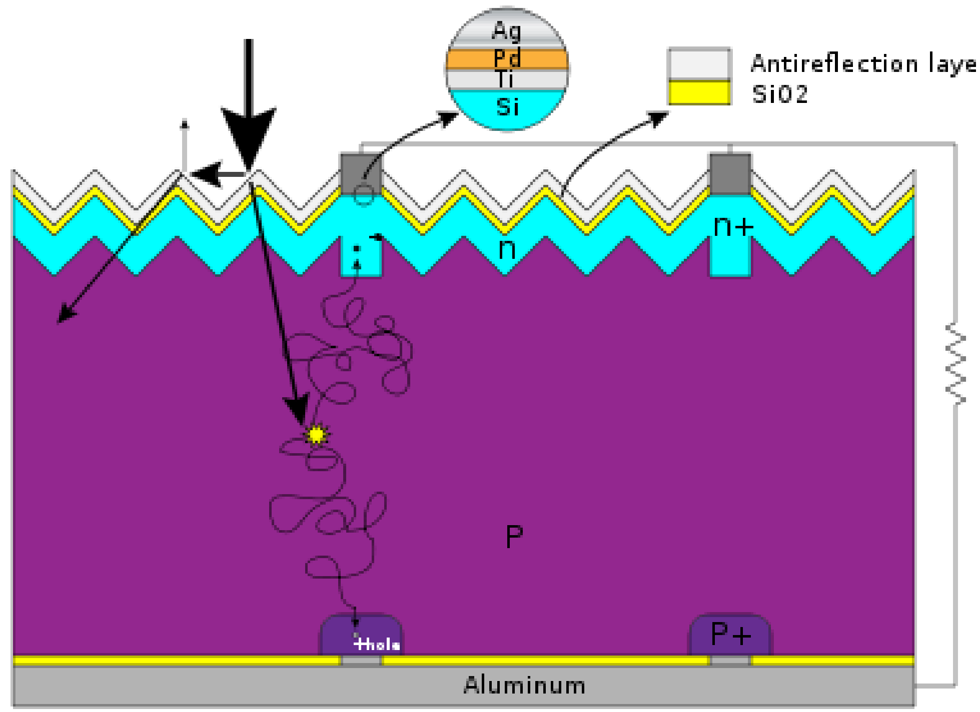
Physics of a Solar Cell – What to pay attention to as we develop the models from elementary solid state physics.

Step 1: Light hitting the solar cell

- Reflection:
  - Anti-reflection coatings (alternating dielectric layers)
  - Texturing to increase number of bounces before reflecting (works against surface recombination)
- Wavelength of light (energy content per photon)
- Angle of incidence
- Cover glass/module optics
- Full metal back coverage can be used to give non-absorbed photons a "second chance" but the metal also creates strong points for electron-hole-pair recombination



