Compound Semiconductor Based Micro-Thermophotovoltaic Power Generation Technologies

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What is Thermophotovoltaic Power Generation?

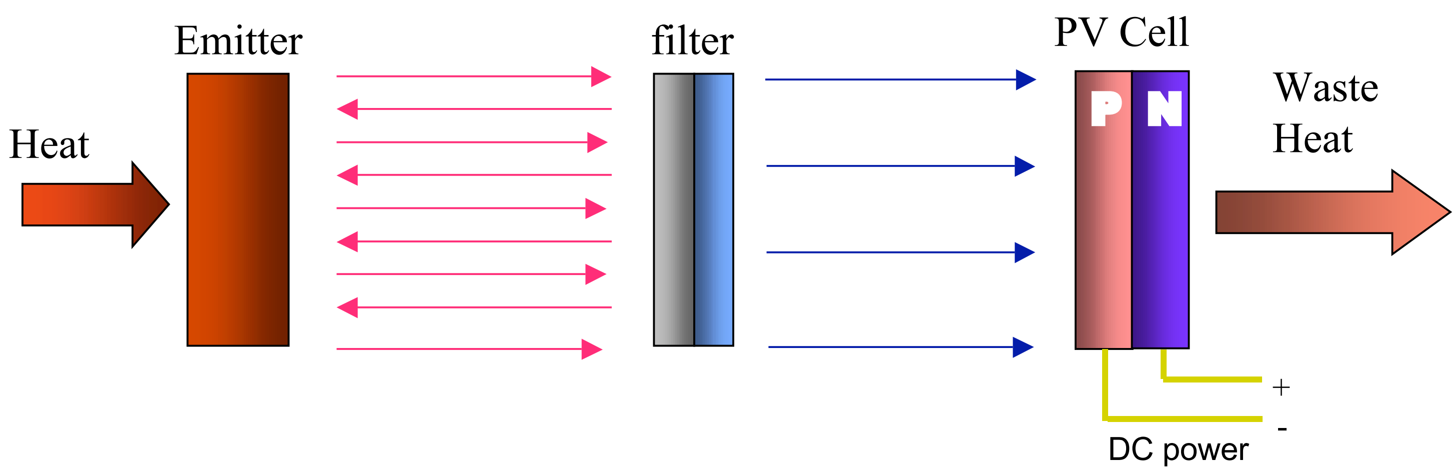
The conversion of thermal radiation to electrical energy directly!

The same principle by which solar power is generated.

Lower bandgap compound semiconductor are used to manufacture tpv cells.

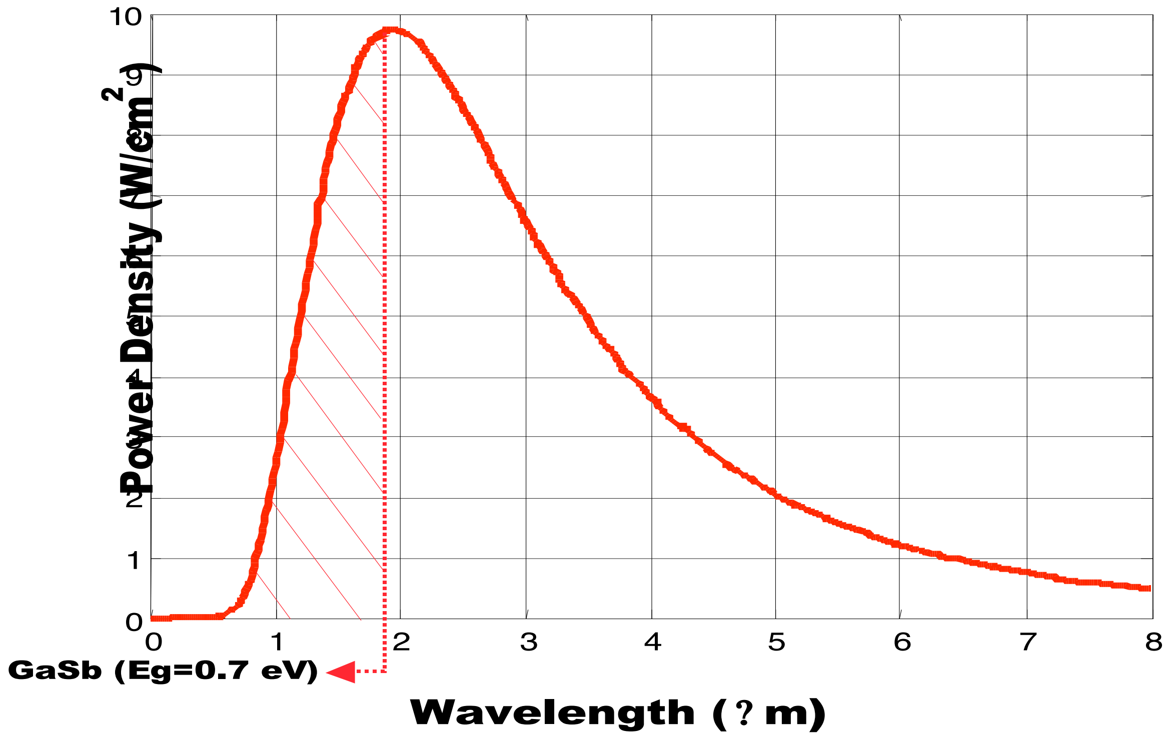
The lower bandgap material better matches the available spectra.

