# Thermophotovoltaic Efficiency Simulation

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## Introduction

Thermophotovoltaic (TPV) power systems, which convert heat into electricity using a photovoltaic diode to collect thermal radiation, have attracted increasing attention in recent work. [1,2]

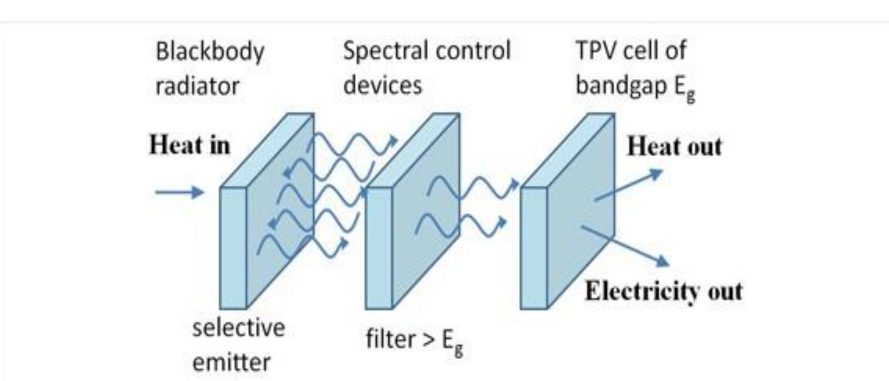



Fig.1 A schematic of a TPV system [1]

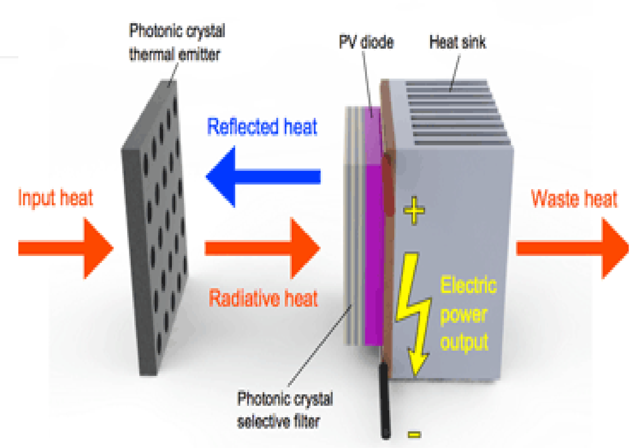



Fig.2 Effective TPV system with a cavity emitter [2]

## Objectives

- Develop a graphical user interface (GUI) using Rappture tool kit
- Allow user to specify the materials and geometric structure of the selective emitter, filter, and TPV diode
- Plot the emittance spectrum and reflection curve as well as calculating the efficiency

## Methodology

Generate the emittance spectrum by a finite difference time-domain simulator, known as MEEP

Use a Fourier modal method simulator, known as S4, which outputs the filter spectrum.

Both of these results are then combined with other data provided in the GUI to yield the overall TPV system efficiency.

