Power Generation via Thermionic Electron Emission

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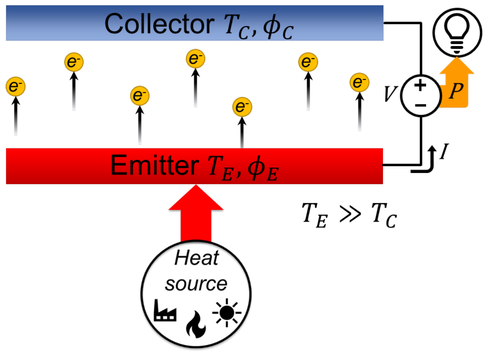
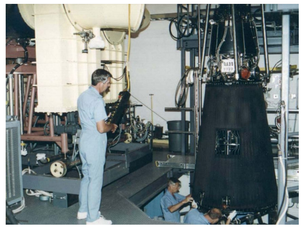
Thermionic Emission

– Thermionic emission is when electrons with high thermal energy escape the surface of a material. These electrons can then be collected, and the resulting current can be used to power loads. This process is known as thermionic energy conversion or TEC.



Background of TEC

– TEC was researched and used extensively from the 1960s to the 1980s for space applications.



– TEC was eventually abandoned due to low efficiency and power throughput in comparison to other modern systems.

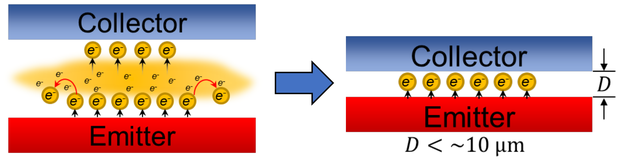
– Due to technological advancements in material science and the introduction of nanoscale physics, interest in TEC has been reignited as it has the potential to be a clean energy generation method capable of passively recycling high to mid-grade waste heat.

Enhancement of TEC

Negative Space Charge

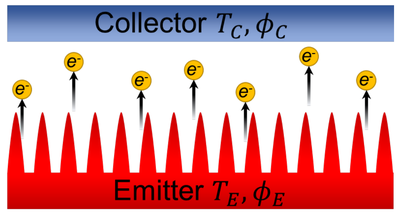
– The accumulation of negative charges between the electrodes which hinders the emission of further electrons negatively impacting the efficiency.

– Decreasing the gap distance to less than 10 μm eliminates this effect.

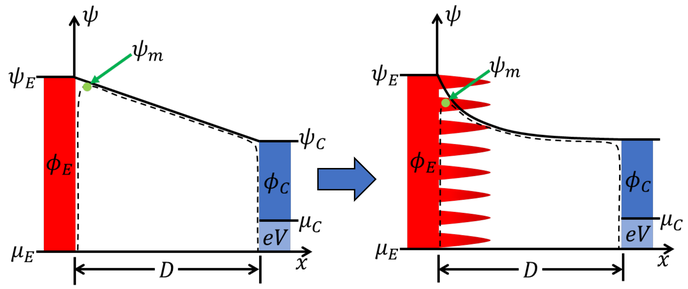


Surface Engineering

– The addition of surface features to the emitter can decrease the amount of energy required to emit an electron and can also increase the power throughput of the system.



– The inclusion of these surface features reduces the overall potential barrier that the electrons must overcome in order to escape the material's surface.



Experimental Setup

Developing a Versatile Nanoscale Thermionic Energy Conversion Setup

In order to further research the enhancement of thermionic energy conversion, a versatile setup must be designed with the following requirements.

– Accurately measure charge transport between two parallel plates in high vacuum conditions.

– Reach emitter temperatures above 1500 K via laser heating.

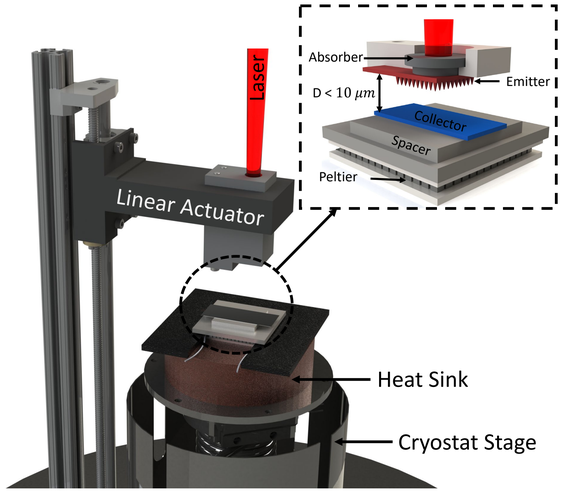
– Feedback control both the emitter and collector temperatures

– Minimize heat transfer between setup components, especially between the emitter and collector.

– Maintain a micro-nanoscale gap distance between the emitter and collector.

– Precisely vary the gap distance between the emitter and collector with nanoscale resolution.

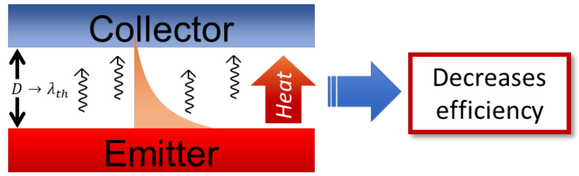
– Test and characterize a variety of different surfaces for electron emission including 2D surfaces and engineered surfaces.



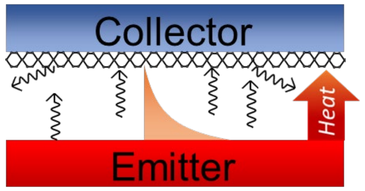
Future Works

Suppression of Near-Field Thermal Radiation

– When the gap distance is comparable to the thermal characteristic wavelength of the emitter, an enhancement in heat transfer beyond the classical blackbody limit occurs, decreasing the overall efficiency



– Suppression of near-field may be possible through the use of 2D materials, which can be transparent to electrons but block the heat transfer between the two electrodes.



Acknowledgments

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