TPV Block Diagram

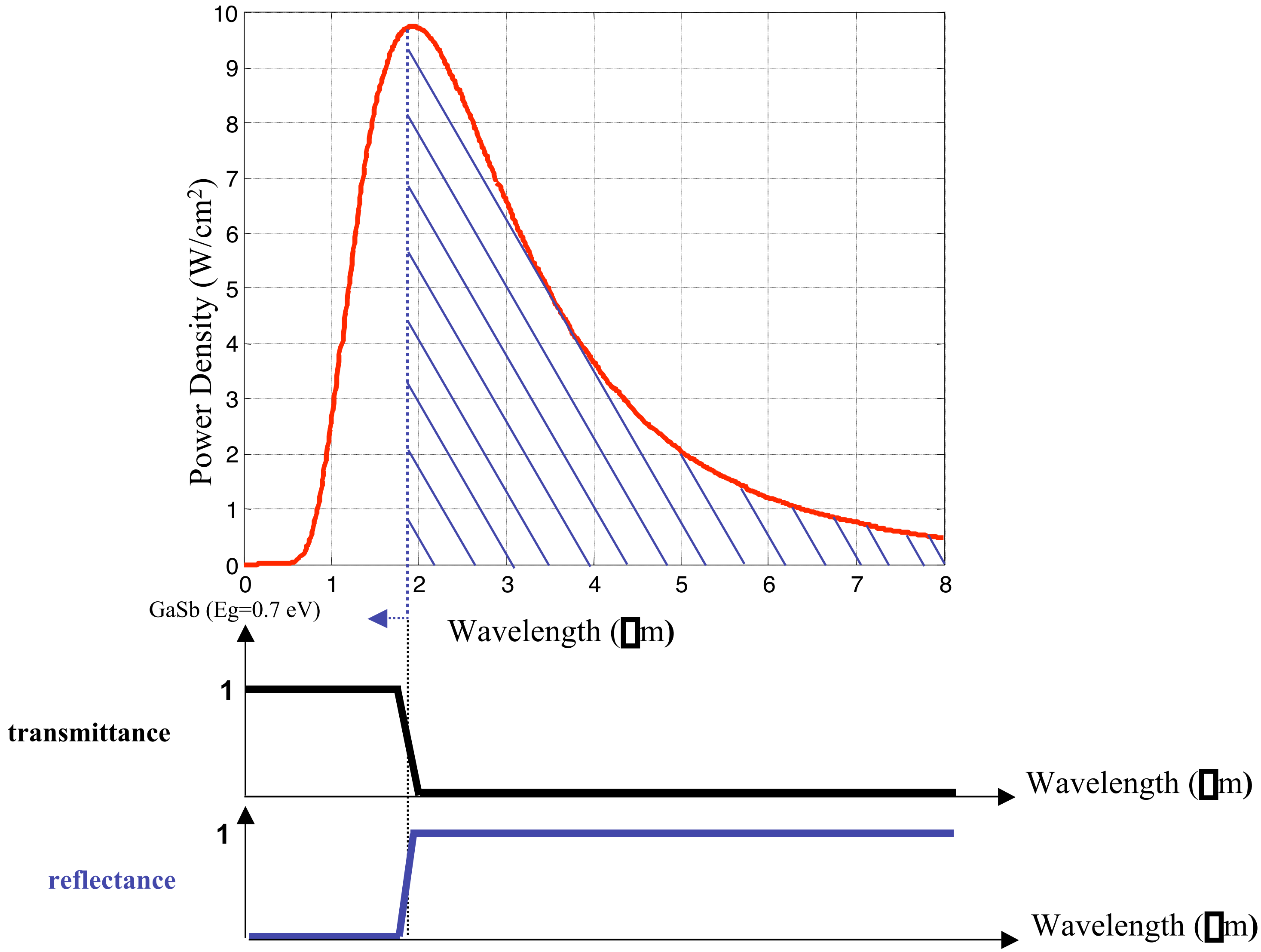


The emitter is heated and emits radiation. Typically with black-body like sprectrum

SiC is commonly used for this purpose: (Operated at temperatures in the 1500-1800K region)



Ideal Filter for TPV Application



What has tpv to offer in the real world?

