ZnTe is of current interest for photovoltaic applications and as a possible buffer layer for growth of HgCdTe or HgCdSe. Moreover, the ZnTe/GaSb heterostructure itself is of potential interest for cascade solar cells. Thus, different approaches geared towards optimizing the epitaxial growth of high quality ZnTe/GaSb are under active investigation. Atomic hydrogen was investigated for surface preparation of GaSb for subsequent growth of ZnTe and ZnTeSe. A detailed microstructural study of these ZnTe/GaSb samples was performed using cross-section transmission electron microscopy as well as x-ray photoelectron spectroscopy, x-ray diffraction, atomic force microscopy.

**15. SUBJECT TERMS**
- atomic hydrogen
- GaSb
- ZnTe
- MBE
Use of atomic hydrogen to prepare GaSb substrates for subsequent ZnTe growth by MBE

**ABSTRACT**

ZnTe is of current interest for photovoltaic applications and as a possible buffer layer for growth of HgCdTe or HgCdSe. Moreover, the ZnTe/GaSb heterostructure itself is of potential interest for cascade solar cells. Thus, different approaches geared towards optimizing the epitaxial growth of high quality ZnTe/GaSb are under active investigation. Atomic hydrogen was investigated for surface preparation of GaSb for subsequent growth of ZnTe and ZnTeSe. A detailed microstructural study of these ZnTe/GaSb samples was performed using cross-section transmission electron microscopy as well as x-ray photoelectron spectroscopy, x-ray diffraction, atomic force microscopy and imaging photoluminescence measurements. We will present results indicating that we are able to get smooth, clean and stoichiometric GaSb surfaces suitable for subsequent epitaxial growth without using an Sb overpressure. In particular, ZnTe layers with thicknesses of 200 nm and below have highly coherent and sharp interfaces with the GaSb, and exhibit very low densities of dislocations. Thick ZnTeSe/GaSb layers with dislocation densities in the mid-104 cm-2 have been grown.
Use of atomic hydrogen to prepare GaSb substrates for subsequent ZnTe growth by MBE

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Growth Details

- Grown with Elemental Zn and Te.
- ZnTe layers between 50 to 2100 nm thick were deposited.
- This was followed by ten periods of alternating exposures of Zn and Te for 5s and Zn for 60s.
- Oxides removed by 20 min exposure at 400°C to atomic hydrogen.
- During nucleation, the substrate temperature was raised to 320°C and the surface was exposed to Zn for 60s
- The sample was exposed to Zn for 60s, Zn for 5s and Zn for 60s.
- This was followed by ten periods of alternating exposures of Zn and Te for 5s and Zn for 60s.
- ZnTe layers between 50 to 2100 nm thick were deposited.

Oxide Removal Methods

1. Thermal Oxide Desorption
   - 2Sb2O5 → Sb4 + 5O2
   - Ga2O3 → Ga2O + O2
   - Decomposes > 550 °C
   - 4GaSb + 3O2 → 2Ga2O3 + Sb4

2. Atomic Hydrogen Cleaning
   - Desorbs > 400 °C
   - Ga2O3 + 4H → Ga2O + 2H2O
   - 2Sb2O5 + 20H2 → Sb4 + 10H2O

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ACKNOWLEDGEMENTS

XPS : Atomic-H cleaning of GaSb(111)B

XPS and RHEED indicate atomic-H cleaning at 400°C is required to remove surface oxides

Use Large Atomic-H Overpressure

Ga2O3 + 4H → Ga2O + 2H2O
2Sb2O5 + 20H2 → Sb4 + 10H2O

XPS : Composition Analysis on Atomic-H Cleaned GaSb

AFM : Atomic-H cleaning of GaSb(111)B

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Lattice Matching and Atomic-H Cleaning Results in Low Dislocation Epilayers

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<th>2-µm thick ZnTe/GaSb (211B)</th>
<th>2-µm thick ZnTe/GaSb (100)</th>
<th>1.2-µm thick ZnTe0.99Se0.01/GaSb (211B)</th>
</tr>
</thead>
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<td>~3x10^7 cm^-2</td>
<td>~7x10^7 cm^-2</td>
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<tr>
<td>200 nm</td>
<td>350 nm</td>
<td>1000 nm</td>
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TEM : XPS and RHEED indicate atomic-H cleaning at 400°C is required to remove surface oxides

Conical PL : Use Large Atomic-H Overpressure

H2 Cleaning

```
Ga2O3 + 4H → Ga2O + 2H2O
2Sb2O5 + 20H2 → Sb4 + 10H2O
```

SEM : Focus in Low Dislocation Epilayers