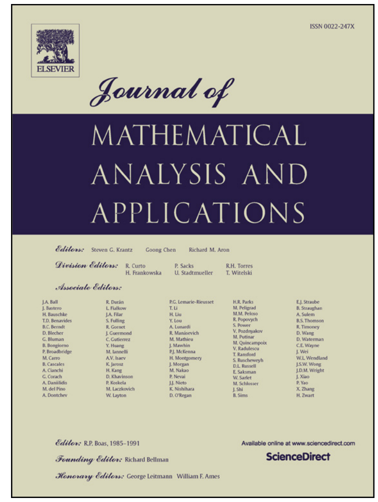
Accepted Manuscript



Existence and uniqueness for a two-temperature energy-transport model for semiconductors

G. Alì, V. Romano

PII: S0022-247X(16)30834-4
DOI: http://dx.doi.org/10.1016/j.jmaa.2016.12.038
Reference: YJMAA 20978

To appear in: *Journal of Mathematical Analysis and Applications*

Received date: 7 December 2015

EXISTENCE AND UNIQUENESS FOR A TWO-TEMPERATURE ENERGY-TRANSPORT MODEL FOR SEMICONDUCTORS*

G. ALÌ[†‡] AND V. ROMANO[§]

Abstract. An existence and uniqueness result for a two-temperature energy-transport model is proved, in the one-dimensional steady-state case, considering a bounded domain and physically appropriate boundary conditions. The model arises in the description of heat effects in semiconductors, the two temperatures account for the electron and the lattice temperature.

Key words. Energy-transport models; semiconductors; existence and uniqueness.

AMS subject classifications. 35J25, 35Q79, 82D37

1. Introduction. The effects of crystal heating have became crucial for the design of electronic devices with nanoscale dimensions, due to the possibility of having hot spots, that is, zones where the temperature of the lattice is very high, even close to the melting one. This has increased the interest on the analysis of thermal effects in semiconductors and prompted the formulation of improved models (see for example [1, 2]). Recently more sophisticated energy-transport models, based on closure relations obtained by employing the maximum entropy principle, have been proposed, e.g. see [3, 4, 5, 6, 7, 8], and used for simulating electron devices [9, 10, 11].

The main features of these models is to include an additional variable representing the lattice temperature and a relative equation for that. The scattering mechanisms force equilibrium between the electron and lattice temperature. In turn the latter tends to an equilibrium state with the environment. The simplest way to take into account such a physical effect is with a relaxation time approximation involving two relaxation times, one for the electron-phonon interaction and another for the phonon-environment interaction.

From a mathematical point of view one has a standard energy-transport model augmented with a balance equation for the lattice temperature.

The first energy-transport model for semiconductors was introduced by Stratton [12], in 1962. The first mathematical results had to wait 35 years after the presentation of the model, and are due to Degond, Génieys and Jüngel [13, 14] (for a comprehensive review see [15] along with [16] for the modeling aspect). They consider a general parabolic-elliptic system, arising in irreversible thermodynamics with thermal and electrical effects, which includes as a special case the energy-transport model. This general model is studied in a bounded multi-dimensional domain, with physics-based mixed Dirichlet-Neumann boundary conditions, under the restrictive hypothesis of uniform parabolicity and existence of a strictly positive energy.

A few years later, Chen, Hsiao and Li consider the same model, with unphysical no-flow boundary conditions, proving a stability theorem for small initial perturbations, without the last two restrictive assumptions [17].

*This work was supported by the Italian GNFM (INDAM). The author V.R. acknowledges the financial support of the project FIR 2014, University of Catania, Italy.

[†]Dipartimento di Fisica, Università della Calabria - Ponte P.Bucci 30B, I-87036 Arcavacata di Rende (CS), Italy (giuseppe.ali@unical.it).

[‡]INFN-Gruppo collegato di Cosenza, Arcavacata di Rende I-87036, Cosenza, Italy.

[§]Dipartimento di Ingegneria Industriale, Università di Catania, viale A. Doria 6, 95125 Catania, Italy (romano@dmi.unict.it).