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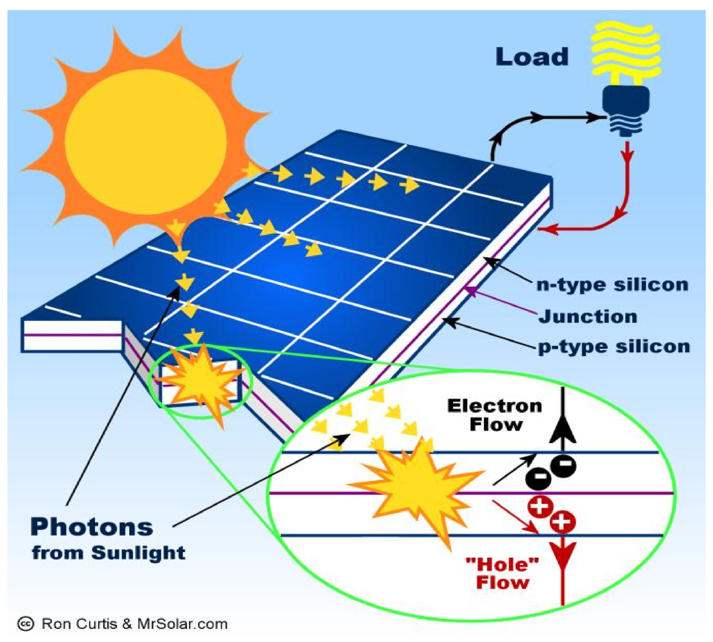
Gallium Arsenide for PV applications

Abstract

The extensive use of fossil fuels is well-known to be the main cause of global warming, pollution, and natural disasters. PV technology is the most promising alternative to coal, gas, and oil. Currently silicon is the most widely used material in PV industry, but its low efficiency and high cost of production is the major problem. Gallium Arsenide is believed to be the most suitable option for the development of future solar cells.

What are Photovoltaics?



Photovoltaic cells are used to produce electricity by absorbing sunlight. Some semiconductor materials such as Si, GaAs and Ge have a property known as the photoelectric effect that causes them to absorb photons and release electrons. Releasing these electrons results in an electric current that can be used as electricity.

Current Problems

Fossil fuels

global warming | pollution | Natural disasters

PV

- Clean and renewable energy source
- Free energy source
- Energy available anywhere in the world
- High cost
- Low efficiency
- No energy production at night

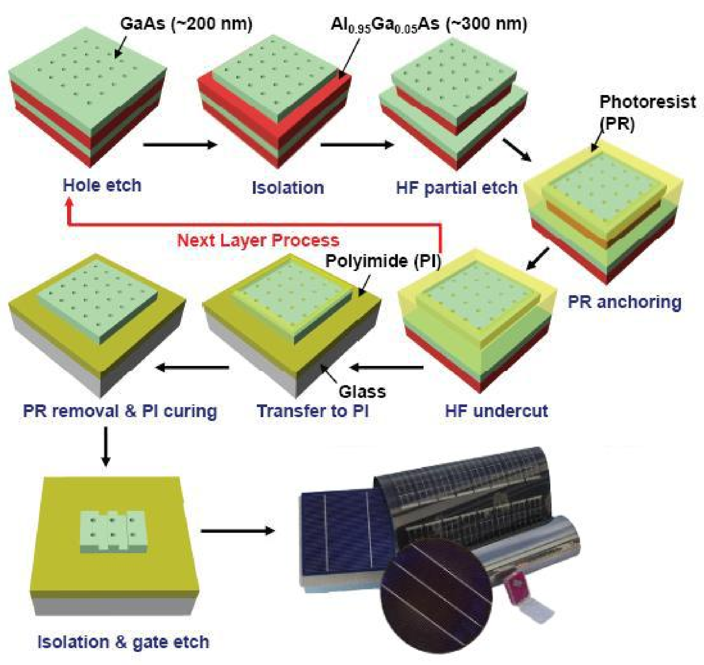
Gallium Arsenide	Silicon
+ Its high electron mobility allows faster operation and it has a wide band gap. + High light absorption. + Direct and high band-gap, hence operation at high temperatures. + Useful for hetero-junction solar cells. + Works with much higher frequencies than silicon equivalents. + The energy efficiency of a single junction of GaAs photovoltaic cell is 31% under ideal condition (University of Maryland n.d.). + The energy efficiency is 25% under normal condition.	+ Very cheap (200 mm Si is 40 dollars) and abundant material. + Easy and well-known doping techniques. + Crystallization and high purity can be achieved through simple manufacturing processes. + Silicon dioxide layers can be grown through a simple chemical reaction with oxygen. + Relatively high band gap resulting in a low intrinsic carrier concentration, hence low leakage current.
- High cost (152.4 mm GaAs cost 200 dollars). - Its weight is about 5.15 times higher than silicon. (144.645 g/mol)	- Has an indirect band gap (around 1.12 eV) and a phonon is emitted instead. - In homo-junction silicon solar cells, only a small portion of radiation is absorbed. Low and High energy photons are not converted into electrical energy. - It is a stiff and non-flexible material. - Works only with a strong sunlight. - Reacts with organic and inorganic impurities, which result in fast degradation. - Under ideal conditions: 25% efficiency. Under normal condition: 10.69%. (Wiley 2013)

