Nanotechnology for Sustainable Energy:
A Very Small Solution to a Very Big Problem

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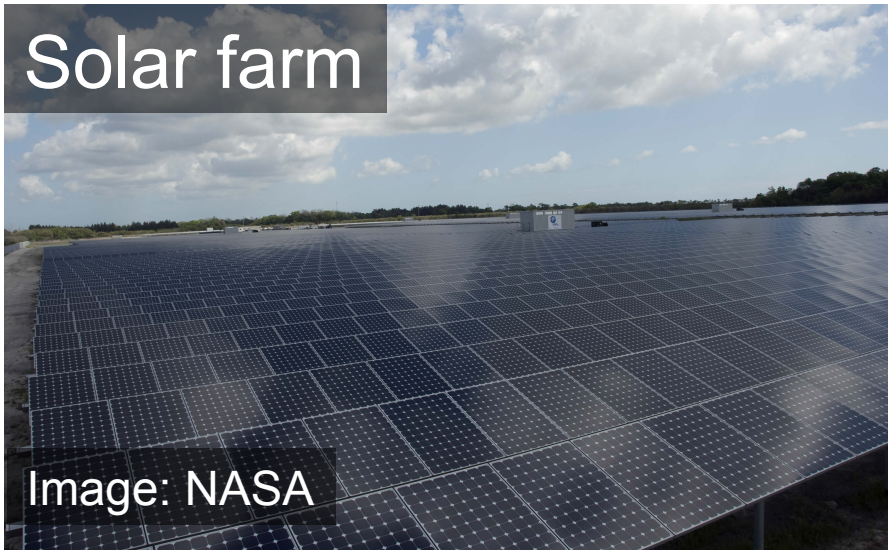
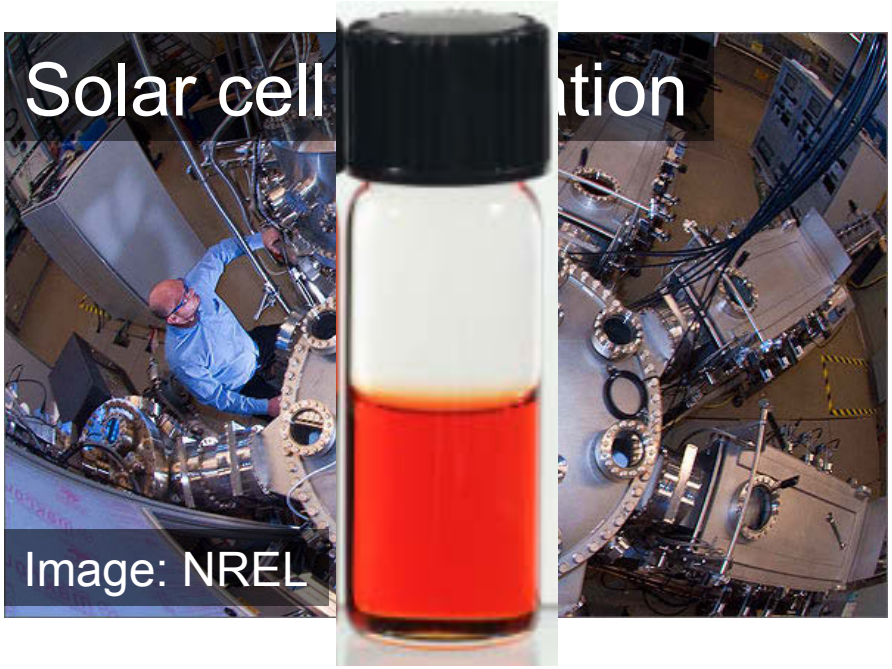
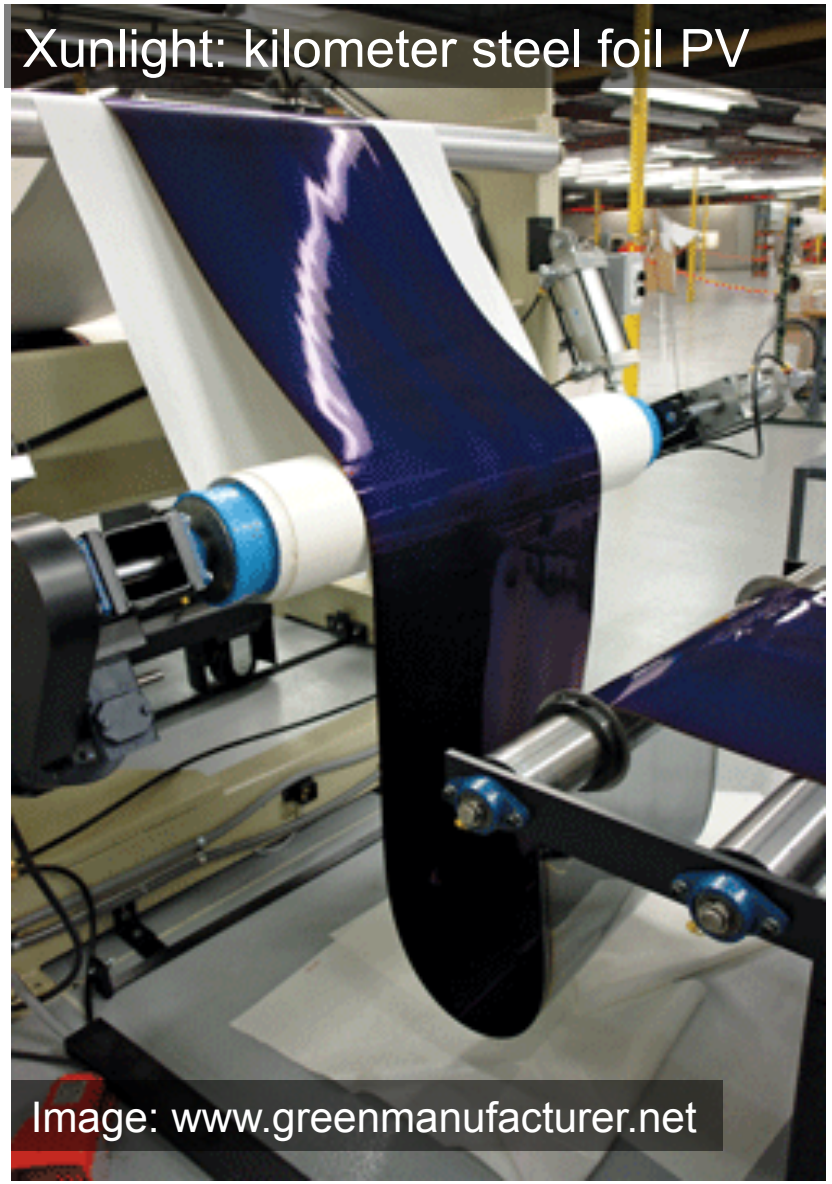
A high-stakes experiment

