Proyecto Consolider-Ingenio 2010 “GENESIS-FV”

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

Madrid 28/ 02/2011

Santiago Silvestre

Line L :

Intermediate band materials by sputtering

- **Milestones**
- **GaAs & GaAs (Ti) Sputtering processes**
- **Si(Ti) HiT solar cell**

Consolider

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CONSOLIDER GENESIS FV

Line	Milestones year 3 (15/09/2009)	Degree of fulfilment (14/09/2009)	Milestones year 5 (15/09/2011)	Degree of fulfilment (17/02/2010)
L Intermediate band material By Sputtering	IB Material	**1 patent at OEPM+ PCT** **P200800571: “Procedimiento para la obtención de Películas de Materiales Semiconductores Incorporando una Banda Intermedia”.**	1 high impact paper	**Communications at Conferences :** - **CDE 2009** - **IEEE PVSC 2010** - **CDE 2011** -**1 Paper (TSF)** -**(In review)**

Collaboration in LINE M: Intermediate band solar cells in bulk material

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 x 10^{17} cm^{-3}
  Size: 4” Diameter x 400 μm

GaAs & GaAs (Ti) Sputtering processes

- Thin films of GaAs(Ti), ranging from 90nm to 250 nm thick, were grown by sputtering on glass substrates

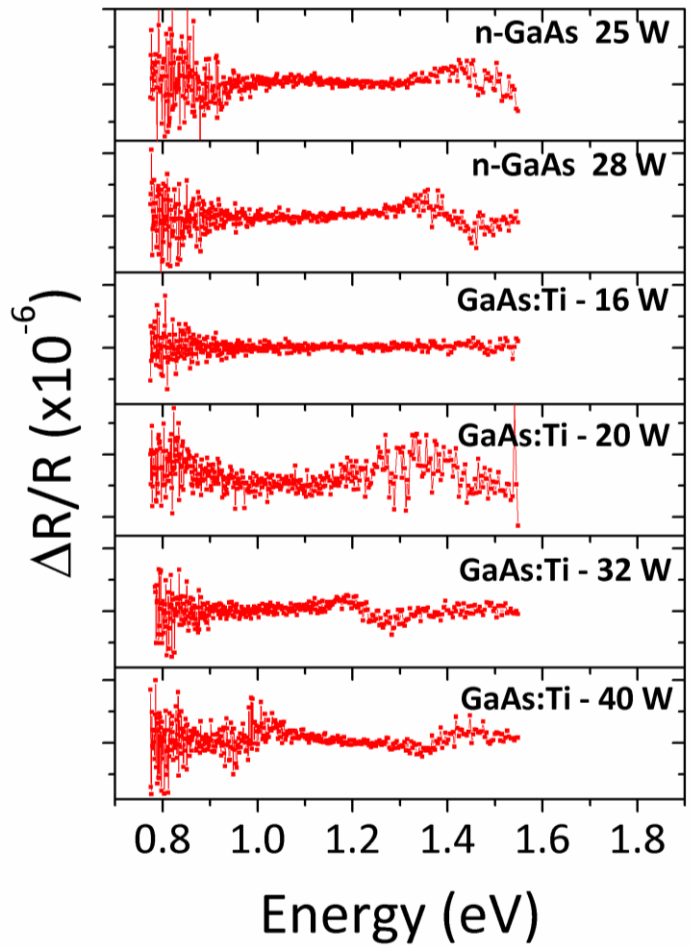
- Sputtering Process conditions :
  - Chamber pressure 5 10^{-3} mbar
  - substrate temperature : 30ºC - 400ºC
  - Ar flux: **5,10 and 15 sccm**
  - R.F. input power ranging from **16 to 40 W**
  - Distance between target & sample : 6.5 cm
  - No sample Rotation along sputtering process

