Quantum Design

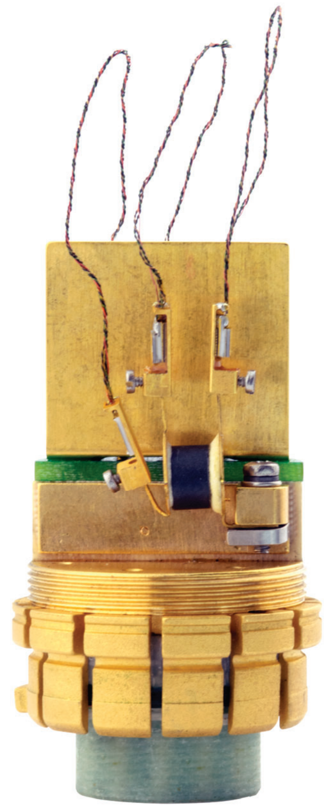
Thermal Transport (TTO)

DynaCool (D670) / PPMS (P670) / VersaLab (V670)

Using the Thermal Transport Option (TTO) all three constituent experimental parameters of the thermoelectric figure of merit (ZT) can be measured simultaneously and continuously as a function of temperature. Operating in high vacuum, a sample is subjected to a thermal pulse and its temperature and voltage responses are recorded. Fitting algorithms based on a model of the thermal circuit extract a sample's thermal conductance and thermopower from these curves, and a resistance measurement is executed immediately after. ZT is automatically calculated as well, and can be evaluated across the full range of temperature and field afforded by the PPMS®.

Key Features

- Simultaneously measure a sample's thermal conductivity, Seebeck coefficient, and electrical resistivity with a single sequence command
- Derived thermoelectric figure of merit and associated uncertainty is automatically calculated
- Mounting hardware included for two- or four-probe configuration to best suit a particular sample's geometry
- Adaptive measurement algorithm enables continuous data acquisition while ramping temperature, eliminating the need to repeatedly wait for stability as in traditional conductance measurements
- Raw data can be viewed for real-time diagnostics of data quality or post-processing using custom fit functions
- User kit includes specialized mounting hardware, lead material, conductive epoxy, and an extra set of heater/thermometers