Static power conversion, a major reliability issue!

Relatively good power density (In the 1.5 – 2.5 W/cm^2 range)

Problems do exits…

The technology does not scale upwards in size very well.

High power , high temperature engineering is exceptionally challenging.

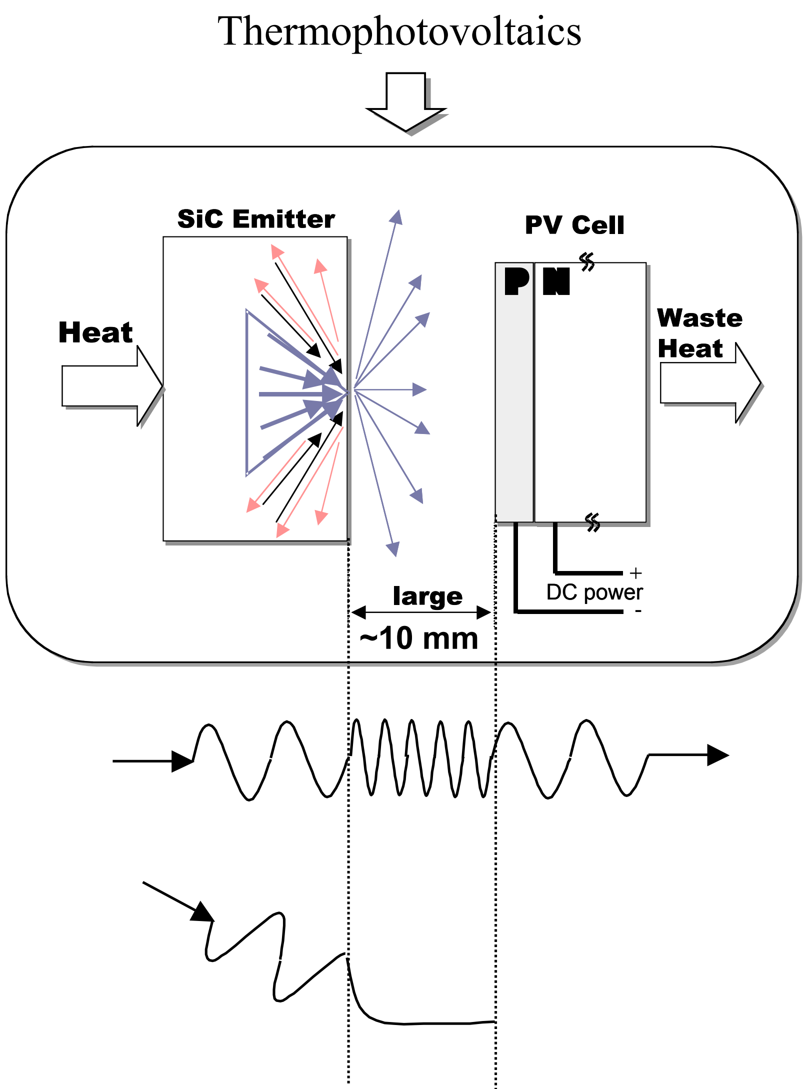
The solution…

Increase the output power density.

