Thermionic emission in heterojunction solar cells – a new view on another old story

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Thermionic emission describes the thermally activated transport of charge carriers across barriers. Especially at heterojunction semiconductor interfaces, where drift-diffusion approaches fail, thermionic emission is the state-of-the-art model to describe the transport of charge carriers. Although the theory behind has been developed many decades ago and despite its importance in photovoltaics, thermionic emission plays only an inferior role the current standard literature of photovoltaic devices. This led us to a thorough revision of the theory of thermionic emission, its representation in semiconductor device simulators, as well as of its effects on the performance of heterojunction solar cells.

In our talk, we will first give a comprehensive review of thermionic emission at semiconductor/semiconductor and at semiconductor/metal interfaces. We will then discuss two major consequences for a solar cell under operation. The first is an emission of electrons from the semicondcutor into the metal with a velocity of approximately 10^7 cm/s. While recombination at such metal contacts can be reduced by proper passivation measures, this emission of electrons is unavoidable and electronic mirrors are mandatory. The second implication of thermionic emission is a voltage drop, which occurs at each heterointerface thereby reducing the internal voltage. Accordingly, each barrier for the current leads to a reduction of the voltage. In order to quantify these effects, we show simulations on sulfide chalcopyrite solar cells with different (ZnSn)O buffers.