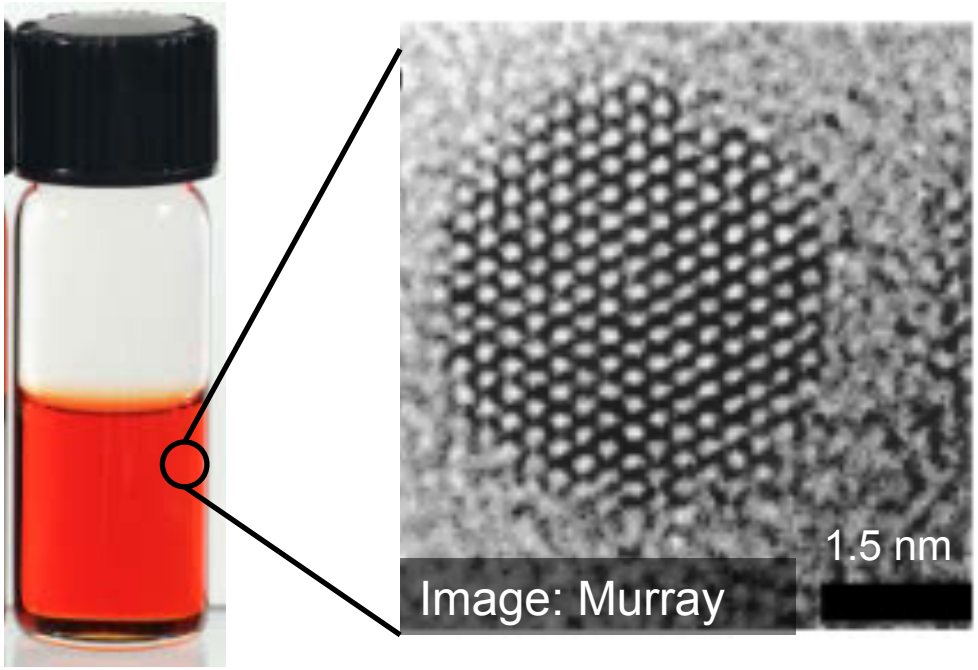
Photovoltaics

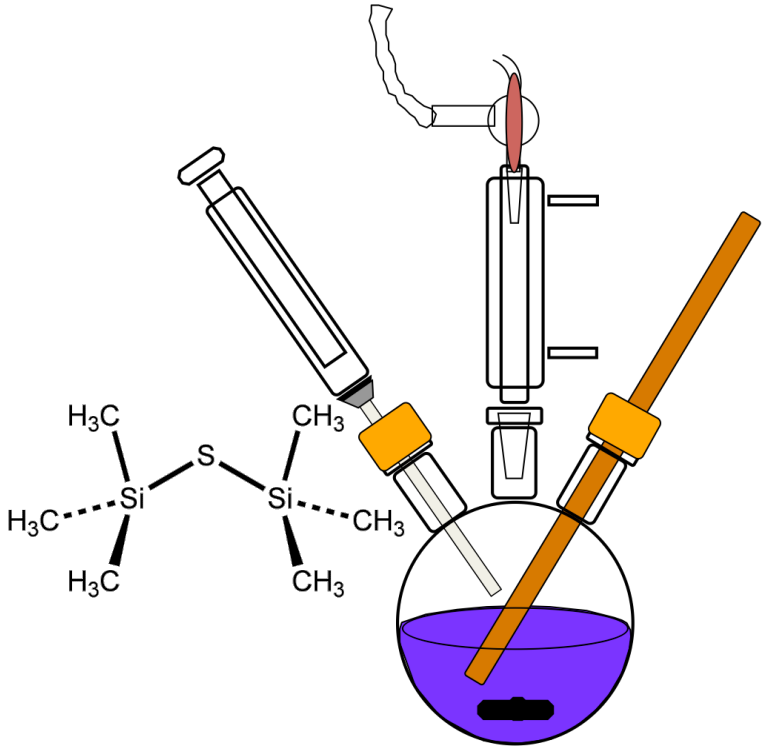




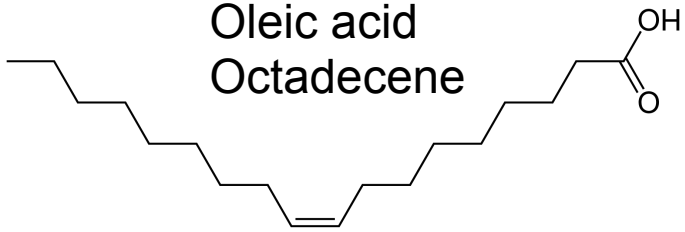


What is in a nanocrystal “ink”



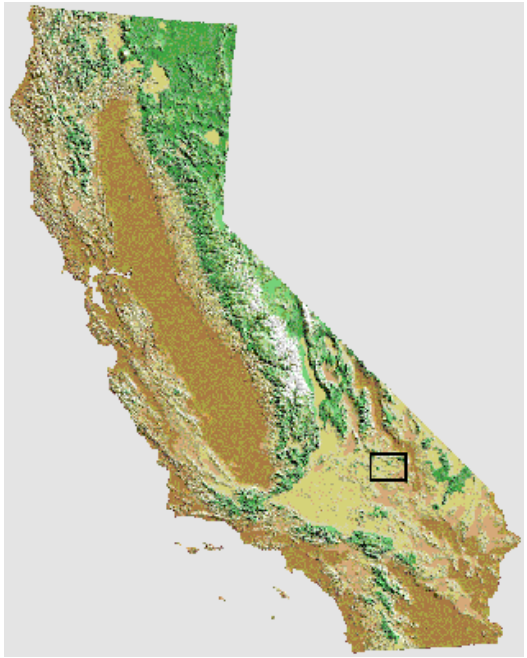


