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Transparent, near-infrared organic photovoltaic solar cells for window and energy-scavenging applications

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presented by Pascal Meier

Content

- Introduction
- Fabrication
- Results
- Applications

Introduction

- Sun light has a low energy density
- Solar technologies need to cover large areas
- Problems: high costs & where to install
- Solution: low-cost, transparent photovoltaic, which can be integrated onto window panes in homes, skyscrapers, and automobiles

Advantages of Organic Solar Cells

- Low production costs
- Transparent
- High mechanical flexibility
- Absorption spectra has distinct maxima and minima

Today's Situation

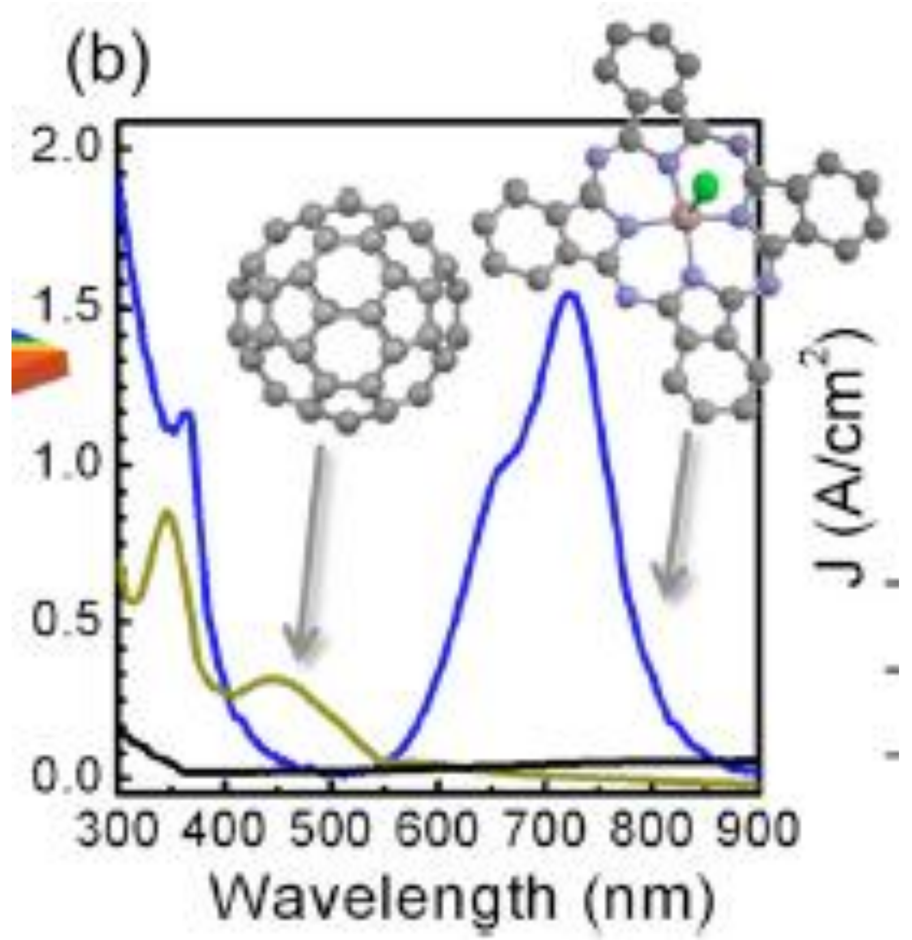
- Window glasses used in *automobiles* are 70% – 80% transmissive to visible light
- Window glasses used in *architectural installations* are 55% – 90% transmissive to visible light
- "Transparent" solar cells have absorption maxima in visible spectrum

