$/N$_2$</td>
<td>0.5</td>
</tr>
<tr>
<td>SiO$_2$ by CHF$_3$</td>
<td>&lt; 0.5</td>
</tr>
</tbody>
</table>

Development of a multi-step etching process combining Cl$_2$/N$_2$, O$_2$ and N$_2$ ICP plasma etching

Figure 1. Absorption lines strength from 2 to 5 µm. (HITRAN 96 database)

Figure 2. Etching of submicron patterns with high aspect ratio in the heterostructure.

Principle of the spectroscopy using an array of single frequency lasers and tunable over a small wavelength range.

Conclusion

- Establishment of a high aspect ratio deep etching process in GaInAsSb/AlGaAsSb system
  - Improvement:
    - Verticality $\Rightarrow$ angle of 2-3°
    - Etched sidewalls $\Rightarrow$ less notching
    - Low roughness

- Successful insertion of this technological step in a complete process

- Record high aspect ratio
- Sensitivity to aluminum concentration
- Profile improvement

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