Lead (II) Oxide
Oleic acid
Octadecene



Aside: material considerations

- 16 TW
- >80% Fossil Fuel



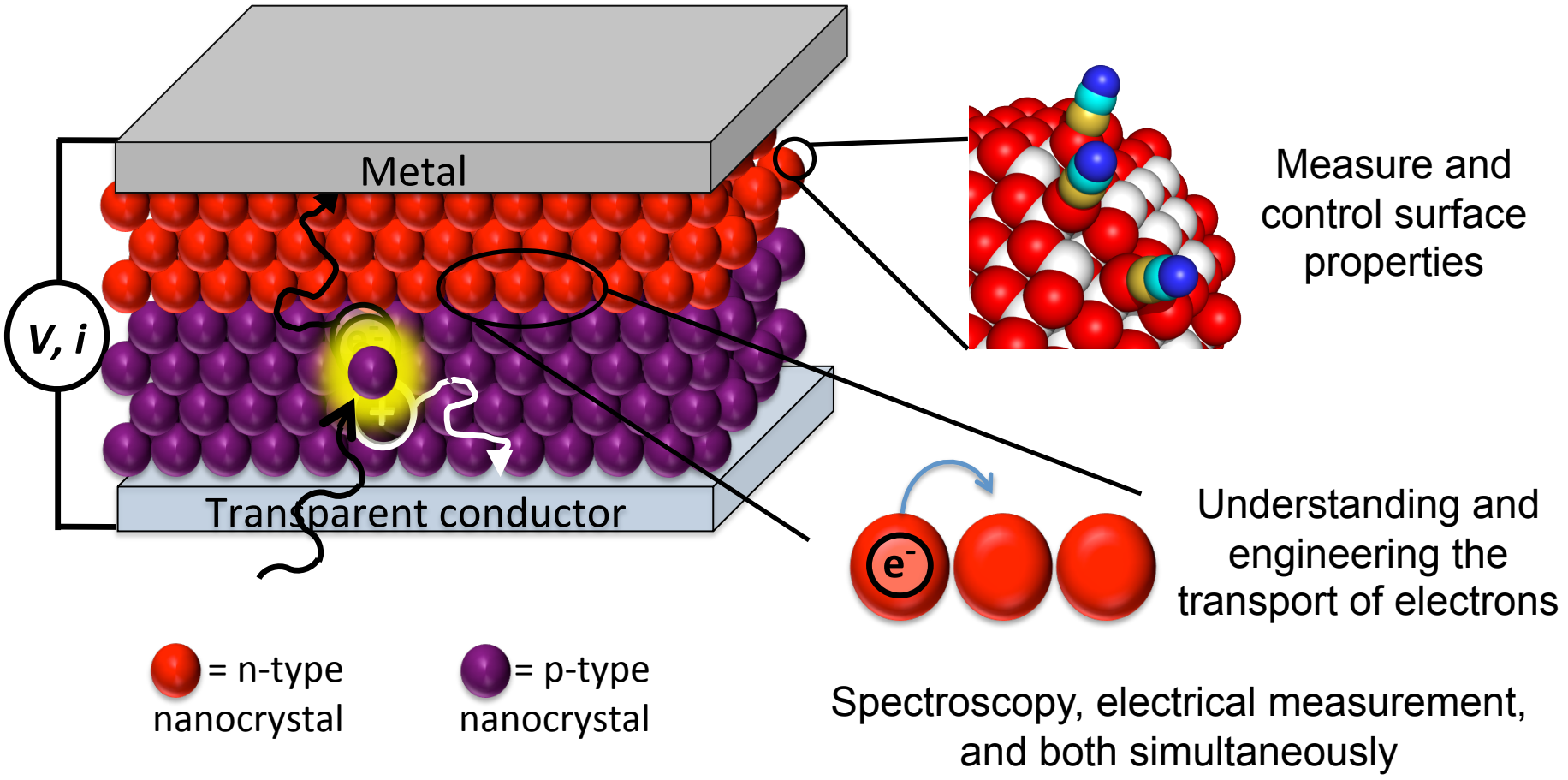
- 170 mi^2 at 15% efficiency
  → California