  → have either low efficiency (< 1%) or

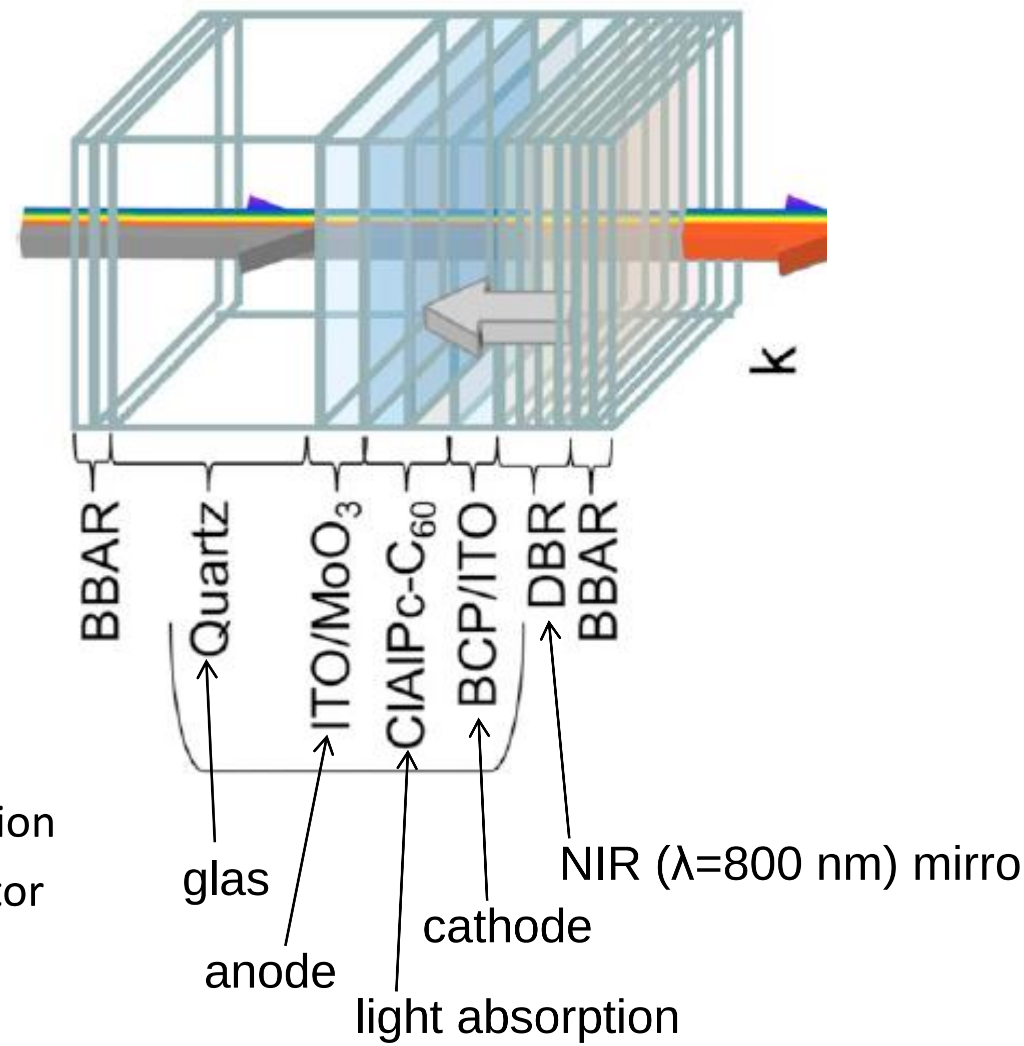
  low transmissivity (10% - 35%)

Used Substances

- Donor: chloroaluminum phthalocyanine (ClAlPc)
- Acceptor: C_{60}
- Peak absorption in UV and NIR (λ~740 nm)



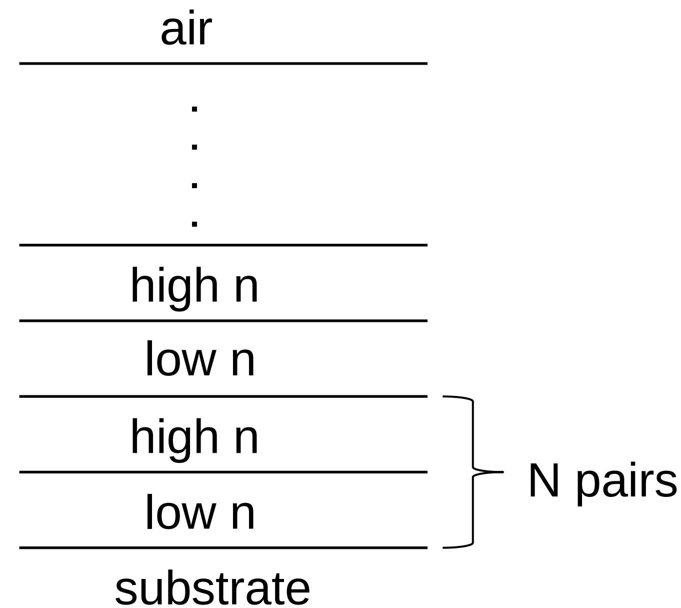
Composition of Solar Cell



- ITO = indium-tin oxide
- BCP = bathocuproine
- BBAR = broad-band antireflection
- DBR = distributed Bragg reflector (TiO_2/SiO_2)

Distributed Bragg Reflector (DBR)