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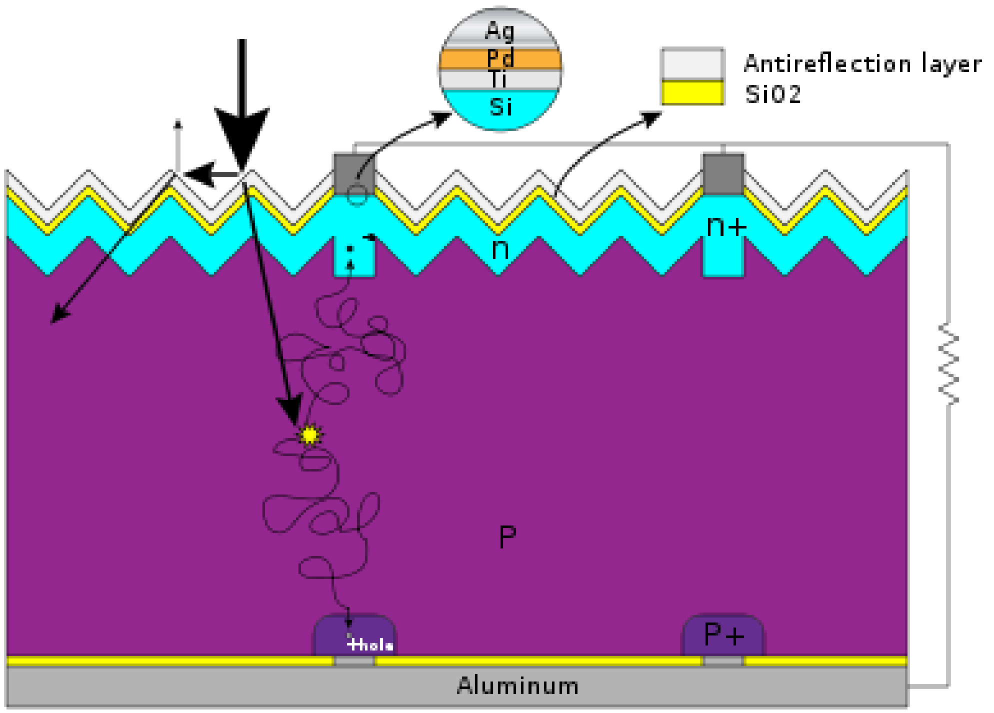
Step 2: Absorbing Light and generating carriers

- Energy bandgap:
  - Determines which photons get absorbed and how soon
  - Direct vs. indirect bandgaps determine how thick the device has to be (thicker absorbs more light but thinner tends to produce more voltage)
- Where in the device the light is absorbed relative to the collecting junction– toward the front or back



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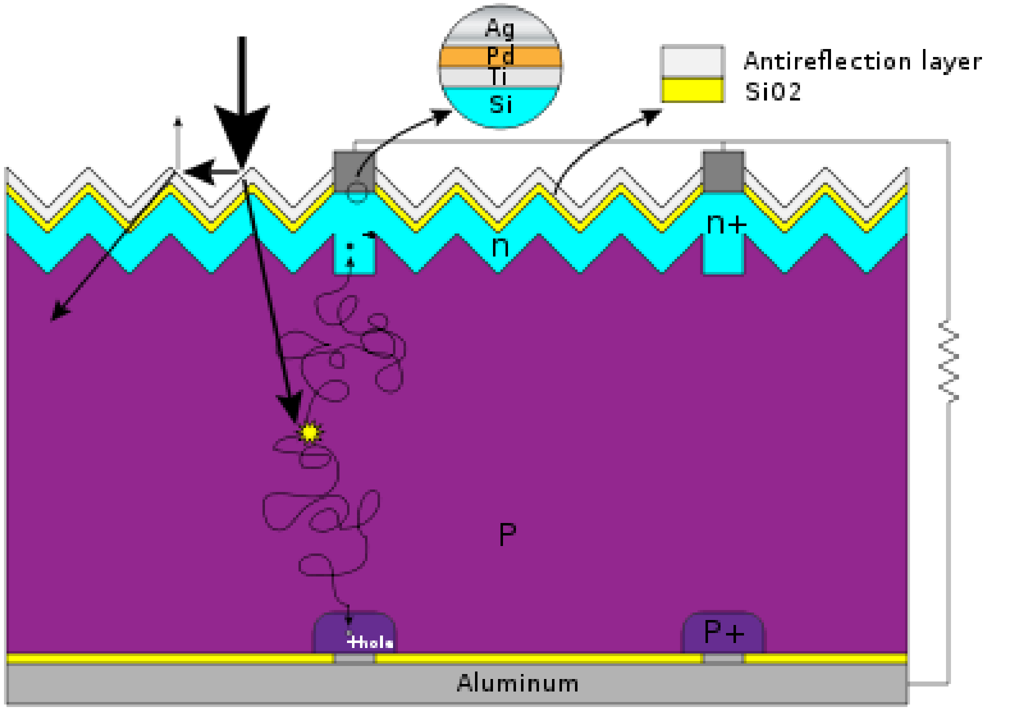
Step 3: Diffusion of electron-hole pairs

- •Recombination (electron killing off a hole) is key.
- •Semiconductors "Minority carrier diffusion length"
    - •Determined by the materials "mobility" and "minority carrier lifetime"
- •Recombination at Internal defects: "trap states" at point defects (missing, extra or displaced atoms), extended defects (missing/extra columns or planes of atoms such as grain boundaries)
- •Surfaces represent "enormous defects"
- •Metal contacts kill off minority carriers.