Reduce the operating temperatures.

But how?

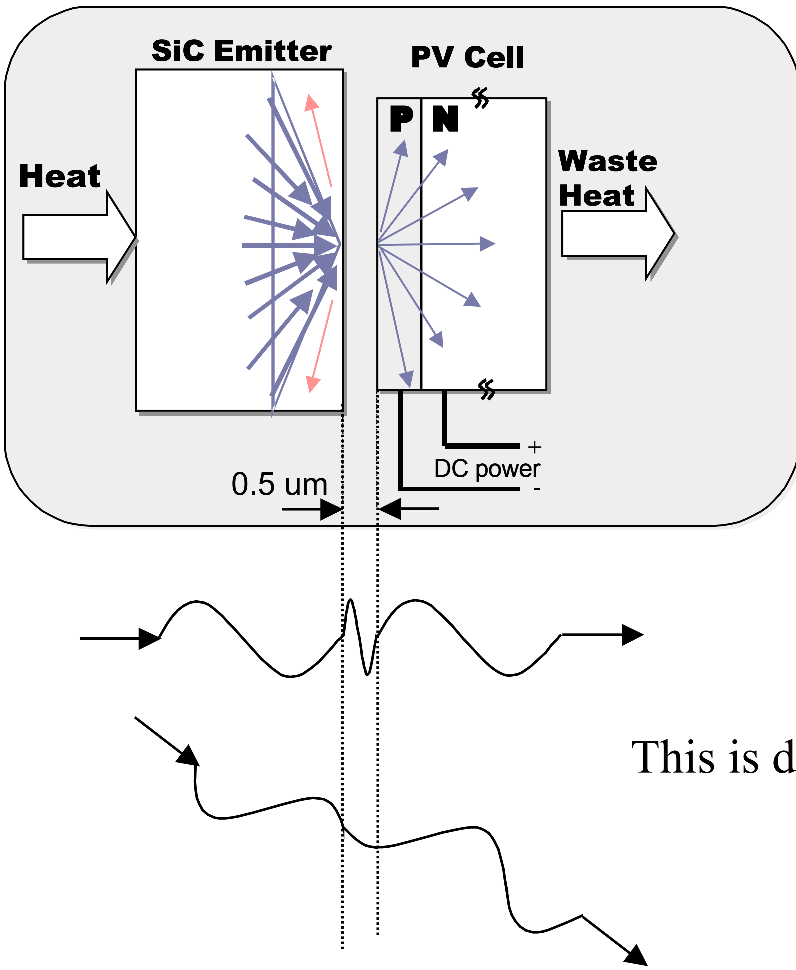
Consider again the situation…



Due to the difference in permitivities only a fraction of the energy in the emitter can be delivered to the PV cell.