Earth abundance

1 **H** Hydrogen 0.15	Atomic # / Symbol / Name / Percent																2 **He** Helium 5.5e-7
3 **Li** Lithium 0.0017	4 **Be** Beryllium 0.00019											5 **B** Boron 0.00086	6 **C** Carbon 0.18	7 **N** Nitrogen 0.0020	8 **O** Oxygen 46	9 **F** Fluorine 0.054	10 **Ne** Neon 3.0e-7
11 **Na** Sodium 2.3	12 **Mg** Magnesium 2.9											13 **Al** Aluminium 8.1	14 **Si** Silicon 27	15 **P** Phosphorus 0.099	16 **S** Sulfur 0.042	17 **Cl** Chlorine 0.017	18 **Ar** Argon 0.00015
19 **K** Potassium 1.5	20 **Ca** Calcium 5.0	21 **Sc** Scandium 0.0026	22 **Ti** Titanium 0.66	23 **V** Vanadium 0.019	24 **Cr** Chromium 0.014	25 **Mn** Manganese 0.11	26 **Fe** Iron 6.3	27 **Co** Cobalt 0.0030	28 **Ni** Nickel 0.0089	29 **Cu** Copper 0.0068	30 **Zn** Zinc 0.0078	31 **Ga** Gallium 0.0019	32 **Ge** Germanium 0.00014	33 **As** Arsenic 0.00021	34 **Se** Selenium 5.0e-6	35 **Br** Bromine 0.00030	36 **Kr** Krypton 1.5e-8
37 **Rb** Rubidium 0.0060	38 **Sr** Strontium 0.036	39 **Y** Yttrium 0.0029	40 **Zr** Zirconium 0.013	41 **Nb** Niobium 0.0017	42 **Mo** Molybdenur 0.00011	43 **Tc** Technetium 0	44 **Ru** Ruthenium 9.9e-8	45 **Rh** Rhodium 7.0e-8	46 **Pd** Palladium 6.3e-7	47 **Ag** Silver 7.9e-6	48 **Cd** Cadmium 0.000015	49 **In** Indium 0.000016	50 **Sn** Tin 0.00022	51 **Sb** Antimony 0.000020	52 **Te** Tellurium 9.9e-8	53 **I** Iodine 0.000049	54 **Xe** Xenon 2.0e-9
55 **Cs** Caesium 0.00019	56 **Ba** Barium 0.034	57–71	72 **Hf** Hafnium 0.00033	73 **Ta** Tantalum 0.00017	74 **W** Tungsten 0.00011	75 **Re** Rhenium 2.6e-7	76 **Os** Osmium 1.8e-7	77 **Ir** Iridium 4.0e-8	78 **Pt** Platinum 3.7e-6	79 **Au** Gold 3.1e-7	80 **Hg** Mercury 6.7e-6	81 **Tl** Thallium 0.000053	82 **Pb** Lead 0.00099	83 **Bi** Bismuth 2.5e-6	84 **Po** Polonium	85 **At** Astatine 0	86 **Rn** Radon

Nanocrystal-based solar cell

Low-cost, wide-area fabrication: spin- and spray-casting, electrodeposition

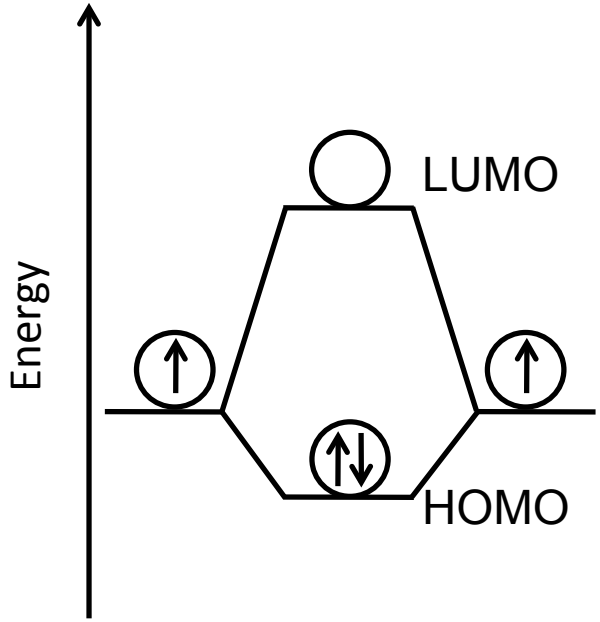


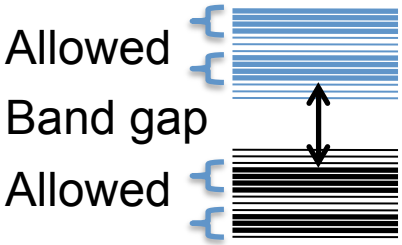
Semiconductors and molecules: only certain allowed states

