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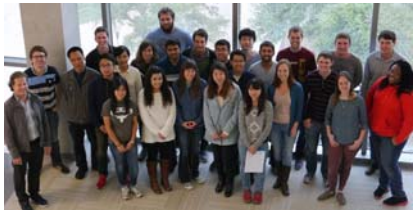
Nanomaterials Chemistry and Engineering



Photovoltaics

Lithium ion batteries

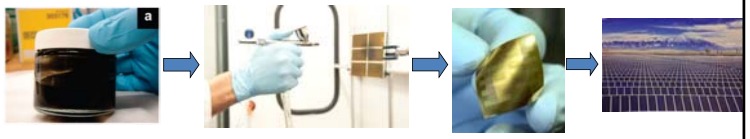
Silicon nanocrystals and nanocrystal/liposome complexes

Nanocrystal superlattices

GOAL:
Make photovoltaic (PV) electricity a major source of energy

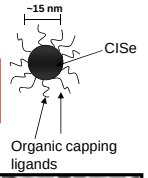
New concepts enabled by nanotechnology:

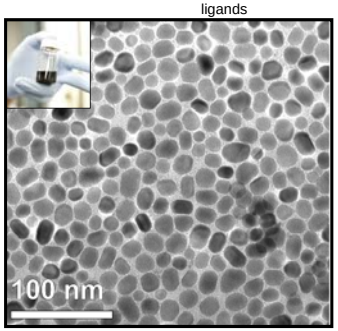
"Low-cost solar cells that can be printed like newspaper"



Chemical synthesis of CIGS nanocrystals

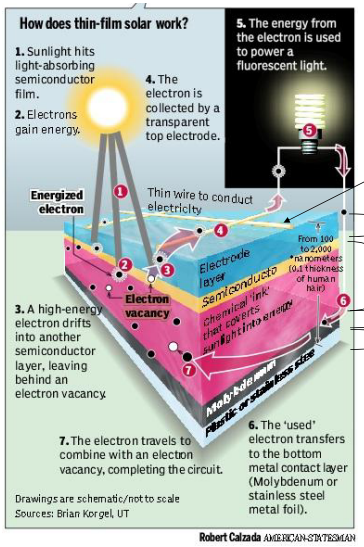
$CuCl + InCl_3 + 2Se \xrightarrow{\text{oleylamine, } 240^oC} CuInSe_2$ nanocrystals





Dariya Reid (undergraduate chemical engineer)

Concept: process the semiconductor layer by room temperature ink deposition



Metal

n-type semiconductor

Nanocrystal ink

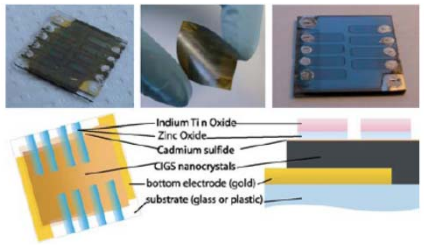
Metal

Glass or plastic support

Energy Environ. Sci., 2010, **3**, 1600–1606
PAPER www.rsc.org/ees | Energy & Environmental Science

Spray-deposited $CuInSe_2$ nanocrystal photovoltaics

Vahid A. Akhavan,[ab] Brian W. Goodfellow,[ab] Matthew G. Panthani,[ab] Dariya K. Reid,[a] Danny J. Hellebusch,[a] Takuji Adachi[bc] and Brian A. Korgel[*ab]



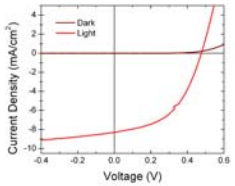


Fig. 3 (Top) Photographs of PVs fabricated by spray-depositing CIS nanocrystals on various substrates: (top left and right) glass and (top, middle) plastic (kapton). (Bottom) Illustration of the device layer structure as viewed from the top and from the side.

Voc = 476 mV
Jsc = 8.3 mA/cm^2
FF = 0.488
η = 1.9%

Efficiency of 2% on plastic

Reader's Digest .com

25 Inventions That Will Improve Your Life

Brilliant ideas, inventions, and gadgets for everyday life.

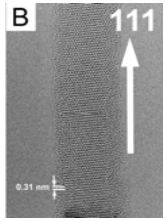
12. Spray-On Solar Panels

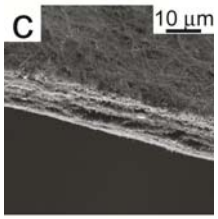
While solar panels are hot with homeowners for warming the house and saving electricity, they're often rejected as costly and tricky to install. Now engineers are racing to make a more consumer-friendly version. One attractive candidate is solar ink. Applied with a spray gun, the ink allows builders and homeowners to turn windows, doors, and roofs into power-generating panels. Just spray it on the way you would on a model airplane, says Brian Korgel, the University of Texas at Austin chemical engineering professor who invented the technology. (The ink can also be printed on plastic sheets using an ink-jet-type printer.) He expects the ink to be available in three to five years.

