On a PDE thermistor system for large-area OLEDs

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We introduce a spatially resolved PDE model describing the electrical and thermal properties of organic devices. The model consists of a current- and heat-flow equation for the electrostatic potential φ and the temperature T, i.e.

$$(1)\qquad \begin{aligned} -\nabla\cdot(\sigma(x,T,|\nabla\varphi|)\nabla\varphi) &= 0,\\ -\nabla\cdot(\kappa(x)\nabla T) &= (1-\eta(x))\sigma(x,T,|\nabla\varphi|)|\nabla\varphi|^2. \end{aligned}$$

The novel feature of this thermistor-like system is the conductivity function σ which has the form

$$\sigma(x,T,|\nabla\varphi|) = \sigma_0(x)F(x,T)|\nabla\varphi|^{p(x)-2}.$$

Here, σ_0 denotes an effective conductivity coefficient and $F(x,T) \sim \exp(-E_\mathrm{a}/(k_\mathrm{B}T))$ is a factor resulting from an Arrhenius temperature law. The activation energy E_a characterizes the hopping transport of electrons between stochastically distributed energy levels of molecular sites nearby. Finally, $p(x) \geq 2$ is a piecewise constant exponent resulting from a power law in the current-voltage relation for the materials in the subdomains of the device. In particular, the current-flow equation is of $p(x)$-Laplace-type with $p(x)$ characterizing the different current-voltage laws in the organic, non-Ohmic ($p > 2$) and metallic, Ohmic layers ($p = 2$). We present first analytical results for the thermistor system as well as a discretization scheme based on finite-volume methods [1]. In particular, we show that under suitable geometric assumptions the resulting discretization scheme coincides with coupled electrical and thermal network models of large-area OLEDs introduced in [2].

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References

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