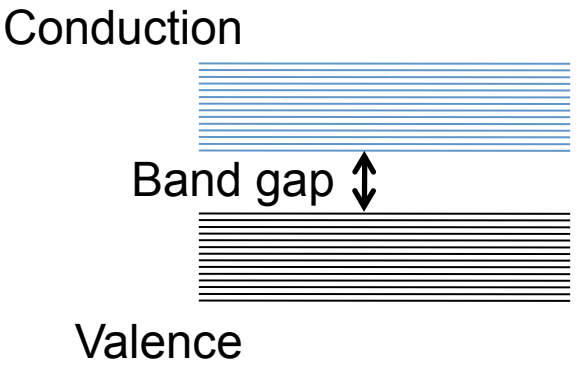
Linear combination of atomic orbitals (LCAO) leads to MOs

Large number of atoms → states cluster into bands

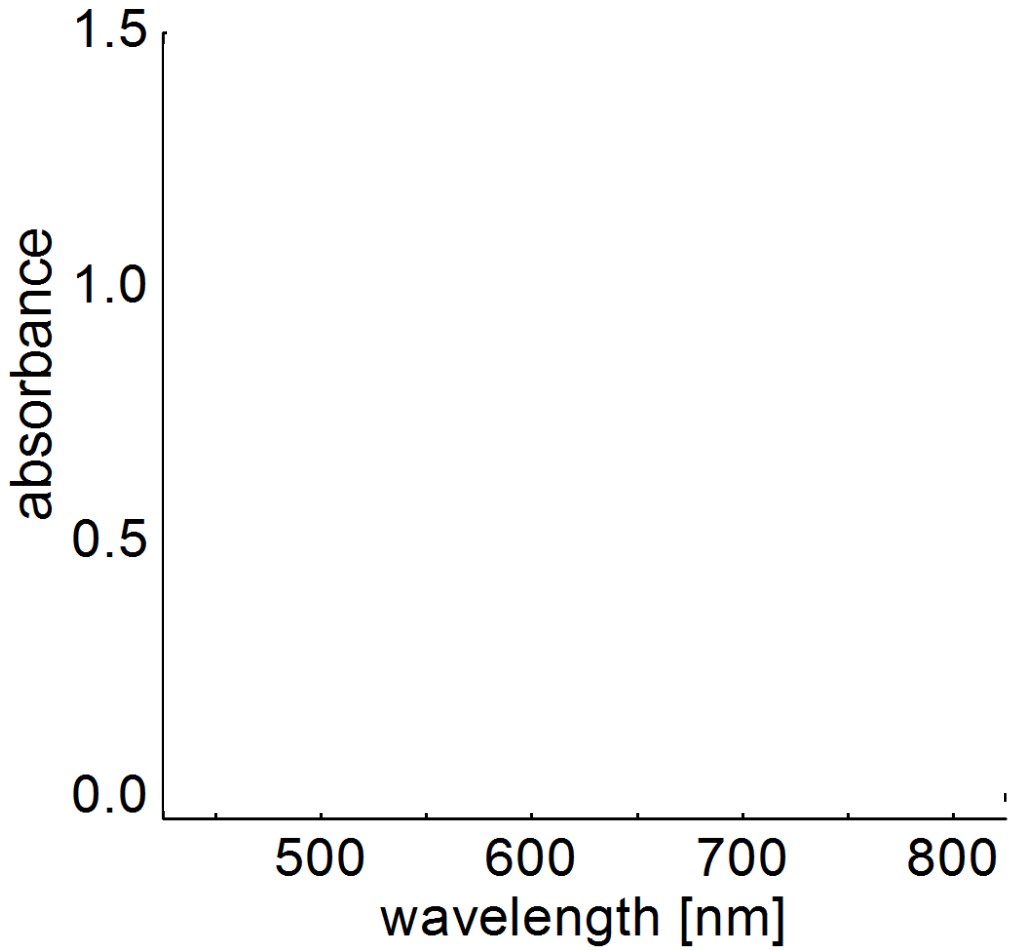
Size can restrict the available states