## Results and discussion

- Input layers

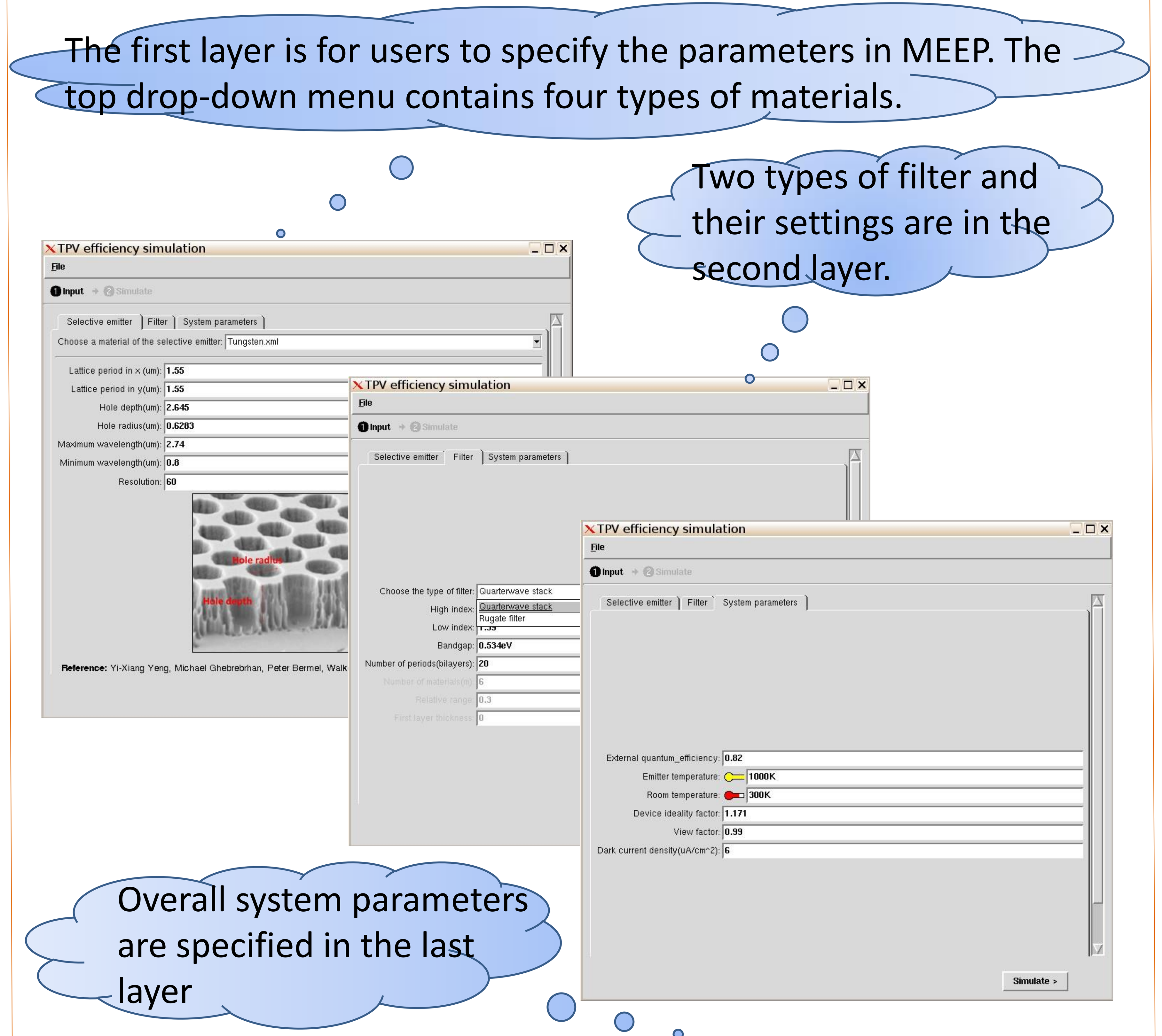
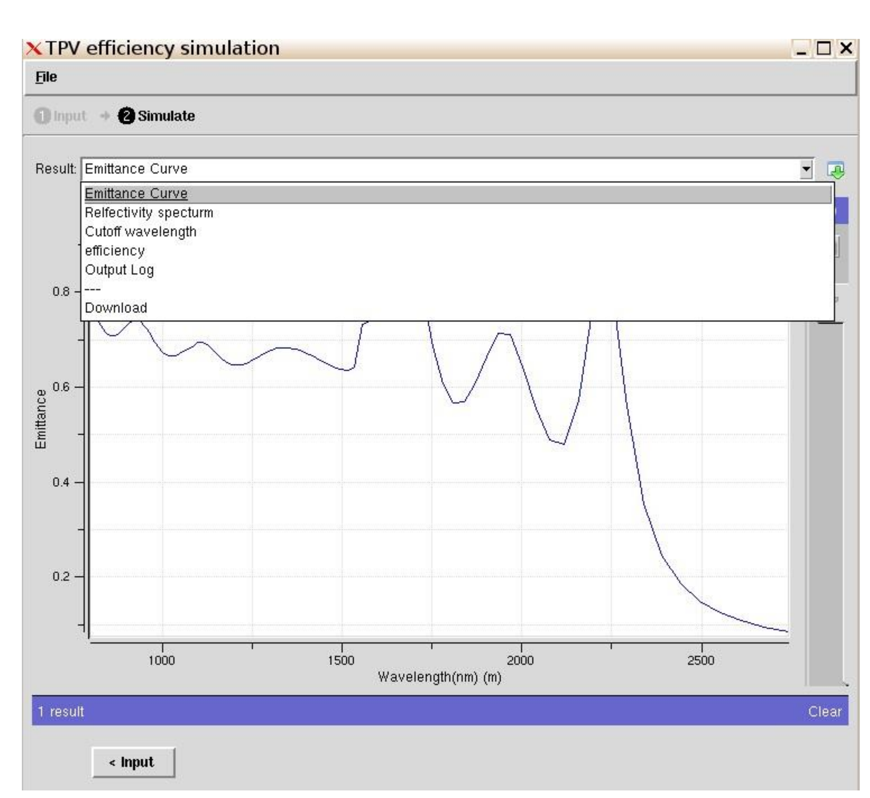



Fig.3 Inputs screenshots of the tool

- Output layers



The emittance spectrum of the selective emitter, the reflectivity spectrum and the cutoff edge of the optic filter as well as the efficiency of the overall system are displayed in the result section.