GaAs & GaAs (Ti) Sputtering processes

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

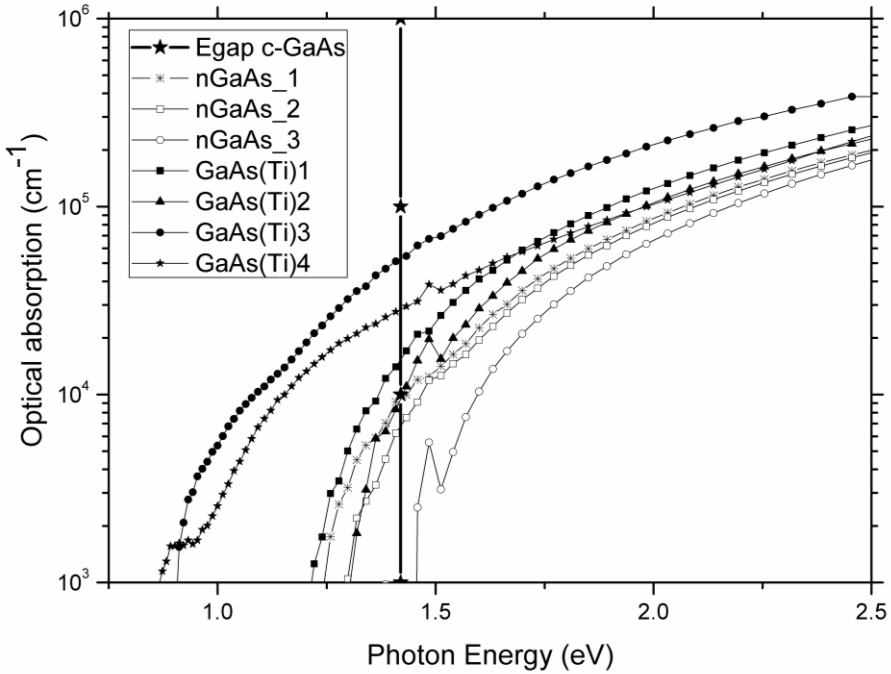
- Residual crystallization of n-GaAs samples
(PR-signature around 1.4 eV)

-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



$$(\alpha\, h\nu)^{1/2} = C_{Tauc}(h\nu - E_{Tauc})$$

Sample	Eg_{TAUC} (eV)	C_{TAUC} ($cm^{-1/2}eV^{-1/2}$)	$\alpha(cm^{-1})$ lower limit	$\alpha(cm^{-1})$ upper limit
GaAs(Ti)1	1.12	982.86	$2.6\ 10^5$	$9.96\ 10^5$
GaAs(Ti)2	1.13	695.70	$1.38\ 10^5$	$5.68\ 10^5$
GaAs(Ti)3	0.99	679.55	$1.71\ 10^5$	$3.47\ 10^5$
GaAs(Ti)4	0.83	405.46	$8.72\ 10^4$	$2.55\ 10^5$
n_GaAs1	1.15	538.04	$1.4\ 10^5$	$3.11\ 10^5$
n_GaAs2	1.23	574.35	$6.62\ 10^4$	$3.38\ 10^5$
n_GaAs3	1.29	581.97	$5.03\ 10^4$	$3.26\ 10^5$

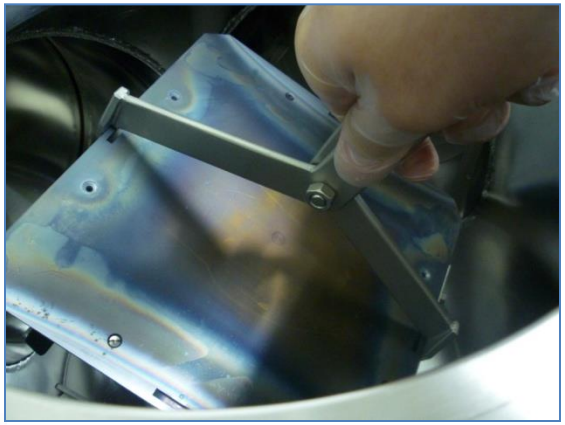
Optical Absorption is enhanced by Ti in all samples

The differences in α and Eg_{TAUC} between samples of n-GaAs and GaAs(Ti) are consistent with the presence of an intermediate band.

Si(Ti) HiT Solar cell

Hot-Wire CVD ?

