Hybrid Solar Cells Based on Amorphous Silicon and P3HT Heterojunction

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Introduction

• Organic/inorganic hybrid solar cells combine the absorption, low-cost and processability characteristics of polymers with the environmental stability and carrier mobility properties of inorganic semiconductors

• Poly(3-hexylthiophene) (P3HT) and poly(6,6-phenyl C61-butyric acid methyl ester) (PCBM) have been the polymers predominantly used in most organic photovoltaics. Amorphous silicon (a-Si) is regarded as a good candidate as inorganic material. It is abundant, non-toxic and can be deposited as thin films or patterned into nanostructures by simple processes

• The hybrid solar cells presented are formed by the flat heterojunction between an organic electron donor (P3HT) and n-type amorphous silicon as the inorganic electron acceptor. Devices with a blend of P3HT and PCBM have also been studied. The following structures have been fabricated:
  A. ITO/PEDOT/P3HT/a-Si(n)/Ag
  B. ITO/PEDOT/P3HT:PCBM/a-Si(n)/Ag
  C. ITO/a-Si(n)/P3HT/Ag
  D. ITO/a-Si(n)/P3HT:PCBM/Ag

Schematic view of standard (top) and inverted (bottom) cells. ITO and silver are front and back electrodes, respectively. P3HT is the photovoltaic material on devices A and C while P3HT:PCBM blend is that of devices B and D. N-type amorphous silicon (a-Si(n)) was deposited by RF sputtering. PEDOT:PSS is used as a hole transfer layer

• The cells have been studied by means of their current-voltage (I-V) characteristic, transmission measurements and quantum efficiency (QE). This study presents for the first time the impedance spectroscopy characterization of the a-Si(n)/P3HT interface. From this, CV measurements, circuit models and further electronic characterization has been obtained

Device Fabrication

  • Substrate Cleaning Procedure
  • a-Si(n) Sputtering
  • P3HT or P3HT:PCBM Spin Coating
  • Ag Thermal Evaporation

Experimental Details

Device Fabrication

  • Substrate Cleaning Procedure
  • a-Si(n) Sputtering
  • P3HT or P3HT:PCBM Spin Coating
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Characterization

  • I-V Characteristic
  • Impedance Measurements
  • C-V Measurements
  • Transmission Measurements
  • QE Measurements

Optical Characteristics

I-V and C-V Characteristics

Impedance Measurements

Results and Discussion

Optical Characteristics

I-V and C-V Characteristics

Impedance Measurements

Experimental and fits for RCPE model for an impedance spectrum at +0.5V in the dark. Impedance Bode and phase diagrams

The table shows fitting results for the RC and RCPE models from the fits shown above

Conclusion

• Fabricated hybrid solar cells and analyzed their optical and electrical characteristics

• Impedance spectroscopy has been performed and the a-Si(n)/P3HT interface has been characterized

• Results from this study reveals a behavior close to that of organic solar cells

References

Impedance spectroscopy of optimized standard and inverted P3HT:PCBM organic solar cells
Hybrid solar cells based on thin-film silicon and P3HT
Amorphous-silicon/polymer solar cells and key design rules for hybrid solar cells