An existence result for a class of electrothermal drift-diffusion models with Gauss–Fermi statistics for organic semiconductors

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The presentation is concerned with the analysis of a drift-diffusion model for the electrothermal behavior of organic semiconductor devices. For this purpose a generalized van Roosbroeck system coupled to the heat equation is employed, where the former consists of continuity equations for electrons and holes and a Poisson equation for the electrostatic potential, where the latter features source terms containing Joule heat contributions and recombination heat. In doing so we extend the model frame of [5] which considered classical semiconductors to the organic situation. Our model takes into account the special features of organic semiconductors like Gauss–Fermi integrals for the statistical relation between chemical potentials and densities, and mobility functions depending on temperature, density and on the electric field strength. The isothermal drift-diffusion system for organic semiconductors in this setting is studied from an analytical point of view in [2] (stationary case) and [3] (instationary problem).

We verify the existence of solutions for the stationary electrothermal drift-diffusion problem by an iteration scheme and Schauder's fixed point theorem. The underlying solution concept is related to weak solutions of the van Roosbroeck system and entropy solutions of the heat equation (see [4]). Additionally, for data compatible with thermodynamic equilibrium, the uniqueness of the solution is verified.

It was recently shown that self-heating significantly influences the behavior of organic semiconductor devices like organic LEDs, see [6]. Phenomena like S-shaped current voltage relations as well as inhomogeneous luminance could also be described using coarser models such as $p(x)$-Laplace thermistor models balancing the total current flow and the heat flow. Analytical results concerning this model class can, e.g., be found in [1].

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