Relaxation calorimetry works by supplying a pulse of heat to the sample and measuring the time constant at which the sample warms up (when the pulse starts) and cools down (after the pulse has finished). We offer a relaxation calorimeter which can be used with several measurement methods, suitable for a wide range of experimental conditions.

The measurement cell is mounted inside the low-temperature vacuum probe, which can be used with our Cryogen-Free or Liquid Helium systems. The probe is loaded into the Variable Temperature Insert via an airlock, allowing for fast sample exchange. The sample platform is a thin, 6-mm diameter sapphire disk, with a miniature heater and a temperature sensor. The platform is suspended on thin wires, which provide a known heat link between the sample and the thermal bath. The sample is attached to the sapphire disk using high thermal conductivity grease (Apiezon N). Ideally the sample should be a thin plate, typically 0.5 to 1 mm thick, with lateral dimensions between 1 and 6 mm. As a guide, the sample size should be chosen such that the value of the heat capacity at room temperature is between 0.5 and 50 mJ/K. Usually the suitable sample mass is in the range between 1 mg and 200 mg. Such samples can be easily weighed, so that specific heat (per kg or per mole) can be calculated. The addenda heat capacity of the platform and Apiezon grease need to be measured separately.

To cover the full range of experimental requirements, we offer several measurement methods which are implemented with the heat capacity probe.

**Key features**

- Compatible with all Cryogenic VTI systems
- Probe loaded into the system via an airlock, so samples can be exchanged without warming the VTI
- Sample mass: typically 1 - 200 mg
- Sensitivity: 1 μJ/K
- Absolute accuracy: 1 μJ/K
- High-vacuum sample chamber (requires a turbo pump or an optional cryopump)
Small pulse method (traditional Relaxation Calorimetry)

When the heat capacity \( C(T) \) can be assumed to be constant for a small heat pulse, the thermal time constant \( \tau \) and the thermal conductance of the link \( K \) between the platform and the bath can be directly measured. The heat capacity is obtained as \( C = K \tau \).

Large pulse method

When the heat capacity \( C \) is a strong function of temperature \( T \) (at very low \( T \) or in the vicinity of a phase transition), the shape of the sample's thermal response can deviate from the exponential form, and the small pulse method can lack sensitivity or incur large systematic errors. Using the large pulse method, it is possible to obtain a section of the \( C(T) \) curve (rather than one point) from the thermal response to the heat pulse. This improves the accuracy of data and increases the speed of measurement.

AC method

If the thermal conductivity of the sample is low, the response can also be non-exponential due to the so called \( \tau_2 \) effect. To take this into account, a variant of alternating current (AC) calorimetry can be used. When the heat is applied as a sine function at a frequency \( f \), the sample temperature responds with a certain phase shift. The effects of heat capacity and thermal conductivity make distinct contributions to the in-phase and the out-of-phase components, and so can be clearly separated.

Example data: superconducting phase transition of Niobium measured using the large pulse method.