Plasma-enhanced chemical vapor deposition PECVD



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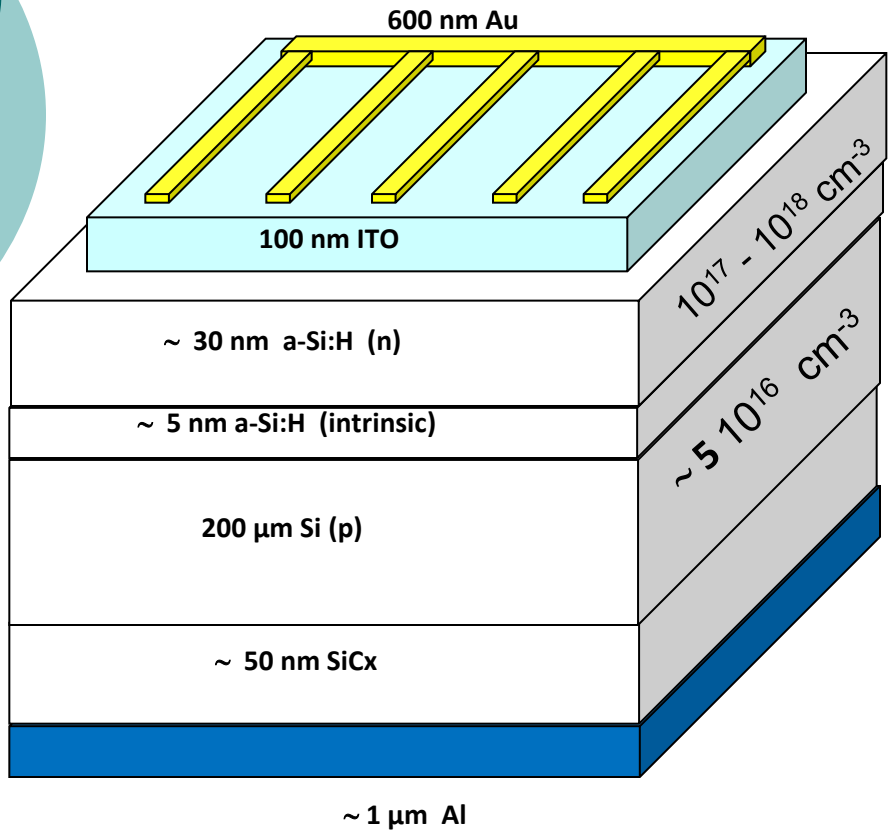
Si(Ti) HiT Solar cell