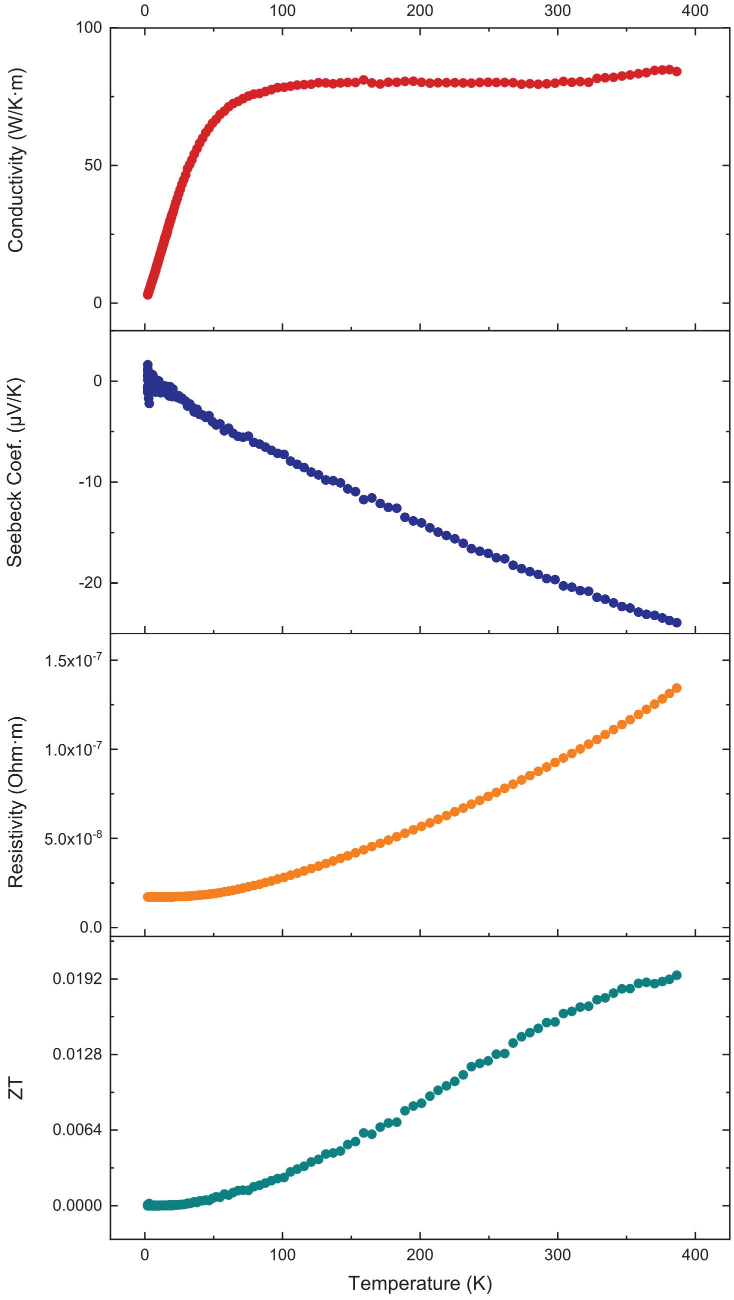


TTO Puck with Disk-Shaped Sample Installed

Thermal Transport Option Puck installed in the Puck Mounting Station

Thermal Transport (TTO)

DynaCool (D670) / PPMS (P670) / VersaLab (V670)



A typical response of the three properties measured by the TTO (thermal conductivity, Seebeck coefficient, electrical resistivity) are all shown, along with the calculated thermoelectric figure of merit ZT, for the nickel reference sample included with the option.

Thermal Transport (TTO) Specifications (for zero-field)

Thermal Conductance [K]

Typical Accuracy:	± 5 % or ± 2 µW/K, whichever is greater, for T < 15 K ± 5 % or ± 20 µW/K, whichever is greater, for 15 K < T < 200 K ± 5 % or ± 0.5 mW/K, whichever is greater, for 200 K < T < 300 K ± 5 % or ± 1 mW/K, whichever is greater, for T > 300 K
Estimated Dynamic Range*:	1 to 25 mW/K for high T = 400 K 100 µW/K to 100 mW/K for T ≈ 50 K 10 µW/K to 1 mW/K for T ≈ 1.9 K

Thermal Conductivity [$\kappa = K \cdot (L/A)$]

Estimated Dynamic Range*:	0.1 to 250 W/m·K @ T = 300 K

Seebeck Coefficient [S]

Typical Accuracy:	Error in S = ± 5 % or, Error in S = ± 0.5 µV/K or, Error in V = ± 2 µV, whichever is greatest
Estimated Dynamic Range*:	1 µV/K to 1 V/K

Resistivity [$\rho = R \cdot (A/L)$]

Typical Precision:	0.01% for 1 Ω @ 200 µA
Estimated Dynamic Range*:	10 µΩ to 5 MΩ

Thermoelectric Figure of Merit [$ZT = T \cdot S^2/(\kappa \cdot \rho)$]

Typical Accuracy:	± 15 % (Assumes ± 5% accuracy of K and S and negligible contributions from T, ρ)

Speed of Acquisition

Typical Temperature Slew Rates:	± 0.5 K/min, T > 20 K ± 0.2 K/min, T < 20 K

Operational Range 1.8 to 400 K; 0 to 16 T**

*Range estimates can depend significantly on an individual sample's aspect ratio and heat capacity.

**Measuring under both applied magnetic fields greater than H = 0.1 T and temperatures below T = 20 K may require additional corrections due to the temperature sensors' intrinsic magnetoresistance.

Specifications subject to change without notice.