NASA TECH BRIEF

Marshall Space Flight Center

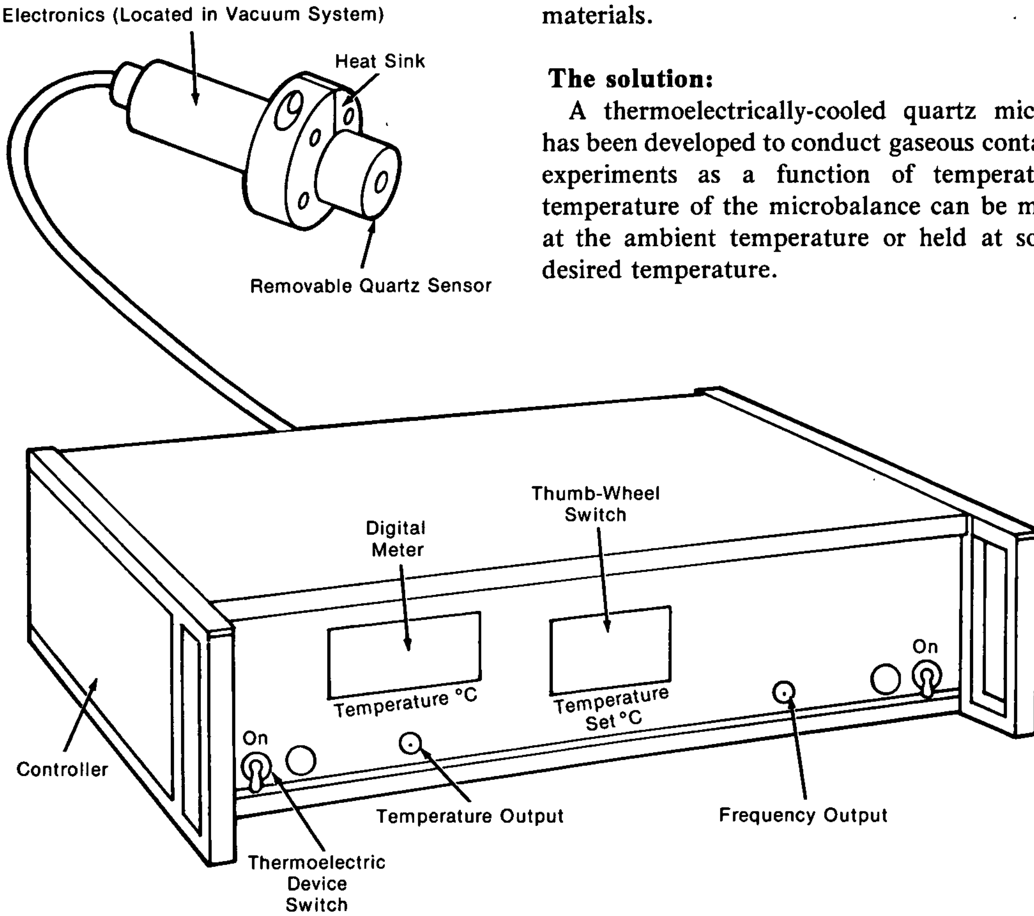
Thermoelectrically-Cooled Quartz Microbalance

The problem:

Quartz crystal microbalances can be used to weigh exceedingly small quantities, such as thin (less than an angstrom) films of solid materials. Attempts have been made to extend this technique for monitoring gas adsorption on solids. The microbalance is placed near the solids to be monitored, and the gas adsorbed on the quartz crystal is weighed. These attempts have been frustrated by the temperature dependence of the adsorption process. A quartz microbalance generates enough heat to keep it several degrees hotter than its surroundings, and thus gas adsorption on the quartz crystal will not be the same as on surrounding materials.

The solution:

A thermoelectrically-cooled quartz microbalance has been developed to conduct gaseous contamination experiments as a function of temperature. The temperature of the microbalance can be maintained at the ambient temperature or held at some other desired temperature.



Thermoelectrically-Cooled Quartz Crystal Microbalance Instrumentation

(continued overleaf)

How it's done:

The microbalance has a two-stage thermoelectric device that is used to control the temperature of the quartz crystal. Heat can be pumped to or from the balance by the Peltier effect. A heat sink is used to store heat upon cooling.

The device is small, requires no coolant, has no moving parts, and can be operated remotely with a single pair of electrical leads. The thermoelectric device is a series of solid-state bismuth telluride junctions that will automatically control, in a vacuum, the crystal temperature from -50° to 100° C with an accuracy of ±0.5° C.

For operation over this range, the heat sink must be kept below 40° C. This is insured by mounting it on a 6-cm thick metal bracket. The lower operating range may be extended to -59° C by mounting the heat sink on a 1.2-cm thick metal bracket which will remove up to 2.8 W at -59° C.

The thermoelectrically-cooled quartz crystal microbalance is shown in the figure. The operating temperature is set with a thumb wheel on the controller, and temperature can be read out on a digital display. The temperature sensor is a precision platinum resistance thermometer.

A matched pair of precision 20-MHz quartz crystals is used to measure mass loading. They are optically polished and plated with aluminum. One crystal, the sensor, is coated with magnesium fluoride to allow in-situ reflectivity measurements to be made while contamination is collecting on its surface. The other crystal is the reference crystal.

The microbalance output is the beat frequency between the two oscillating crystals. The beat relates directly to the mass on the sensor. The use of a reference crystal eliminates frequency changes caused by ambient temperature variations.

The microbalance can be set at any desired temperature within its operating range. It may also be set at ambient; then heat generated in the oscillating crystal will be removed to keep the temperature the same as that of the surroundings. By dropping the temperature in steps, surface contamination can be measured as a function of temperature. The crystal can be cleaned by increasing the temperature to 100° C.

Note:

Requests for further information may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Code AT01
Marshall Space Flight Center, Alabama 35812
Reference: B75-10076

Patent status:

NASA has decided not to apply for a patent.

Source: D. McKeown of
Faraday Laboratories Inc.
under contract to
Marshall Space Flight Center
(MFS-23101)

Categories: 04 (Materials)
03 (Physical Sciences)