Separate measurement of electron and holes photo-induced Seebeck effect from photoluminescence of hot carrier solar cells

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Hot carrier solar cells (HCSC) have been proposed to increase the power conversion efficiency of photovoltaic devices beyond the Shockley-Queisser (SQ) limit (~33%) [1]. In this type of solar cells, the excess kinetic energy of hot carriers (HC) is converted to useful electricity rather than being lost through thermalization mechanisms. From a device perspective, achieving these features requires two ingredients: an absorber where carriers exhibit a slow cooling rate, and energy selective contacts for hot carriers extraction. While both ingredients have been successfully investigated separately [2], [3], there are very few realizations of full HCSC structures to date [3], [4], and none exceeding the SQ limit.

Achieving a HCSC requires a better understanding of basic processes, in particular heat and carrier transport. Indeed, HCSC are midway between classical photovoltaic physics and thermoelectricity. Hence it is of prime importance to investigate the thermoelectrical properties of HCSC such as their Seebeck coefficient.

In the present study, we investigate contactless measurement of photo-induced Seebeck effect. Using a hyperspectral imager under punctual illumination, one can measure the carrier temperature gradient as we move away from the laser spot, along with the associated Quasi-Fermi Level Splitting gradient. Both those quantities can be used to measure an ambipolar photo-induced Seebeck coefficient [6]. We extend the usual continuous wave photoluminescence (CWPL) analysis tools to extract independent temperatures for electrons and holes, following a theoretical development proposed in [7], which enables us to measure separately the electron and hole Seebeck coefficient in an InGaAsP QW.

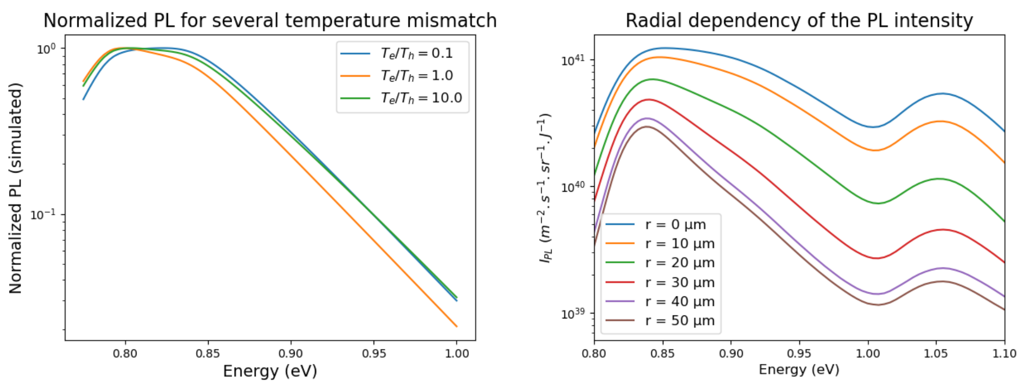

Figure 1: (left) influence of electron-hole temperature mismatch on the PL profile of an InGaAsP QW [modelled]. (right) radial dependency of the PL spectrum of an InGaAsP QW [measured]. The change of slope at high energy (~0.95 eV) is indicative of a hot carrier effect.

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