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 other techniques.

**SUBJECT TERMS**

atomic hydrogen GaSb ZnTe MBE

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14. 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 other techniques.

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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-10^4 cm^-2 have been grown.
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**Growth Details**
- Grown with Elemental Zn and Te.
- 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, Zn and Te for 5s and Zn for 60s.
- This was followed by ten periods of alternating exposures of ZnTe during 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 ZnTe/GaSb layers with dislocation densities in the mid-10^4 cm^-2 have been grown.

**Oxide Removal Methods**

1. **Thermal Oxide Desorption**
   
   \[ 2 \text{Sb}_2\text{O}_5 \rightarrow \text{Sb}_4 + 5\text{O}_2 \]
   \[ \text{Ga}_2\text{O}_3 \rightarrow \text{Ga}_2\text{O} + \text{O}_2 \]
   Decomposes > 550 °C

   \[ 4\text{GaSb} + 3\text{O}_2 \rightarrow 2\text{Ga}_2\text{O}_3 + \text{Sb}_4 \]

2. **Atomic Hydrogen Cleaning**
   
   Desorbs > 400 °C
   \[ \text{Ga}_2\text{O}_3 + 4\text{H} \rightarrow \text{Ga}_2\text{O} + 2\text{H}_2\text{O} \]
   \[ 2\text{Sb}_2\text{O}_5 + 20\text{H}_2 \rightarrow \text{Sb}_4 + 10\text{H}_2\text{O} \]

**Use of atomic hydrogen to prepare GaSb substrates for subsequent ZnTe growth by MBE**


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