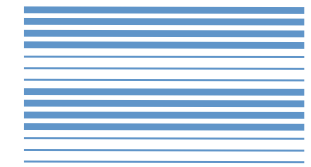






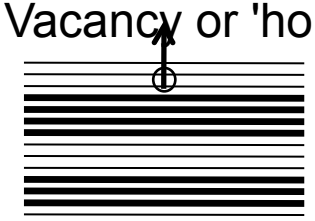
Measuring nanocrystal excitations



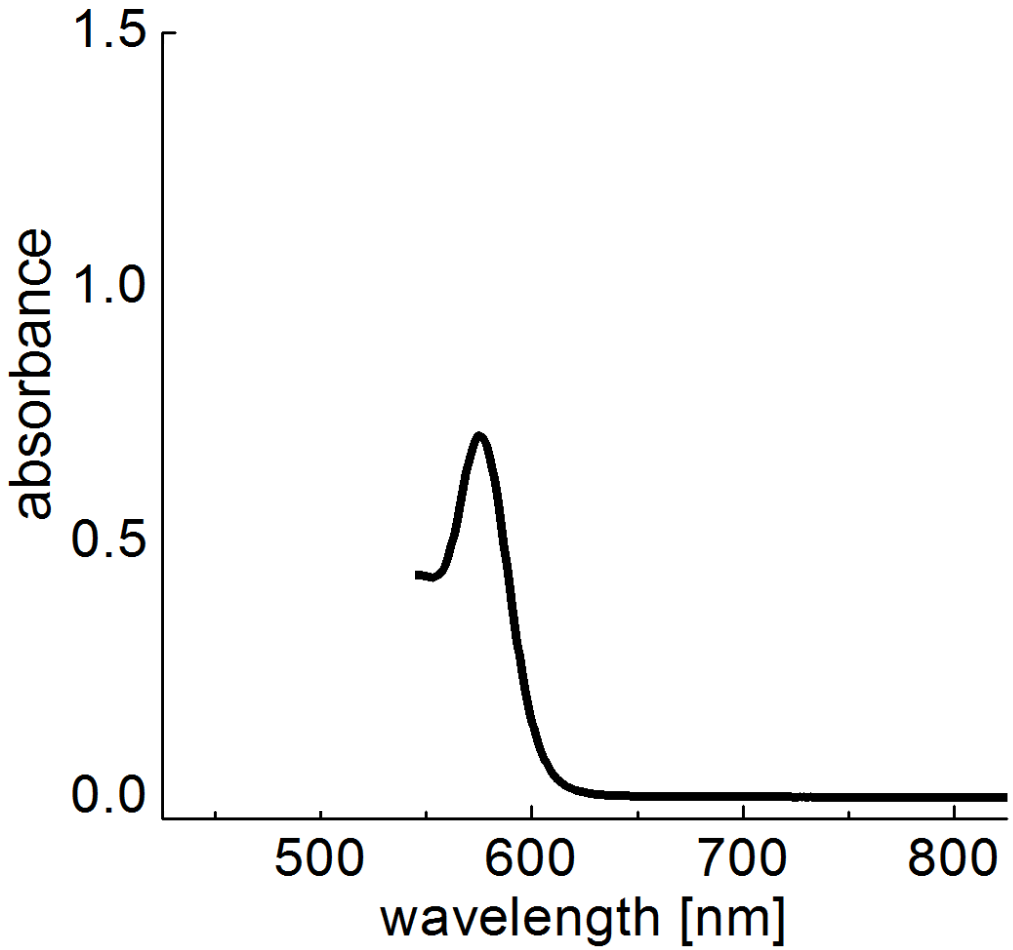


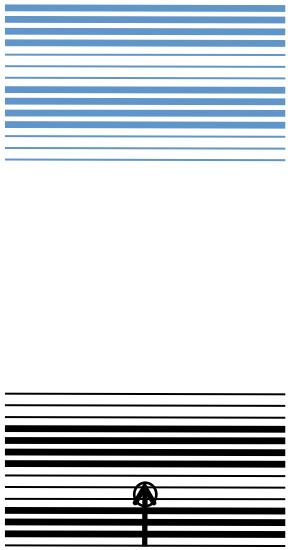
Excited electron

Vacancy or 'hole'

