Embedded Microfluidic/Thermoelectric Generation System for Self-Cooling of Electronic Devices

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Abstract

There has been a demand for efficient and clean energy due to the rising cost of energy and increasing environmental awareness. Thermoelectric generation is a promising technology which converts waste heat into electricity in an efficient and clean way. Micro-thermoelectric devices can benefit from thermoelectric micro-power generation and energy harvesting replacing the use of batteries or external power supply. The ability to integrate a high number of thermoelectric pairs into a small device with the miniaturization of TEG devices has been described as a promising technology to provide high voltage from a small temperature difference. In this paper, an innovative embedded microfluidic/TEG system (µF/TEG) system is proposed which enables a device to be able to provide power to its cooling system eliminating external power input and resulting in energy efficient and more reliable heat removal system. Micro heat sink based on microfluidic system (µFS) could remove high heat fluxes as a result of both increased area and higher convection heat transfer coefficient (HTC).However µFS systems are associated with larger pressure losses and pumping power which could be supplied from the embedded TEG systems. The proposed system with a total maximum thickness of less than 900 µm can be easily embedded into the MEMS systems or microchips to provide onsite cooling. Moreover, systems in remote area applications could benefit from such autonomous cooling system.

Use of COMSOL Mutliphysics® software

The research identifies important heat transfer, fluid flow and electrical parameters and optimization to enable the system to generate enough electricity to cool itself. Due to the complex multiphysics nature of the problem, numerical simulations were conducted using the FEM solver COMSOL. 3D simulation was implemented on half part of the model using the symmetric condition to reduce computational need. The conjugate heat transfer module is used to study fluid flow and heat transfer parameters. The effect of voltage and current from Seebeck effect in the TEG were incorporated using contributions .Mesh grid independence study were carried out and fine mesh with 616660 elements were used. The number of degrees of freedom solved was 67085. Segregated group solvers were used for solving Electric potential (V), Temperature field (T), Velocity field (U), and pressure (P). Sample results in Figure 1,2,3.

Figures used in the abstract

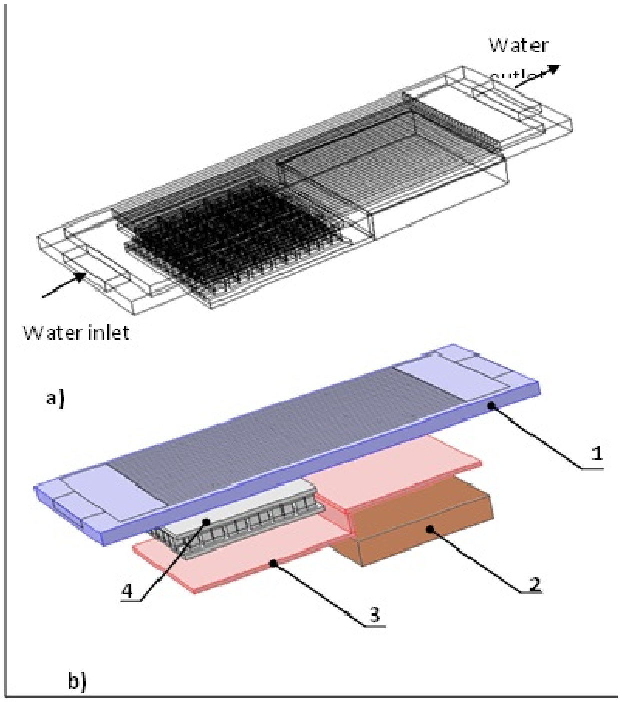

Figure 1: Embedded MicroTEG/microfludic system a) Wire frame rendering b) assembly diagram. (1- Microfluidic system; 2-Heated aluminum block; 3-Spreader; 4- TEG module).

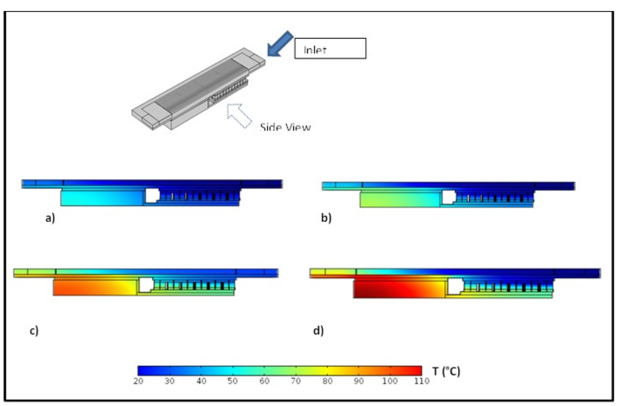

Figure 2: Temperature distribution (Side View) for heating power input a) 50 W b)75 W c)100 W d) 125 W.

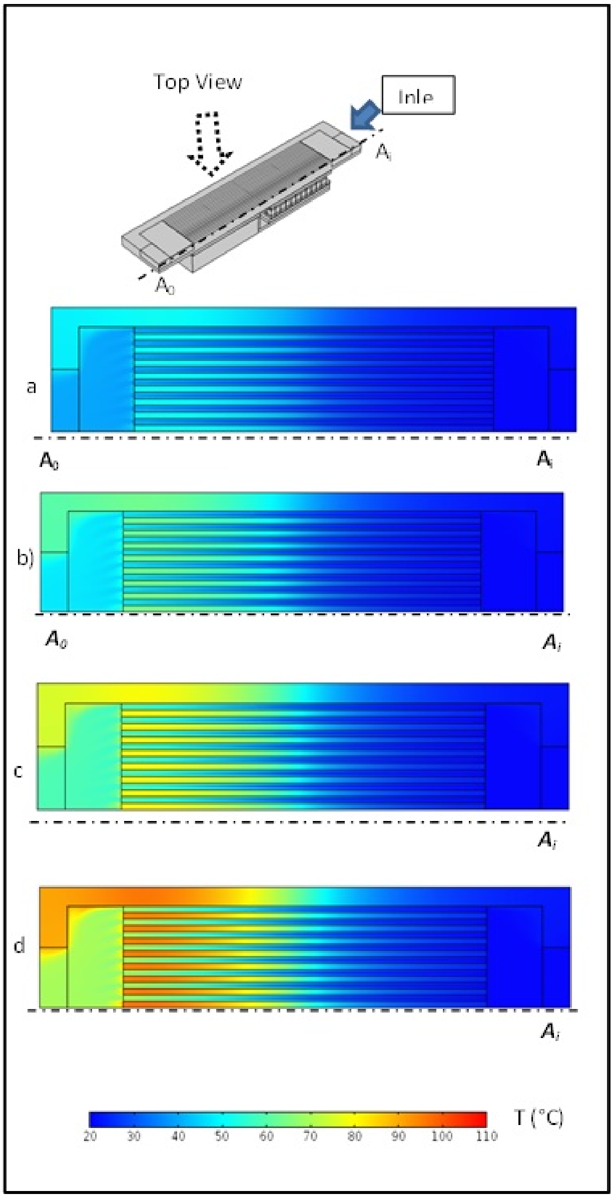

Figure 3: Temperature distribution (Top View) for heating power input a) 50 W b)75 W c)100 W d) 125 W.