

A Vacuum PV/Thermal Hybrid Collector with CPC-Tube design

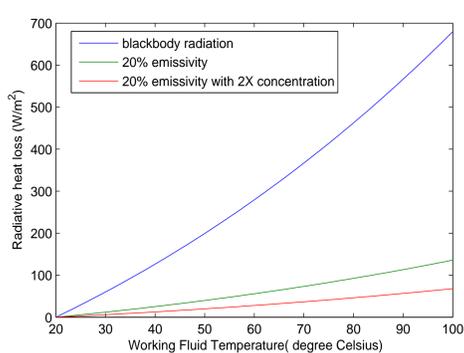
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Background

The heat generated from a PV panel is mostly treated as wasted energy. The PV/Thermal hybrid collectors (PVT) can potentially take the full advantage of this low temperature heat and at the same time reduce the area needed to deploy both PV and thermal collectors. By doing so it can reduce the payback time of the system and fit into the applications which has strict area limitations. The research in this poster aims to show a PVT collector design that can be energy efficient, compact, and cost effective.

Rationality behind the Design

The current major challenge for PV/T system is the reduction of heat loss. Without the vacuum and selective coating, the solar cells can not be used as an effective thermal absorber, because the radiative heat loss goes up with T^4 , and the emissivity of most solar cells' encapsulations are high. Therefore a PV/T design needs a high concentration (more than 10X) to keep up with the radiation loss by limiting the radiating area. Otherwise the PV/T system has to suffer from the low thermal efficiency at a higher working temperature.



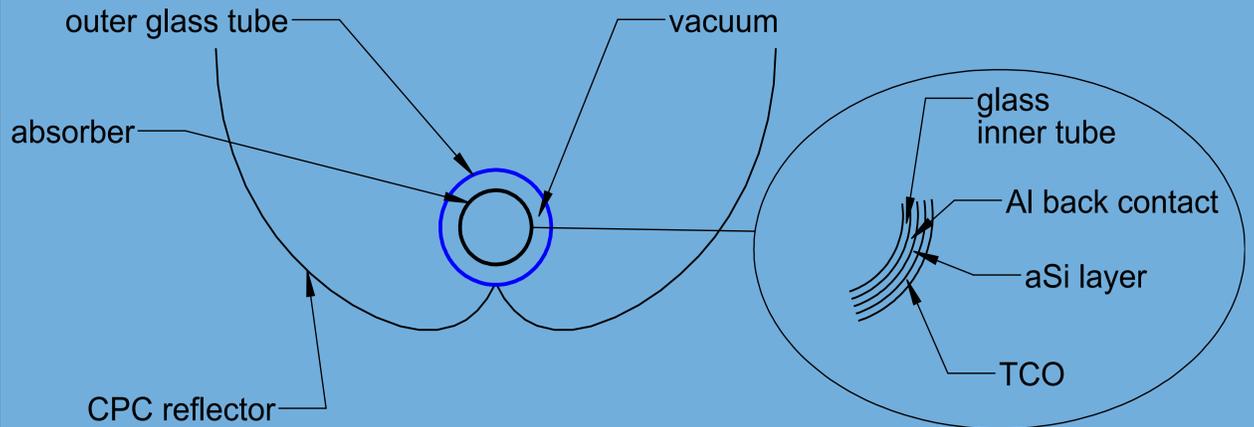
With a vacuum tube design not only the heat exchange problem can be solved, the transparent electrode layer (TCO, or transparent conductive oxide) of the thin film PV can also be engineered[1] so that it becomes a selectively transmissive coating to stop the radiative heat loss while allowing sun radiation to be efficiently absorbed by the next layer. A vacuum tube PVT design is both cost effective by using only glass as the raw material, and thermodynamically efficient by using vacuum as the insulation. It also exhibits the full benefits of the PV/T system which is compact, efficient, and low cost.

References

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- [4] IEA Task 35, *New generation of Hybrid Solar PV/T collectors*. (2007)
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- [6] Z.Pei, C.Sun, M.Tan, L.Wen et al, *Optical and electrical properties of direct-current magnetron sputtered ZnO:Al films*. Journal of Applied Physics (2001)
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Design

Most of the current PVT system design includes a receiver with PV layer at the front side and a thermal conductive layer at the back side. We propose, however, a vacuum tube design with a CPC reflector as shown below.



The absorber is a glass tube coated with aSi or aSi/aSi solar cell as shown in the enlarged picture.

PV has to be flat?

Myth: All PV's should be flat, therefore PVT should be flat.

