Laser-diffused phosphorus emitters for Ge TPV cells

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Thermophotovoltaic (TPV) Energy Conversion

Ge: Low-cost alternative

← **III-V semiconductors**

- ✓ Efficiency, versatility
- ✗ Cost, complex processing techniques

Ge single junction TPV cells: state of the art

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High Cost Alternative (Fraunhofer ISE)

Low Cost Alternative (IMEC)

Low Cost & Reduced Thermal Budget Alternative

Our work: substitution of High Temp Process by laser annealing

2D model:

1D model:

SRV ($\text{cm} \cdot \text{s}^{-1}$)

τ_{bulk} (μs)

“Good scenario”: $SRV = 0 \text{ cm}\cdot\text{s}^{-1}$; $\tau_{\text{bulk}} = 500 \mu\text{s}$

“Bad scenario”: $SRV = 10^5 \text{ cm}\cdot\text{s}^{-1}$; $\tau_{\text{bulk}} = 5 \mu\text{s}$

- A precise control of junction depth and surface doping concentration is needed to optimize TPV performance

Emitter formation: main processing steps

- Energy fluence (J/cm^2) and number of pulses per site

Energy fluence (J/cm^2)

Number of pulses per site

- Energy fluence (J/cm^2) $\rightarrow$ Junction depth (μm)
- Number of pulses per site $\rightarrow$ Junction depth (μm) and surface doping concentration (cm^{-3})

Manufacturing process of a TPV cell based on LTA and SOD

10x

5x

- Laser conditions used: 0.58 J/cm^2 and 60 pulses per site

J-V curve (1 sun @STC)

EQE curve

- We have fabricated Ge TPV cells combining LTA and SOD for the first time in Ge
- Optimum doping profiles were found for 2 different scenarios. Best results to maximize output power:
 - “Good scenario” : moderately doped thick emitter
 - “Bad scenario”: relatively thin highly doped emitter
- A control of the emitter doping profile was achieved by varying :
 - Energy fluence → junction depth
 - Number of pulses per site → junction depth and surface doping concentration

- A new approach for low-cost low-temperature process for Ge TPV cells has been proved. However, an improvement of the quality of the diffused emitters is needed. Future work will consist on:
 - Integration LTA process with surface passivation
 - Laser annealing under N_2 atmosphere (to avoid introduction of active defects)
 - Implementation of locally-doped emitters

Acknowledgments

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Y COMPETITIVIDAD

Horizon 2020
FUTURE EMERGING TECHNOLOGIES

AMADEUS
ultra high temperature energy storage

Thank you for your attention

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