Fig.4 Outputs screen shot of the tool

## Case study

- Efficiency versus Number of periods

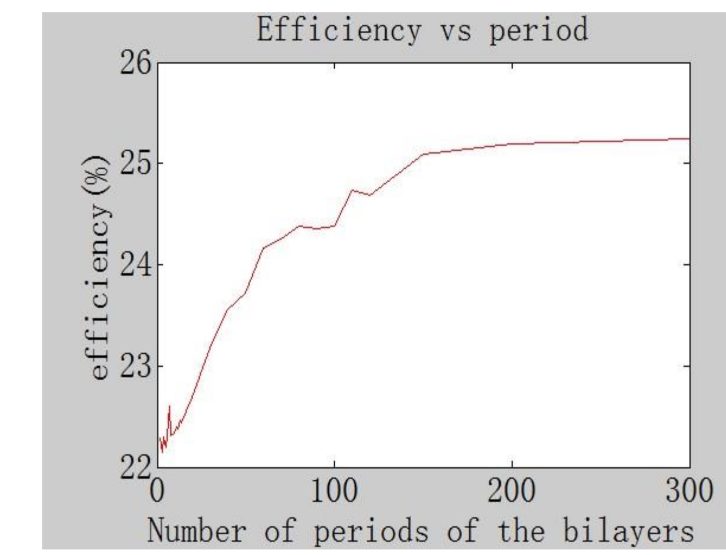



Fig.5 TPV system efficiency versus number of periods

From the plot we can see the filter performance increases rapidly with periods at first, and then saturates as max reflection approach 100%.

- Efficiency versus Temperature of the emitter

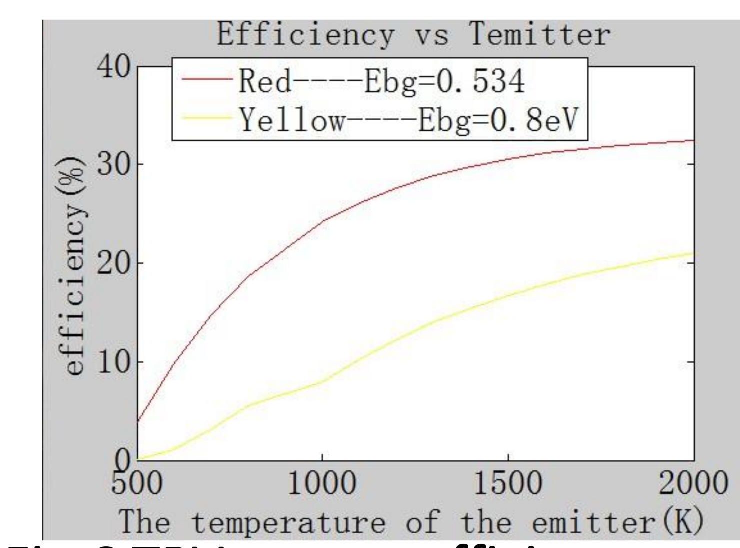



Fig.6 TPV system efficiency versus temperature of the emitter

Fig. 6 shows that the efficiency of the system increases with the emitter temperature. The performance of low-bandgap diodes saturates at 2000 K.

## Conclusions and future work

We built a tool with a graphical user interface for simulating TPV system efficiency. It was successfully used to optimize component design parameters, such as filter periods and operating temperature, and can also be applied to other problems of interest to experimentalists.

## References

1. TSB project with QinetiQ, Wafer Technology, Pilkington and RWE npower, "Low Bandgap Thermo-photovoltaic cells for Clean Energy Generation from Waste Heat".
2. Ivan Celanovic, Peter Bermel, Marin Soljacic, "Thermophotovoltaic power conversion systems: current performance and future potential", Japanese Society of Applied Physics 80, 0687-0691 (2011).