3D-Model of Asymmetric Thermo-Electric Generator Modules for High Temperature Applications

Marcel Dannowski[1], Wieland Beckert[1], Lisabeth Wagner[1], Hans-Peter Martin[1]
[1] Fraunhofer Institute for Ceramic Technologies and Systems IKTS
Winterbergstraße 28, 01277 Dresden, Germany

Introduction: Thermoelectric moduls are characterized by a direct conversion of thermal energy into electrical energy. The thermoelectric module presented here is characterized by a novel module design and a lage temperature range.

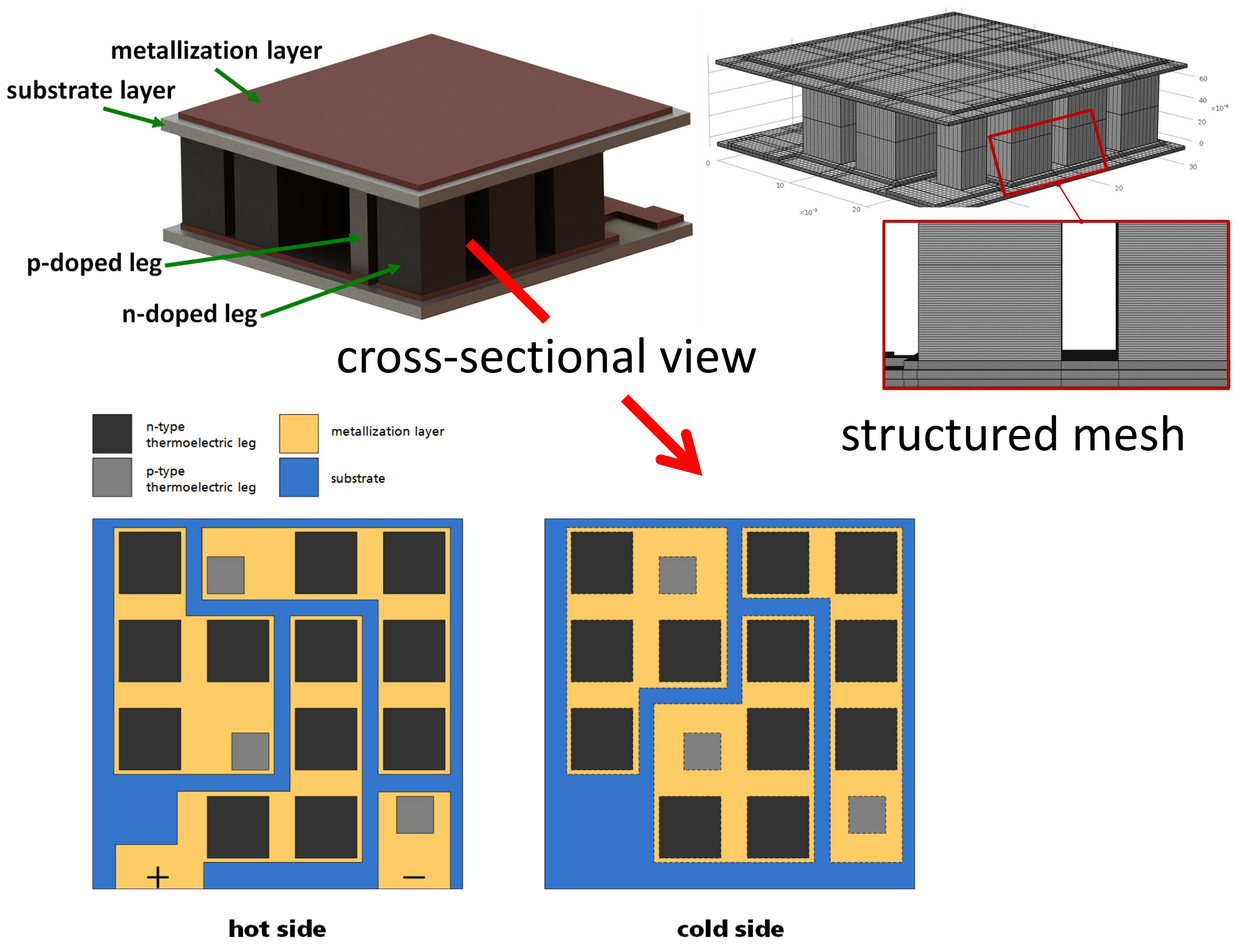

Figure 1. Asymmetric thermoelectric modul as well structured mesh of geometry

Computational Methods: Equation 1 shows the partial differential equation in coefficients notation as it is stored in COMSOL Multiphysics .

$$\begin{cases} e_a \dfrac{\partial^2 u}{\partial u^2} - d_a \dfrac{\partial u}{\partial t} - \nabla \cdot \left(c\nabla u + \alpha u - \gamma\right) + \beta \cdot \nabla u + \alpha u = f \rightarrow in \ \ \Omega \\ n \cdot \left(c\nabla u + \alpha u - \gamma\right) + qu = g - h^T \mu \rightarrow on \ \ \partial\Omega \\ hu = r \rightarrow on \ \ \partial\Omega \end{cases}$$

Equation 1. PDE in coefficient form

This approach allows to integrate the differential equation which describe the thermoelectric effects.

$$\kappa \frac{\partial^2 T}{\partial x^2} - \vec{j}_{el} \cdot \frac{\partial (ST)}{\partial x} + \vec{j}_{el} \cdot S \cdot \frac{\partial T}{\partial x} = -\frac{\vec{j}_{el}^{\,2}}{\sigma}$$

Equation 2. PDE for the description of thermoelectric systems

Results: As a result, thermal and electrical performance of the thermoelectric module is presented which includes the decoupled electrical power as well as the current-voltage behavior of the module.