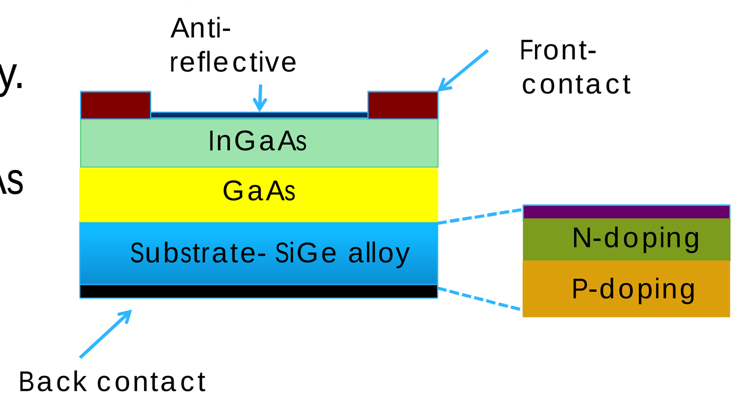
Drawbacks of Gallium Arsenide

- Expensive single-crystal GaAs substrate.
- Crystallization process of GaAs.
- The need for wafers to be grown in precisely controlled conditions

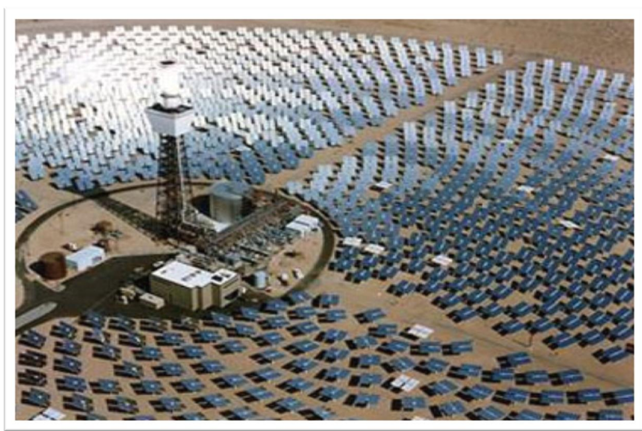
Solutions

1. Growing extremely thin layers of GaAs (1 micron)
   - reduces cost
   - increases already high efficiency
2. Start with a perfect GaAs crystal
   - no energy is lost to imperfections
3. Recycle photons until they are converted to electricity.
4. Fabricating GaAs cells on cheaper substrates
5. Growing GaAs cells on a removable and reusable GaAs substrate
6. Growing stacks of layers of GaAs alternating with aluminum arsenide (AlAs)





Applications for GaAs



Conclusion

In order to establish a sustainable future, more sufficient materials are needed, as well as to meet the needs of the growing population. Even though Gallium Arsenide has a high production cost, the efficiency of solar cells made with this material have proven to be the best alternative for large-scale solar cell applications, such as satellites. It is worth researching new methods for producing GaAs solar cells more efficiently.