The idea is to increase this transfer and use more of the emitters potential

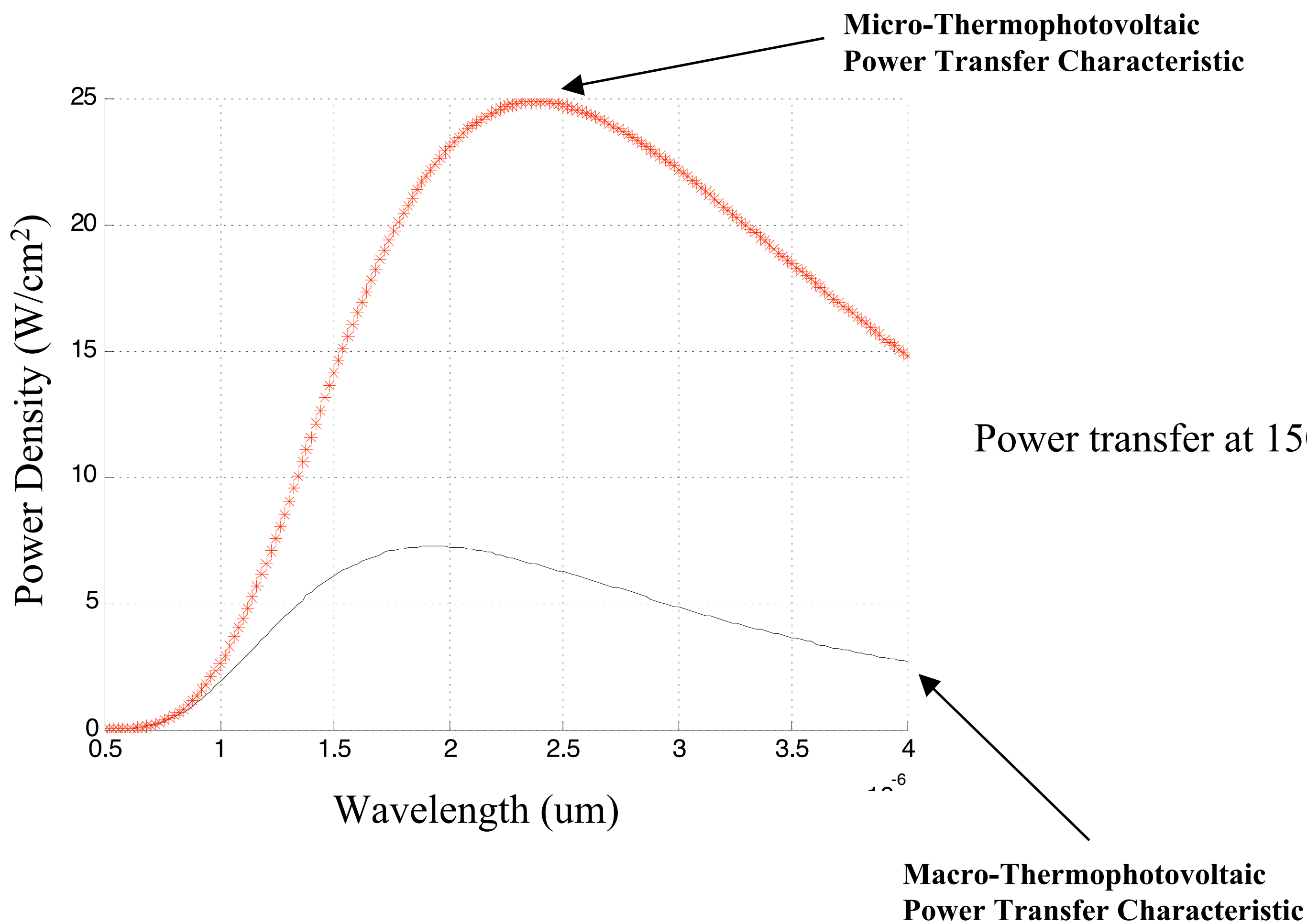
The solution to the problem lies in reducing the distance between the emitter and PV cell to a sub-micron scale…



When the distance is scaled down some evanescent modes in the emitter couple to the PV cell and begin to propagate.

This is described as: Micro-Thermophotovoltaics

The amount of power that is transferred in the micro-tpv case is huge compared to the standard situation!



Power transfer at 1500K

So how can this increased transfer be utilized?

The massive increase in power transfer allows for significantly higher power density.

Alternatively the emitter temperature can be significantly reduced whilst maintaining a power density figure comparable to standard tpv.

The micro-tpv technology offers the possibility of static power generation for use with MEMS devices.

Significant challenges remain…

Although micro-tpv systems can operate at lower temperatures thermal management is still a huge problem.

Spectral control for micro-tpv systems is more challenging than for the conventional tpv systems.

Fabrication of a constant gap is extremely difficult.

Thank you kindly for your attention.