Supplementary Material

Precise Temperature Control and Rapid Heating/Cooling of Infrared Spectroscopy Samples with a Two-Stage Thermoelectric Device

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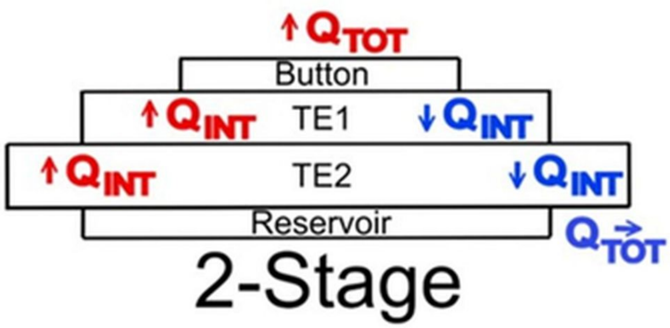

Fig. S1 Heat flow paths in the 2-stage apparatus. Red labels denote button heating and blue labels denote button cooling.

Temperature Estimates

A one-dimensional conductive heat flow model based on the Fourier law of heat conduction was used to estimate the temperature of the top surface of the stainless-steel mesh backing and in the air 0.114 mm above the backing.

Using the Fig. S1 labels, the resistive heat generated by each TE device when the button thermocouple temperature was 100 ^{o}C can be calculated by:

$Q_{TE1} = (I^2R) = (1.00A)^2(1.65\Omega) = 1.65$ W

$Q_{TE2} = (0.80A)^2(2.20\Omega) = 1.41$ W

$Q_{TOT} = Q_{TE1} + Q_{TE2} = 3.06$ W

Q_{TOT} is the total device generated heat pumped to the top surface of TE1.

The fraction of Q_{TOT} that passes through the 6.35 mm diameter backing (Figure 3) is:

$Q_{backing} = (A_{backing}/A_{TE1})\ Q_{TOT} = (31.7\ mm^2/900\ mm^2)(3.06\ W) = 0.11$ W, where $A_{backing}$ and A_{TE1} are the surface areas of the backing and TE1 respectively.

The Fourier law equation is: $\Delta T_{backing} = Q_{backing}\ R_{backing}$, where ΔT is the temperature difference between the backing bottom and top surfaces and $R_{backing}$ is the thermal resistance of the backing. $R_{backing}$ is calculated by $t/kA_{backing}$, where t is the backing thickness, k is the thermal conductivity of stainless steel (15 W K^{-1} m^{-1}), and $A_{backing}$ is the area of the surface that the heat passes through.

$R_{backing}$ = (3 x 10^{-4} m)/[(15 W K^{-1} m^{-1})(3.17 x 10^{-5} m^2)] = 0.63 W^{-1} K

$\Delta T_{backing}$ = (0.11 W)(0.63 W^{-1} K) = 0.07 K or 0.07 ^oC

When the temperature of the bottom surface of the backing is 100 ^oC, the top surface temperature is estimated to be: 100 – 0.07 = 99.93 ^oC

Repeating this calculation after adding a 0.114 mm (mesh wire diameter) air gap:

ΔT_{air} = $Q_{backing}$ ($R_{backing}$ + R_{air}), R_{air} = (1.14 x 10^{-4} m)/[(0.025 W K^{-1} m^{-1})(3.17 x 10^{-5} m^2)] = 143.8 W^{-1} K

ΔT_{air}= (0.11 W)(0.63 W^{-1} K + 143.8 W^{-1} K) = 15.9 K or 15.9 ^oC

The temperature in the air 0.114 mm above the backing is estimated to be: 100 – 15.9 = 84.1 ^oC