Thermally-Actuated, Phase-Change Flow Control for Microfluidic Systems

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Supplemental Materials

1. Videos:

- Sample distribution and metering – the video describes the sample distribution into four metering chambers. When the sample arrives at the downstream, pre-cooled valve, it freezes and blocks the passage
- Filling and emptying a closed loop

2. The Temperature of the Thermoelectric Unit in Contact with the Chip

Measurements of the temperature of the interface between the thermoelectric unit (HOT 2.0-30-F2A, Melcor, NJ) and the polycarbonate substrate indicate that the surface temperature was nearly (within ±0.5 ˚C) uniform.

We carried out a sequence of measurements to determine the temperature of the thermoelectric unit – polycarbonate interface (T_i) as a function of the time (t in s) and the power (P in W) supplied to the thermoelectric unit. The time was measured from the instant when the thermoelectric unit was turned on. The temperature of the thermoelectric unit-polycarbonate interface at time zero and the temperature of the heat sink at all times were approximately 25˚C (the room temperature). The data was correlated (within ±1 ˚C) in the form:

$$T_i = 25 - \left\{27 + 44\exp\left[-\frac{1}{0.7(P+0.4)}\right]\right\}\exp\left[-\frac{1}{0.7(t+0.4)}\right].$$

Fig. 1 depicts the measured (symbols) and correlated (solid lines) temperatures as functions of time.

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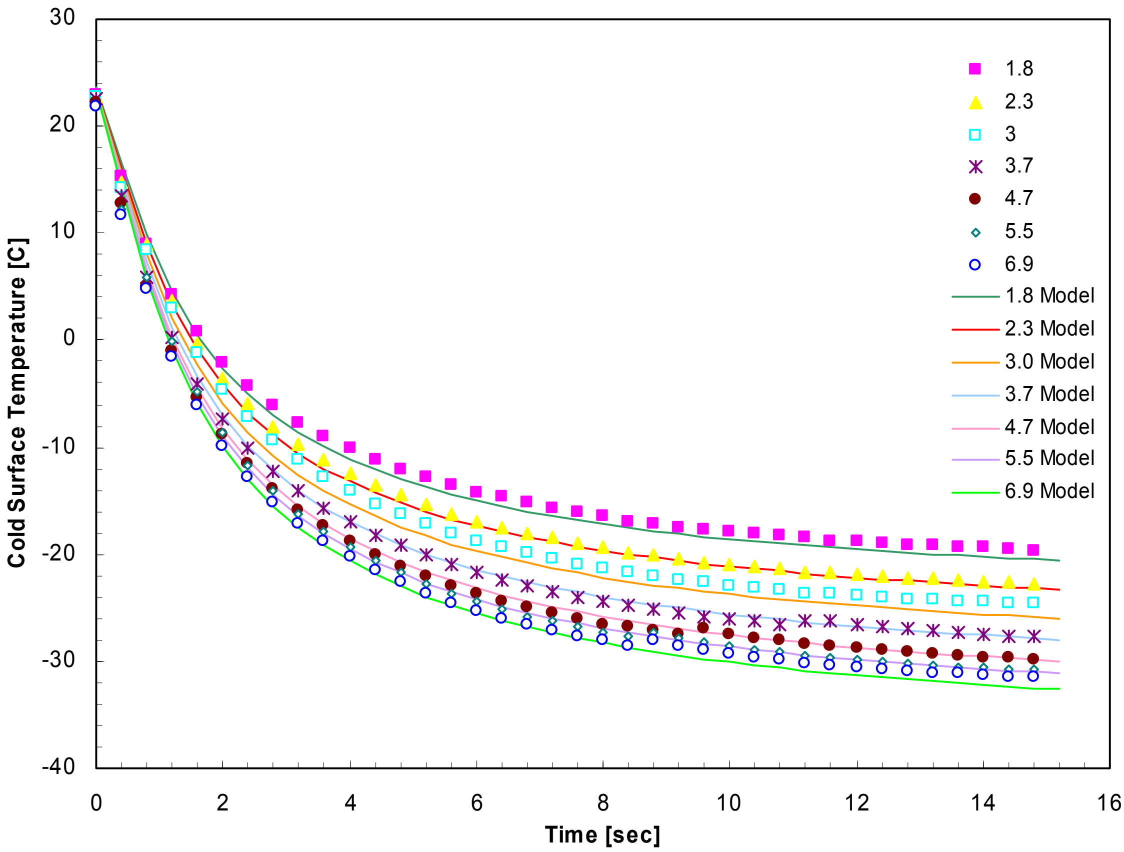