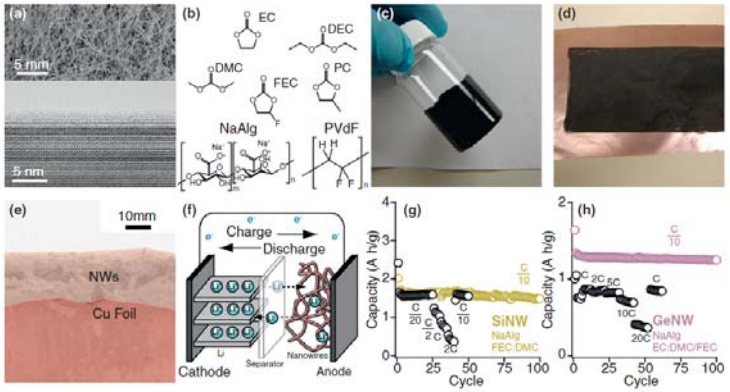
The challenge is to demonstrate commercially viable efficiencies of >10% (currently, the devices function at 3%)

Bulk silicon

Silicon fabric

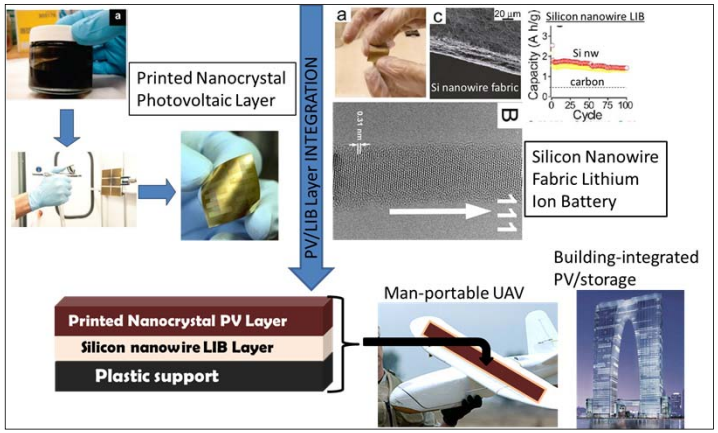






Current Opinion in Chemical Engineering 2013, 2:1–8

Integrated Energy Storage and Harvesting

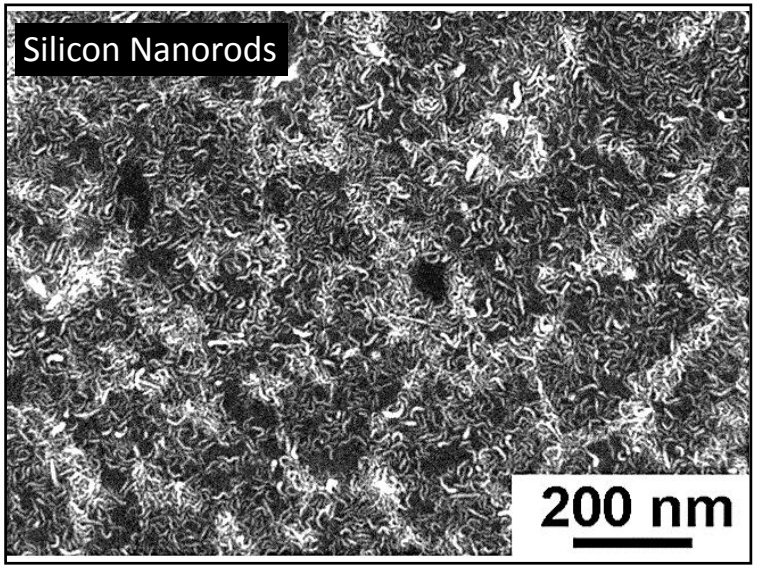


NANO LETTERS

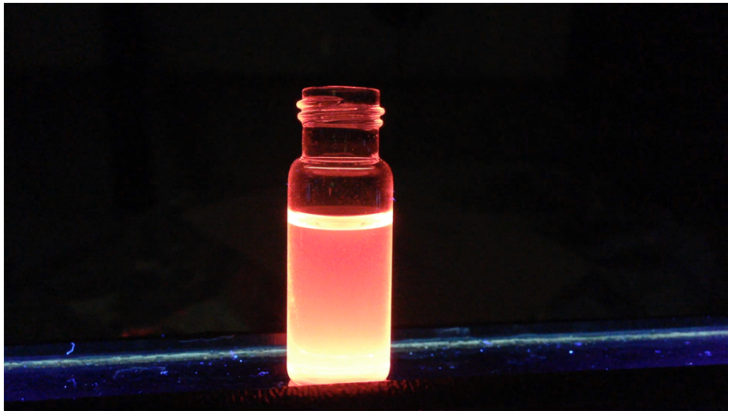
Colloidal Luminescent Silicon Nanorods

Xiaotang Lu, Colin M. Hessel, Yixuan Yu, Timothy D. Bogart, and Brian A. Korgel*

Nano Lett. 2013, 13, 3101–3105



Thiol-capped Si nanocrystals ligand-exchanged with dodecene exposed ethanol (with air/water)