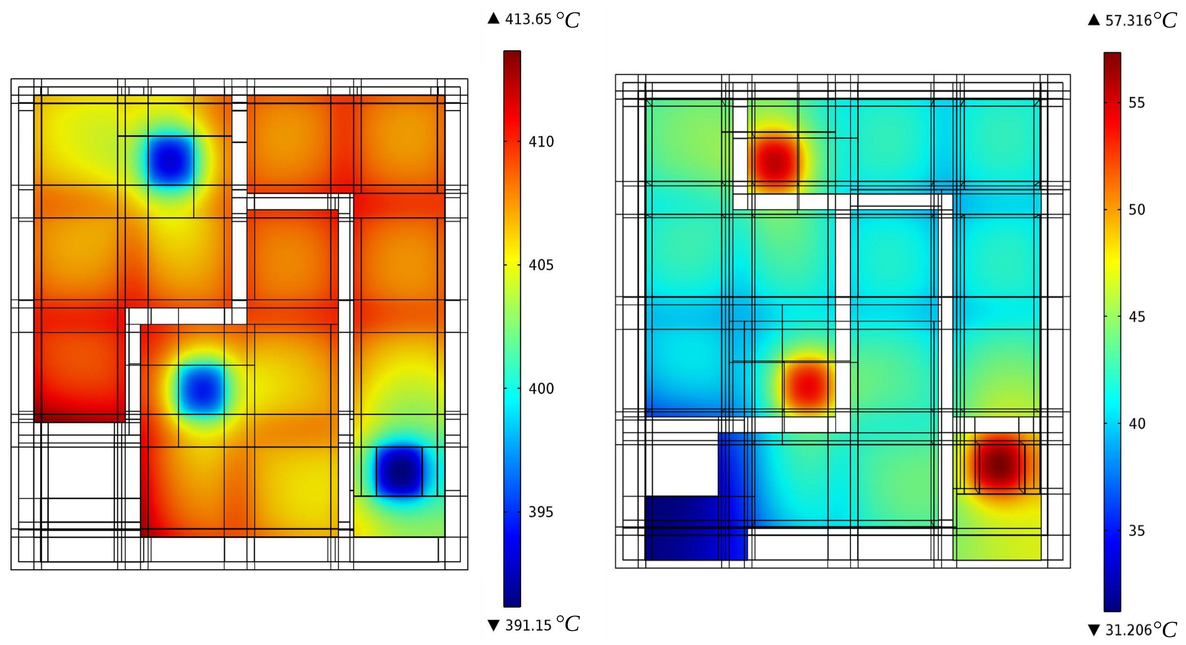

Figure 2. Temperature in the metallization layer

Figure 2 shows by a surface plot the different temperature gradients on the metallization layer.

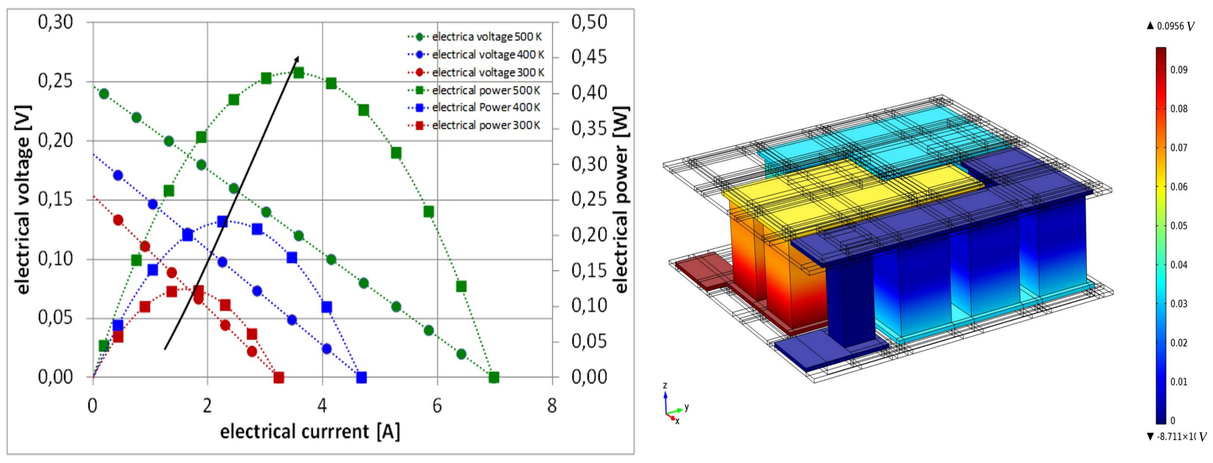

Figure 3. Electrical voltage distribution and the power and voltage across the electric current

Figure 3 illustrate the electrical voltage distribution as well as the power and voltage across the electric current.

Conclusions:

- Modeling asymmetric thermoelectric module with COMSOL Mulltiphysics
- Detailed model on the foundation of equation based modeling

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