Truth: Thin film PV's can be deposited on a curved surface. Using a proper optic design, any extruded convex shaped receiver can be extended into a flat aperture area with nonimaging concentrators.

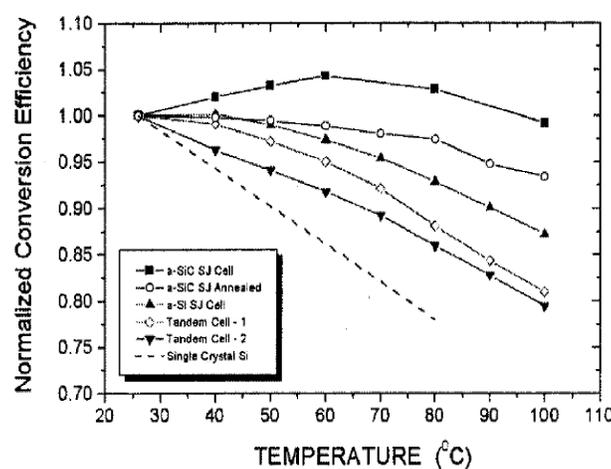
Concentration needs tracking

Myth: A static receiver can not concentrate.
 Truth: The Welford-Winston reflector (CPC) has been known for 30 years as a static concentrator at the thermal dynamic limit.

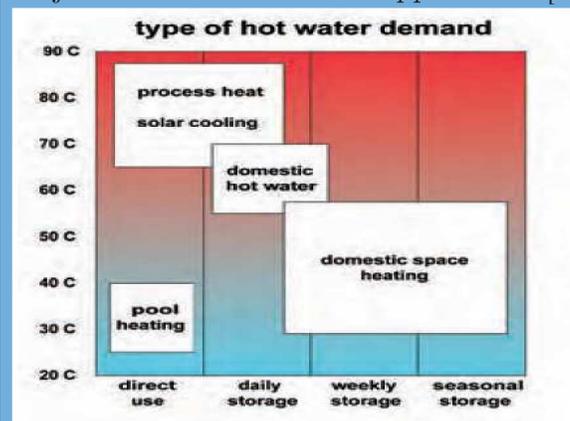
PV works with high T?

Myth: With increased temperature PV efficiency decreases, PVT collectors must work with low PV efficiency.

Truth: Not every PV has the same temperature coefficient, thin film cells are much less affected by temperature compared to crystalline cells, aSi efficiency can even increase with higher working temperature, as shown by the following graph[2]:



Most solar cells have to work with temperature from 20°C to 80°C during summer, the heat quality at this temperature is enough for hot water and space heating, which accounts for the major need of the domestic applications.[3]



The efficiency of aSi is too low

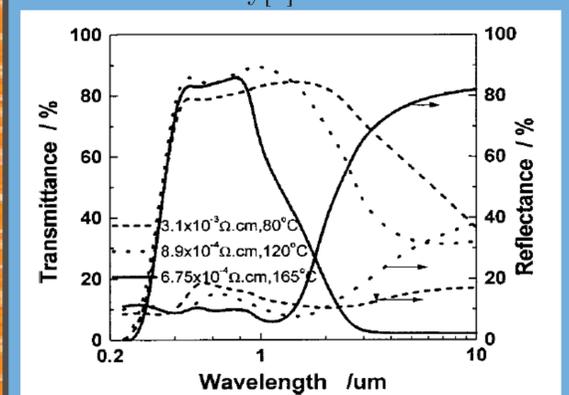
Myth: aSi thin film efficiency is not enough to be cost effective for a PVT application.

Truth: Current available technology for aSi/aSiGe/aSiGe is 10.4%. Although compared to the module record of multicrystalline Si cells(17.8%) it is relatively low, thin film cells in general still have a great potential.[5]

PV is not thermal efficient

Myth: Selective coating has to be highly absorbing for sunlight and highly reflective beyond infrared. Solar cell does not behave this way.

Truth: Selective coating can also be highly transmissive for sunlight and highly reflective beyond infrared. In a vacuum tube design, TCO is the last emissive layer instead of glass/Tefzel/Tedlar[4]. The improvement of Aluminum Zinc Oxide(AZO) as TCO has shown that lower sheet resistance of AZO also results in higher infrared reflectance and thus lower infrared emissivity[6].



Conclusion/Acknowledgement

Energy efficient, low cost design PVT system can be achieved by using vacuum tube and CPC reflector to limit heat loss at higher temperature and using thinfilm technology. We owe thanks to Pratish Mahtani's inspiring work at U of Toronto.[7]