Nanocrystal/Liposome complexes for combined medical diagnostics & therapy

Approach: Pre-synthesize nanocrystals and then add to vesicles

Question: will hydrophobic nanocrystals embed in the vesicle membrane without disrupting its formation?

If so, is there a size limitation? (Membrane thickness is 3.7 nm)

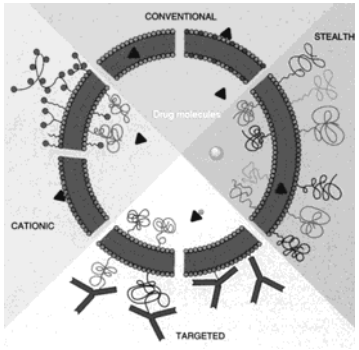
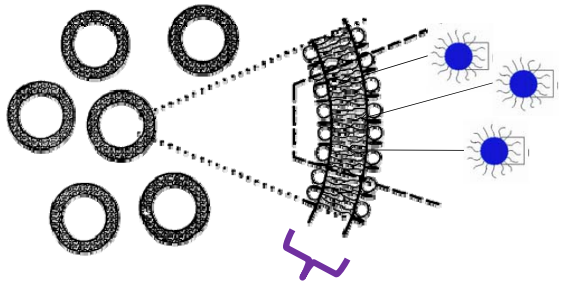


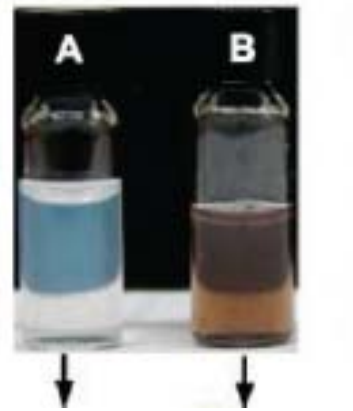
Image from: http://www.uzh.ch/onkwww/images/lipos4.gif

Hydrophobic Nanocrystals in Vesicles (Liposomes)



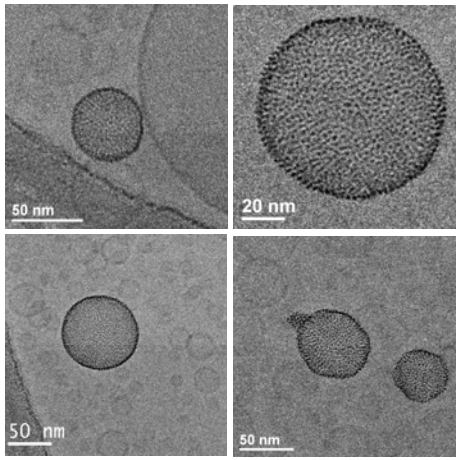
3.7 nm

Liposomes



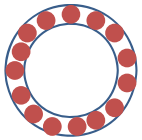
No nanocrystals w/ Au nanocrystals

Loading NCs Into Vesicles: Sonication & Extrusion



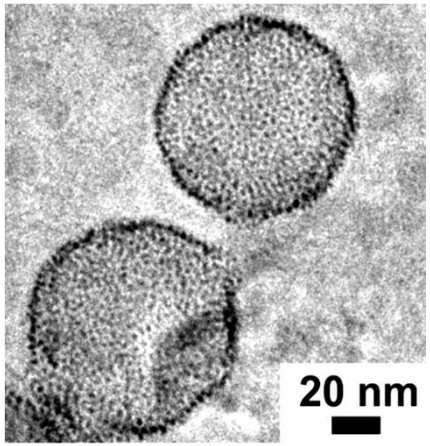
1500 lipid molecules per Au NC

- Many fully-loaded vesicles are found across the grid
- Many vesicles without nanocrystals observed as well



~1300 NC/vesicle calculated for 1.6 nm Au & 50 nm vesicle

Cryo-TEM Images of Au nanocrystal-loaded PC vesicles made by sonication/extrusion



Korgel group

Current focus on photovoltaic devices (solar cells), lithium ion batteries and medical applications of silicon

Research involves materials discovery, advanced analytical characterization, and device/application prototyping

Highly collaborative group—interdisciplinary research without boundaries