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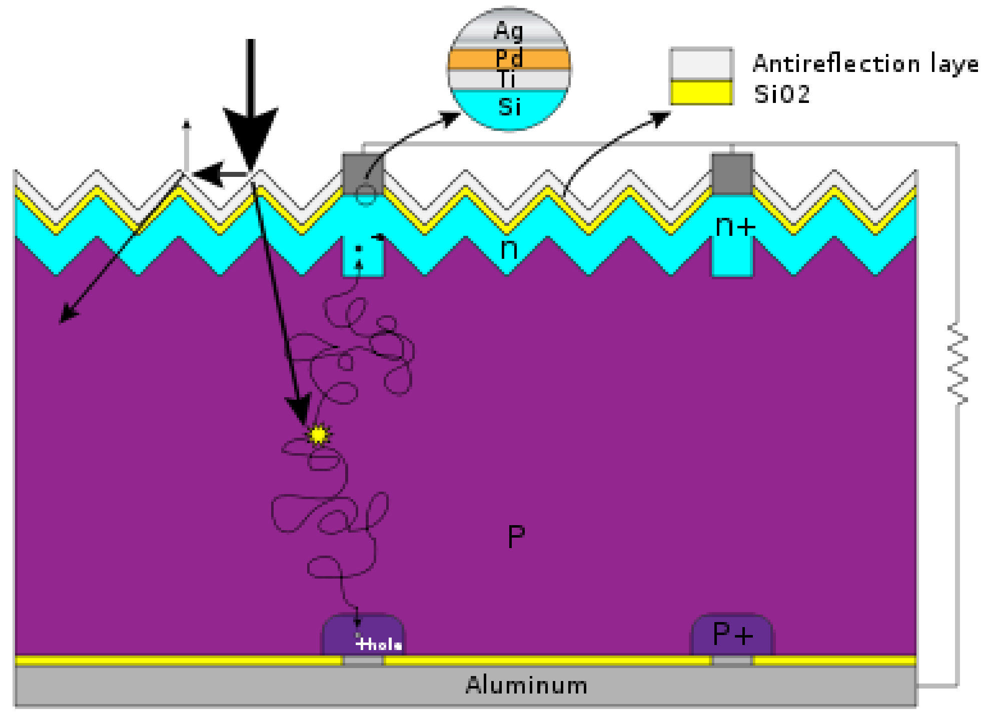
Step 4: Collection or "separation" of electron-hole pairs

•Requires a force, most often resultant from an internal electric field. Can separate the electron from the hole to create a voltage.

- •Treating the region of the device that has an electric field as a dielectric, Q = CV (capacitor, but in a solar cell, C is a highly non-linear function of V)
- •Separated charge can be "discharged" to drive current into an external circuit, i.e. generating power.
- •Local defects near the "junction" or weak electric fields will result in poor isolation of adjacent sides causing Shunting (partial shorting) of the electric fields.
- •After "separation of the electrons from the holes, the carriers are now "majority carriers ready to enter the metal wires.



Physics of a Solar Cell – What to pay attention to as we develop the models from elementary solid state physics.

Step 5: Driving current into solar cell metal wires and external wiring

- Metal "Ohmic Contacts" only carry majority carriers.
    - Separated electrons/holes can enter wires
    - Yet – to – be separated electrons-hole pairs will recombine if they get near the metal

- Resistive losses (series resistances) waste the generated power and are engineered to be minimum

- Metal-semiconductor contacts are a major source of series resistance, long term failure and manufacturing headaches.