Fig. 1: The thermoelectric-polycarbonate interface temperature as a function of time at various thermoelectric power inputs. The symbols and solid lines correspond, respectively, to the experimental data and the correlation.

3. Convective Heat Transfer Coefficient

The convective heat transfer coefficient (h_a) of the polycarbonate-air interface was determined by solving an inverse problem. A 950μm polycarbonate sheet was placed over the thermoelectric module (see insert in Fig. 2). The temperatures at different locations on the polycarbonate-air interface were recorded as functions of time when power of 6.9W was applied to the thermoelectric module.

The problem was solved using 3-D finite-elements, heat transfer model with an assumed heat transfer coefficient h_a. The simulations utilized the empirical formula derived in section 2 to approximate the temperature at the thermoelectric unit-polycarbonate interface. The experimental data was compared with theoretical predictions and h_a was varied to minimize the discrepancy between the experimental data and the theoretical predictions. The optimal heat transfer coefficient $h_a \sim 47.5$ W/k-m^2. Fig. 2 depicts the measured (symbols) and predicted (solid lines) temperatures at various locations along the polycarbonate surface as functions of time.

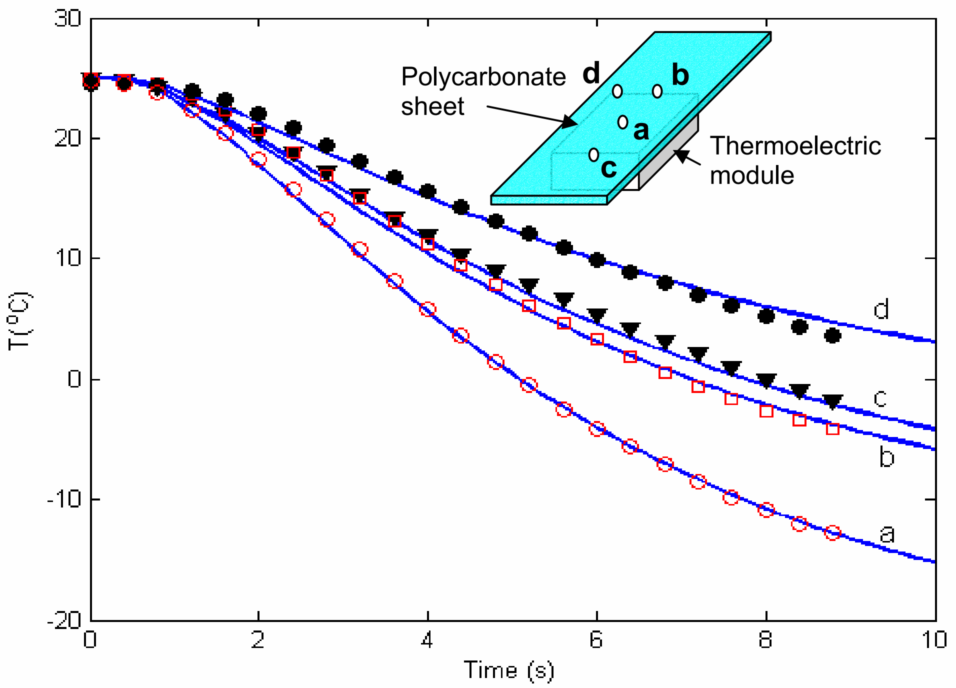

Fig. 2: The measured (symbols) and predicted (solid lines) temperatures at various locations on the polycarbonate surface as functions of time when the heat transfer coefficient $h_a \sim 47.5$ W/k-m^2