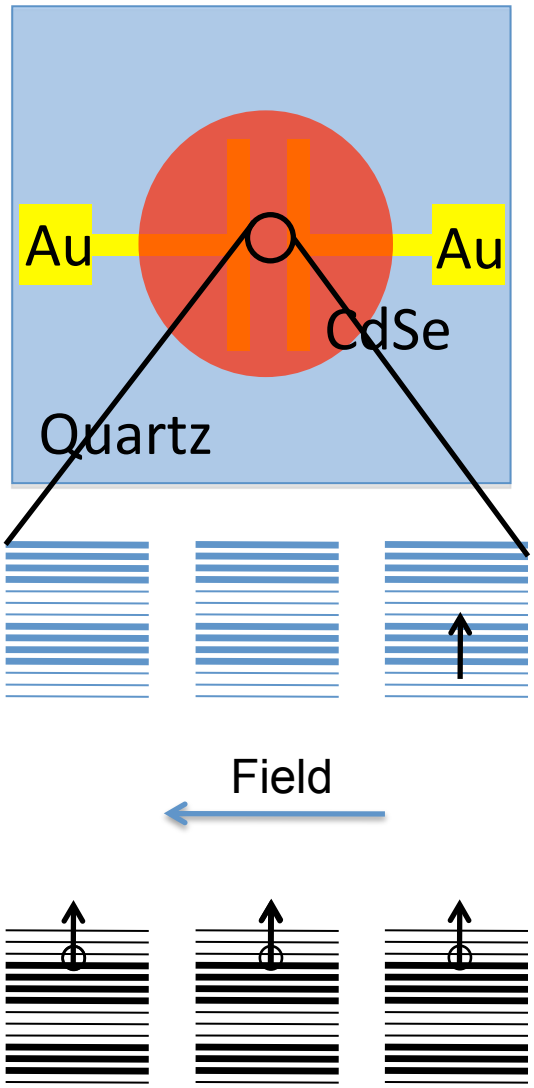


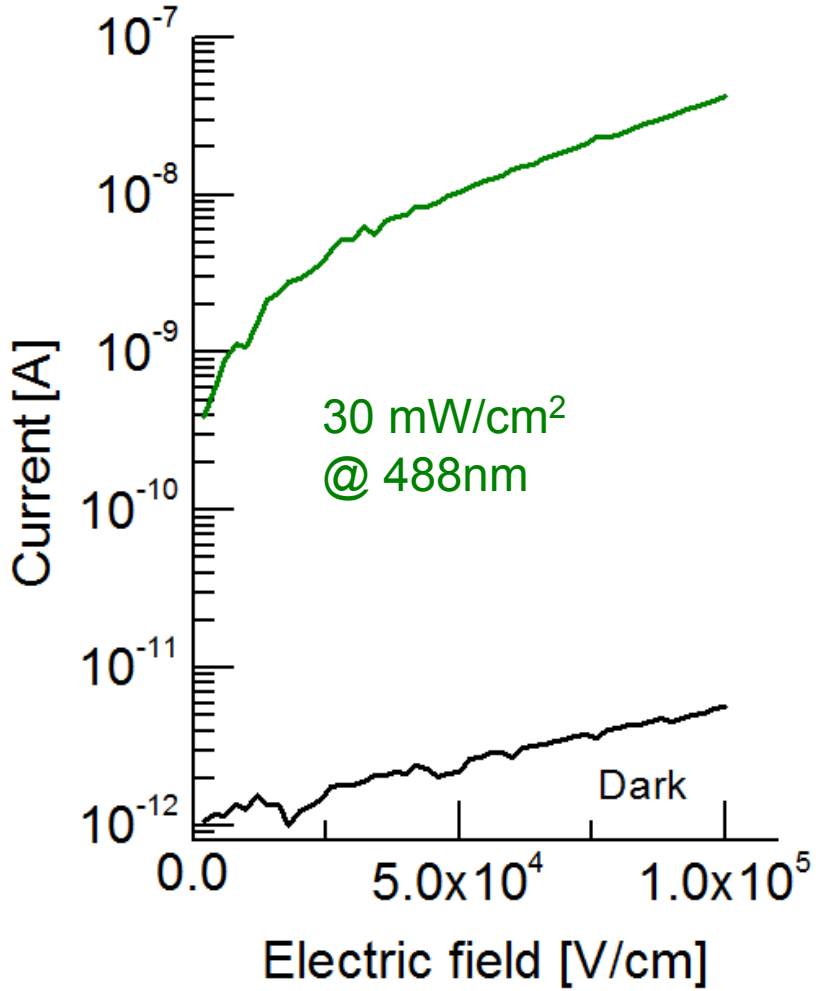
Measuring nanocrystal excitations



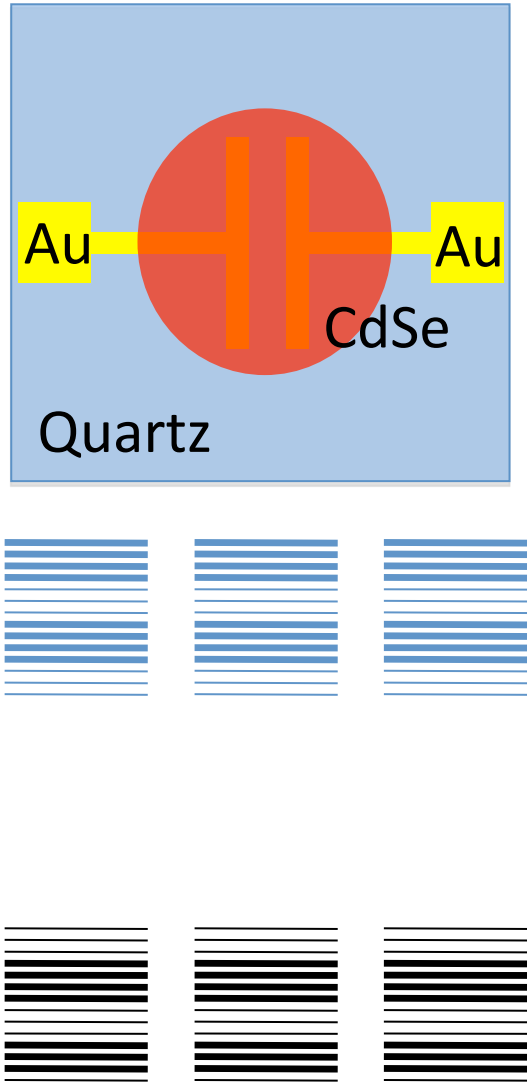


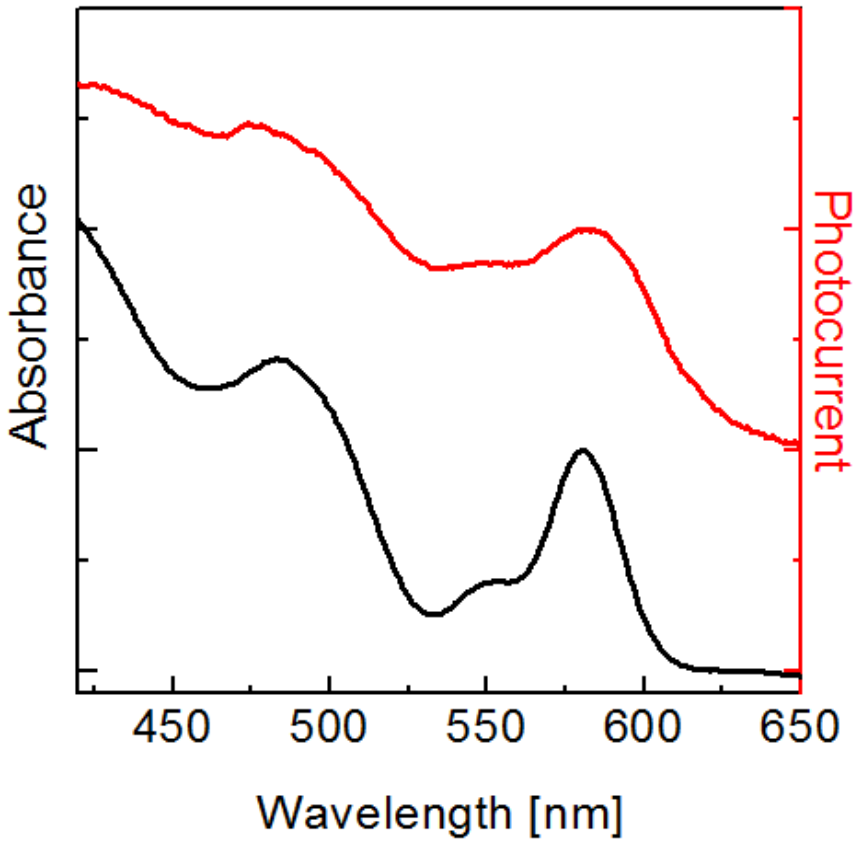
