Proyecto Consolider-Ingenio 2010 “GENESIS-FV”

Investigación en materia de una nueva generación de materiales, células y sistemas para la conversión fotovoltaica

Santiago Silvestre

Line L :

Intermediate band materials by sputtering

- Milestones
- GaAs & GaAs (Ti) Sputtering processes
- Si(Ti) HiT solar cell
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*Investigación en materia de una nueva generación de materiales, células y sistemas para la conversión fotovoltaica*

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<tr>
<td>L Intermediate band material By Sputtering</td>
<td>IB Material</td>
<td>1 patent at OEPM+ PCT</td>
<td>P200800571: “Procedimiento para la obtención de Películas de Materiales Semiconductores Incorporando una Banda Intermedia”.</td>
<td>Communications at Conferences:</td>
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<td>- CDE 2009</td>
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<td>- IEEE PVSC 2010</td>
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<td>- CDE 2011</td>
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<td>- 1 Paper (TSF)</td>
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Collaboration in LINE M: Intermediate band solar cells in bulk material

Madrid 28/ 02/2011
GaAs & GaAs (Ti) Sputtering processes

- Thin films have been deposited on glass substrates under different process conditions in a RF Sputtering System: ESM100 Edwards & RFS5 Generator-300W.

- Two different targets have been used in these processes:
  
  - GaAs (99.5%)-Ti (0.5%),
    Purity: 99,999%,
    Size: 4” Diameter x 0.125”

  - GaAs(n) <100>,
    having a Si impurity concentration of $7 \times 10^{17} \text{ cm}^{-3}$
    Size: 4” Diameter x 400 μm

Madrid 28/02/2011
Thin films of GaAs(Ti), ranging from 90nm to 250 nm thick, were grown by sputtering on glass substrates.

Sputtering Process conditions:

- Chamber pressure: $5 \times 10^{-3}$ mbar
- Substrate temperature: 30°C - 400°C
- Ar flux: **5, 10, and 15 sccm**
- R.F. input power ranging from **16 to 40 W**
- Distance between target & sample: 6.5 cm
- No sample Rotation along sputtering process
GaAs & GaAs (Ti) Sputtering processes

PR-spectra obtained from the n-GaAs and GaAs(Ti) samples

- Residual crystallization of n-GaAs samples
  (PR-signature around 1.4 eV)

- The GaAs:Ti sample grown at 40 W shows two apparent signatures
  (1.4 eV and a 1.0 eV)
GaAs & GaAs (Ti) Sputtering processes

Shimadzu UV-3600 UV-VIS-NIR spectrophotometer

\[(\alpha \ h\nu)^{1/2} = C_{\text{Tauc}}(h\nu - E_{\text{Tauc}})\]

<table>
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<tr>
<th>Sample</th>
<th>(E_{\text{Tauc}}) (eV)</th>
<th>(C_{\text{Tauc}}) (cm(^{1/2}) eV(^{-1/2}))</th>
<th>lower limit</th>
<th>upper limit</th>
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<tbody>
<tr>
<td>GaAs(Ti)1</td>
<td>1.12</td>
<td>982.86</td>
<td>2.6 (10^5)</td>
<td>9.96 (10^5)</td>
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<tr>
<td>GaAs(Ti)2</td>
<td>1.13</td>
<td>695.70</td>
<td>1.38 (10^5)</td>
<td>5.68 (10^5)</td>
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<tr>
<td>GaAs(Ti)3</td>
<td>0.99</td>
<td>679.55</td>
<td>1.71 (10^5)</td>
<td>3.47 (10^5)</td>
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<tr>
<td>GaAs(Ti)4</td>
<td>0.83</td>
<td>405.46</td>
<td>8.72 (10^4)</td>
<td>2.55 (10^5)</td>
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<tr>
<td>(n_{\text{GaAs}}1)</td>
<td>1.15</td>
<td>538.04</td>
<td>1.4 (10^6)</td>
<td>3.11 (10^6)</td>
</tr>
<tr>
<td>(n_{\text{GaAs}}2)</td>
<td>1.23</td>
<td>574.35</td>
<td>6.62 (10^4)</td>
<td>3.38 (10^5)</td>
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<tr>
<td>(n_{\text{GaAs}}3)</td>
<td>1.29</td>
<td>581.97</td>
<td>5.03 (10^4)</td>
<td>3.26 (10^5)</td>
</tr>
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</table>

Optical Absorption is enhanced by Ti in all samples.

The differences in \(\alpha\) and \(E_{\text{Tauc}}\) between samples of \(n\)-GaAs and GaAs(Ti) are consistent with the presence of an intermediate band.
Si(Ti) HiT Solar cell

Plasma-enhanced chemical vapor deposition  PECVD
Si(Ti) HiT Solar cell

Process Description

- Organic cleaning / HF cleaning
- Active layer deposition
  - a-Si:H intrinsic layer
  - Deposition of n doped a-Si:H layer
- Deposition of SiCx passivation layer
- Deposition of Al back ohmic contact
  (Thermal evaporation)
- Laser firing
- Deposition of ITO by R.F. Sputtering
- Lithography of ITO windows and etching
- Front contact Lithography
- Front contact / Au R.F. Sputtering
- Lift-off
Si(Ti) HiT Solar cell (Area : 0.25 cm²)

HIT FEB 2001 SOLAR CELL 0'25 cm² LIGHT RESPONSE

Log( |I| ) (A)

HIT FEB 2001 SOLAR CELL 0'25 cm² DARK RESPONSE

Log |I| (A)
Si(Ti) HiT Solar cell (Area :1 cm²)

Micro and Nano Technologies Group
Departament d’Enginyeria Electrònica

Madrid 28/ 02/2011
Conclusions

- Thin films of GaAs and GaAs(Ti) have been deposited by sputtering on glass under different process conditions. Optical Absorption is enhanced by Ti in all samples.

- The differences in $\alpha$ and $E_{\text{g Tauc}}$ between samples of n-GaAs and GaAs(Ti) are consistent with the presence of an intermediate band.

- First Batch of Si(Ti) HiT Solar cells Fabricated.

- New Batches of Si(Ti) HiT, n_GaAs/GaAs(Ti)/p:GaAs and n_GaAs/GaAs(Ti)/p_Si Solar cells will be fabricated.