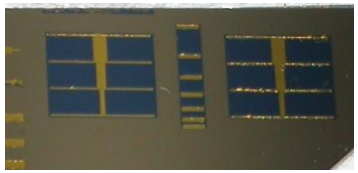


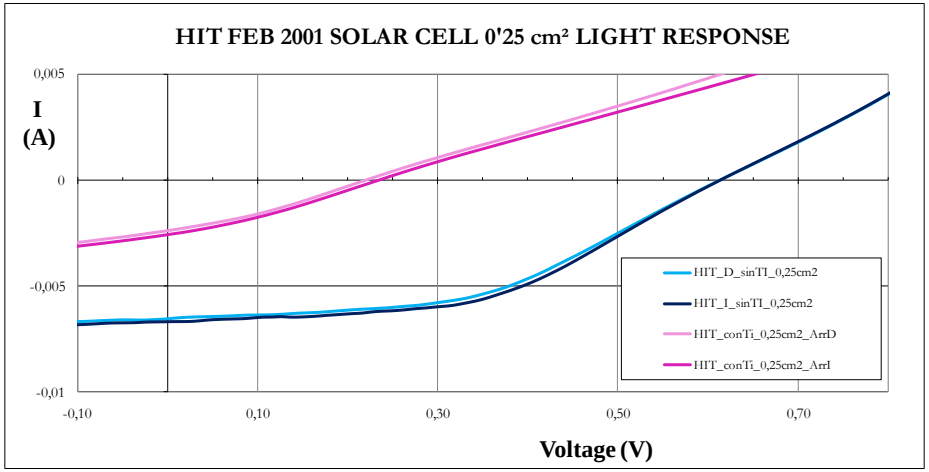
Process Description

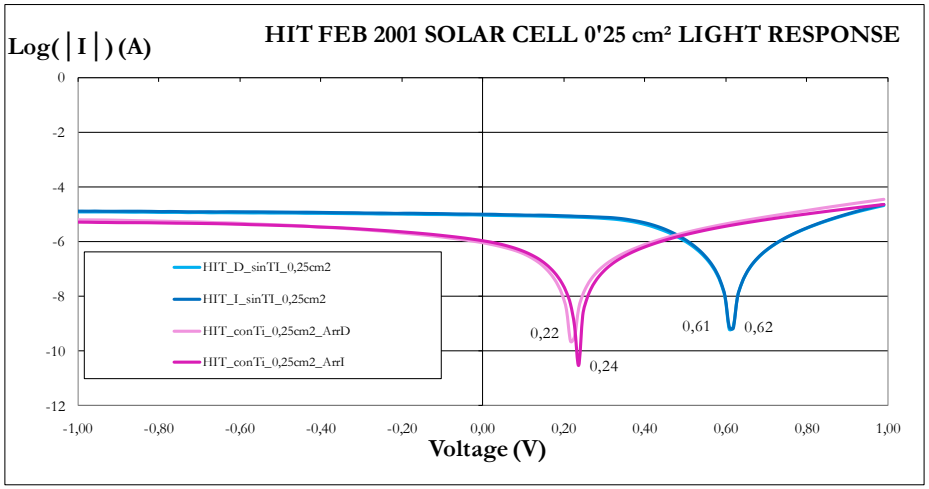
- Organic cleaning / HF cleaning
- Active layer deposition
  a-Si:H intrinsic layer
  Deposition of n doped a-Si:H layer
- Deposition of SiCx passivation layer
- Deposition of Al back ohmic contact (Thermal evaporation)
- Laser firing
- Deposition of ITO by R.F. Sputtering
- Lithography of ITO windows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

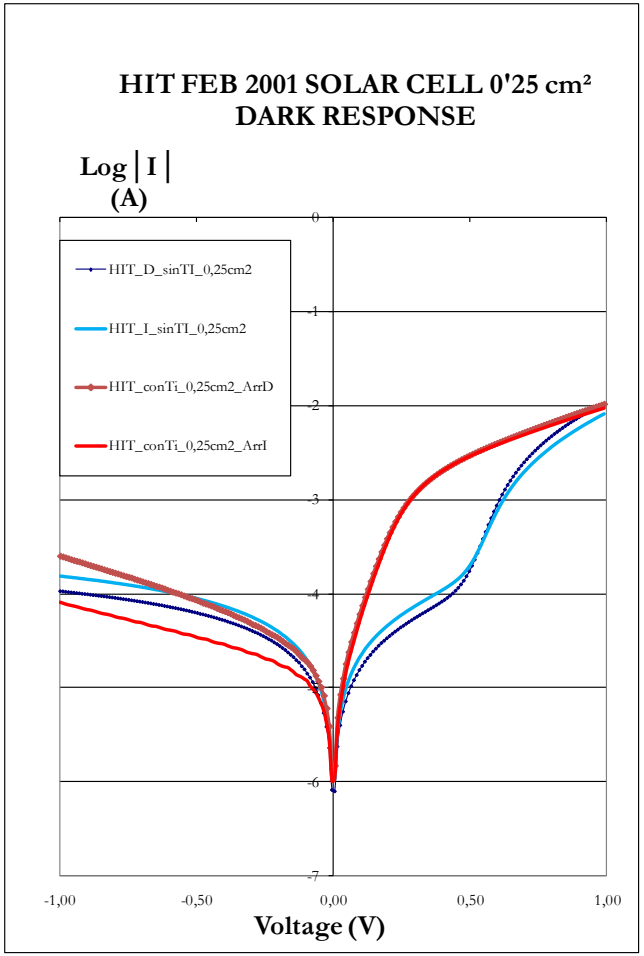
Si(Ti) HiT Solar cell

(Area : 0.25 cm^2)