Quantum dot-based photodetector



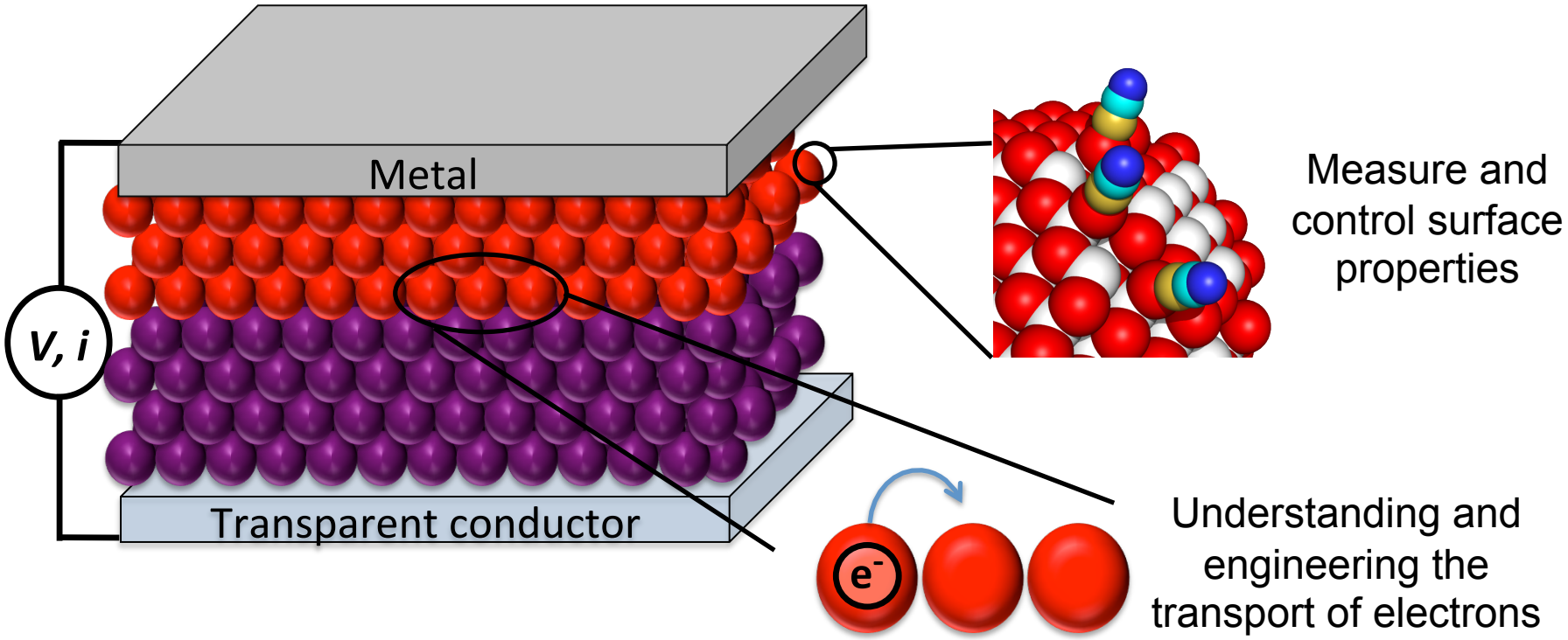


Photocurrent due to nanocrystal excited states





Collected charges originate in the excitation of quantum confined states



Thank you

Questions?