- Used in optical fibers, cavity resonator, and lasers
- Has very high reflectivity at tunable λ
- Consists of alternating layers with high (e.g. TiO_2) and low (e.g. SiO_2) refractive index
- Each layer has same thickness of d = λ/4



$$R = \left[\frac{1 - \left(\frac{n_H}{n_L}\right)^{2N} \frac{n_S}{n_0}}{1 + \left(\frac{n_H}{n_L}\right)^{2N} \frac{n_S}{n_0}} \right]^2$$

Fabrication

- Glass substrates were precoated with 150 nm thick ITO
- MoO_3 (20 nm), ClAlPc (15 nm), C_{60} (30 nm) BCP (7.5 nm) were sequentially deposed via *thermal evaporation*
- The ITO cathode-layer was directly *rf-sputtered* onto the organic layer through a shadow mask
- DBR was grown separately on quartz substrate via *sputtering* 7 alternating layers of TiO_2 and SiO_2

Results

Efficiency of 1.3 ± 0.1%
Transmissivity of 65 ± 3%

} only with ITO

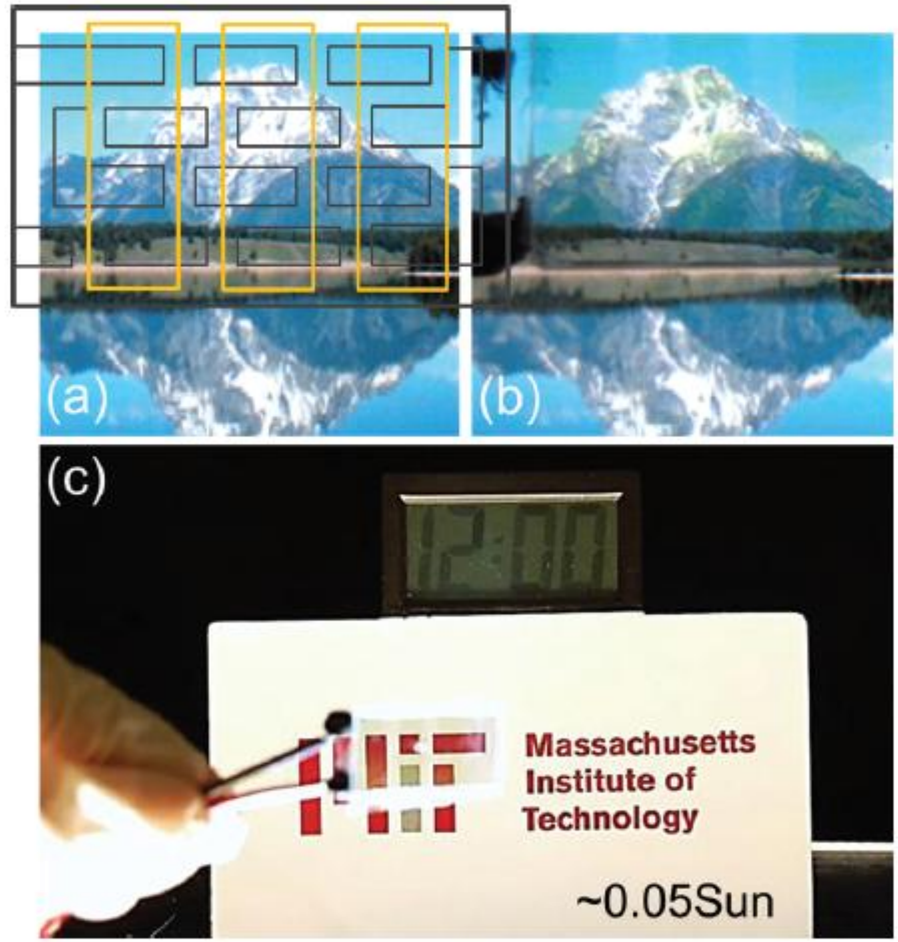
Efficiency of 1.7 ± 0.1%
Transmissivity of 56 ± 2%
Reflectivity of 99% for λ = 695 – 910 nm

} with DBR and BBAR

→ presented solar cells are suitable for window glasses in architectural installations

Application

a) LCD image with overlaid anode drawing
b) Complete solar cell in front of image
c) Solar cell powering LCD clock



Prospect

Without decreasing the transmissivity, efficiency is supposed to increased by:

- switching from planar to bulk-junctions in the subcells
- stacking subcells
- getting the absorption maxima deeper into the IR

→ efficiencies expected above 2 – 3%

thank you for your attention

Do you have any questions?