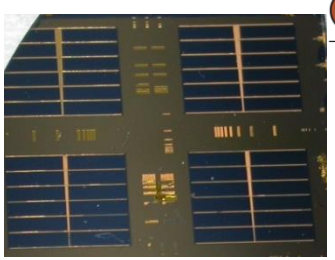


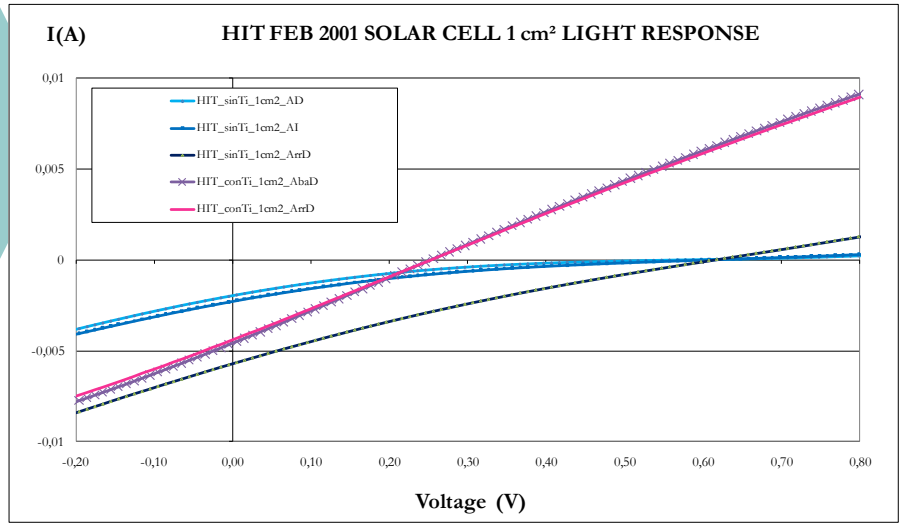


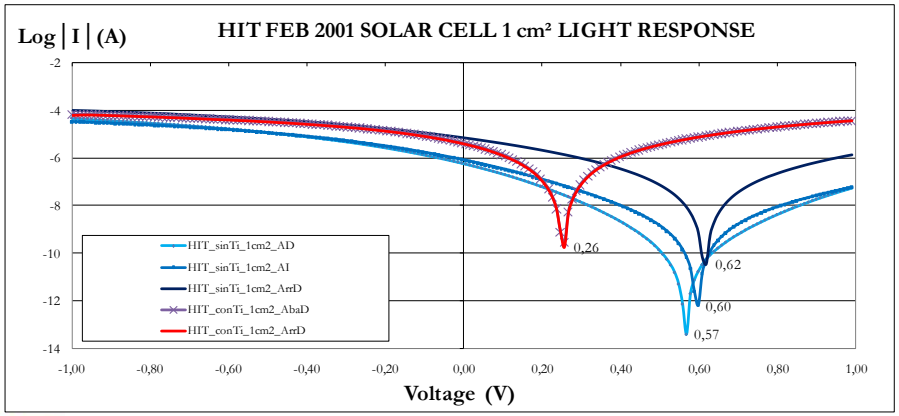


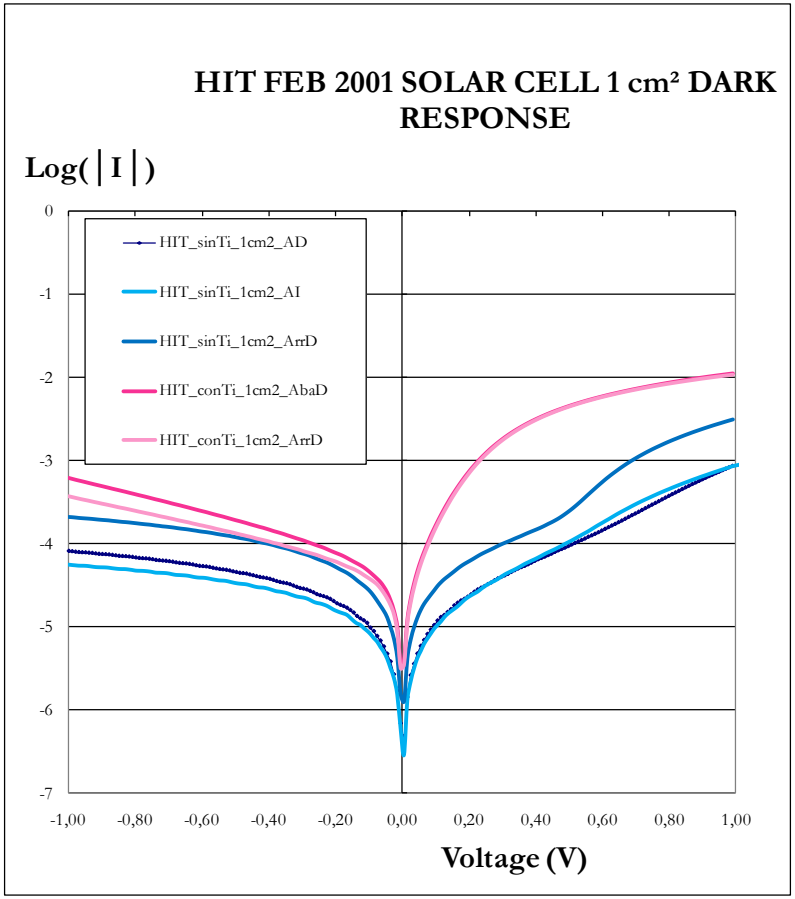
Si(Ti) HiT Solar cell

(Area :1 cm^2)









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 α and Eg_{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