

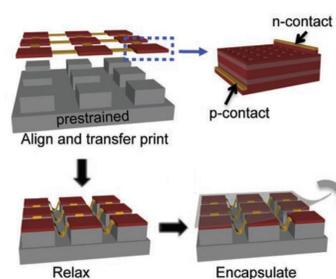
INTRODUCTION

- Fully conformal and stretchable solar cells enable standalone wearables, foldable electronics and drones, among others
- Inorganic solar cells show higher efficiencies but are brittle
- Previous demonstrations focused on organic based cells with lower efficiencies or inorganic materials with complex fabrication techniques



1st stretchable solar cell, organic, 2% efficiency, 20% stretchability
Z. Bao et al., Adv. Mat. 2011

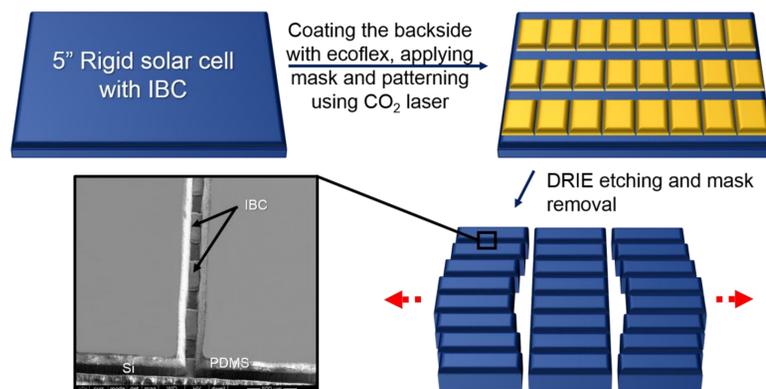
Organic solar cells, 7.9% efficiency, 52% stretchability
T. Somea et al., Nature Energy 2017



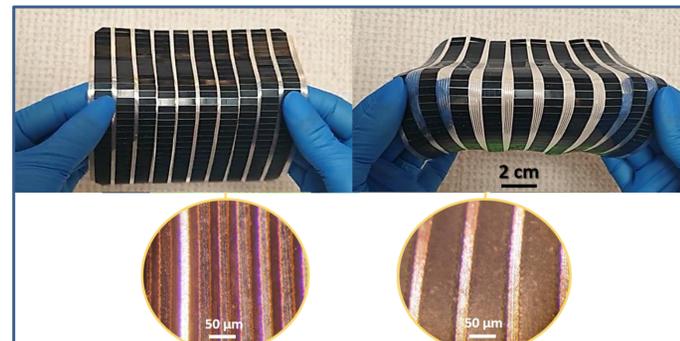
GaInP/GaAs solar cells, 19% efficiency, 54% stretchability
J. Rogers et al., Small 2012

METHOD

- Commercial grade rigid solar cells are converted into their stretchable version using a combination of elastomer encapsulation and corrugation process
- The process is applied on rigid silicon solar cells have an efficiency of 19% and based on the interdigitated back contacts technology
- The corrugation process is based on a combination of CO₂ laser ablation and deep reactive ion etching



RESULTS & DISCUSSION

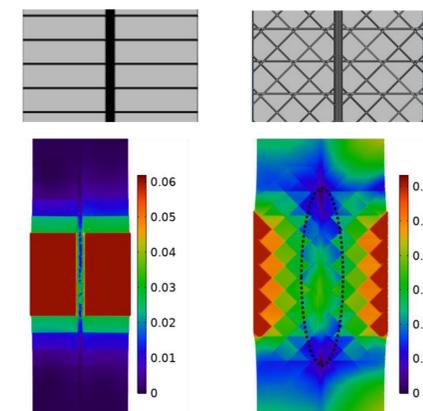


	Rigid	Stretchable
J _{sc}	39 mA/cm ²	38.8 mA/cm ²
V _{oc}	0.64 V	0.64 V
η	19%	18.8%
FF	75.85%	75.74%
Specific weight	0.78 kg/m ²	0.67 kg/m ²

- The strain is absorbed by the elastomer while the rigid area is intact
- Triangular patterns enable a world record stretchability (95%) in solar cells with a high efficiency (19%)

COMSOL SIMULATION

- Three-dimensional finite element method (FEM) analysis was used to replicate the mechanical response of the studied designs
- Triangular patterned cells enable higher deformations and thus higher motion of the islands compared to the linear cells



N. El-Atab et al. Advanced Energy Materials, 1902883, 2019

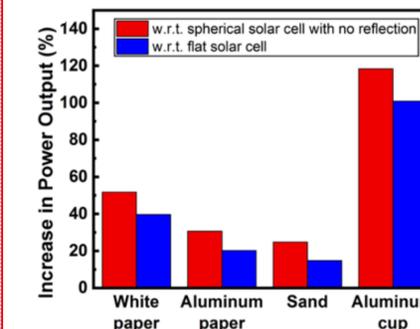
APPLICATION – SPHERICAL SOLAR CELL

- In order to realize a high power conversion efficiency, a solar cell should effectively utilize most of the incoming photons
- A spherical shaped solar cell capable of capturing direct, diffuse and background reflected light without the need for a mechanical sun-tracking tool is demonstrated
- The spherical cell is based on a corrugated silicon solar cell with efficiency of 19%



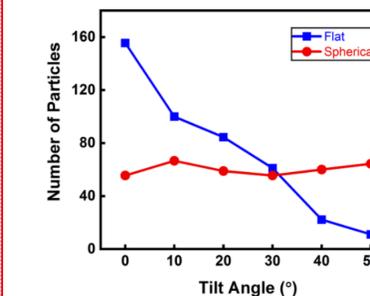
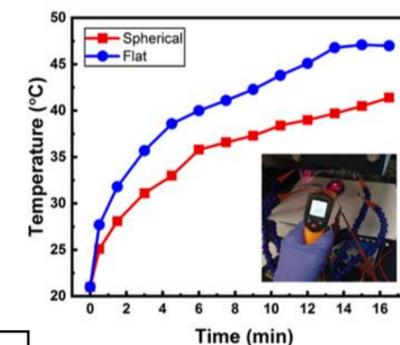
N. El-Atab et al. MRS Communications, 2020

SPHERICAL SOLAR CELL CHARACTERIZATION



Increase in power output by up to 101% compared to a flat traditional cell with the same projection area

Enhancement in thermal performance, 10% reduced temperature due to increased Surface-to-Volume ratio and spherical architecture



Reduced dust accumulation rate compared with a flat traditional cell

CONCLUSION

- A corrugation approach is demonstrated to transform rigid solar cells into their ultra-stretchable version with negligible degradation in electrical performance
- A world record stretchability (95%) and efficiency (19%) are obtained
- The corrugation process is applied to demonstrate a large scale spherical solar cell
- The spherical cell enables increased power output, and enhanced thermal and dust performance compared with a traditional flat cell

Acknowledgment:

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