

Coulomb Blockade Thermometer (CBT) sensors for primary thermometry

Coulomb Blockade thermometer (CBT) is a primary thermometer for cryogenic temperatures based on change of electric conductance of tunnel junction arrays. In CBT, the differential conductance of tunnel junction array is a bell-shaped curve (Figure 1). It has been shown [1], that the full-width of the curve depends only on the (electron) temperature of the sensor and on some constants of nature.

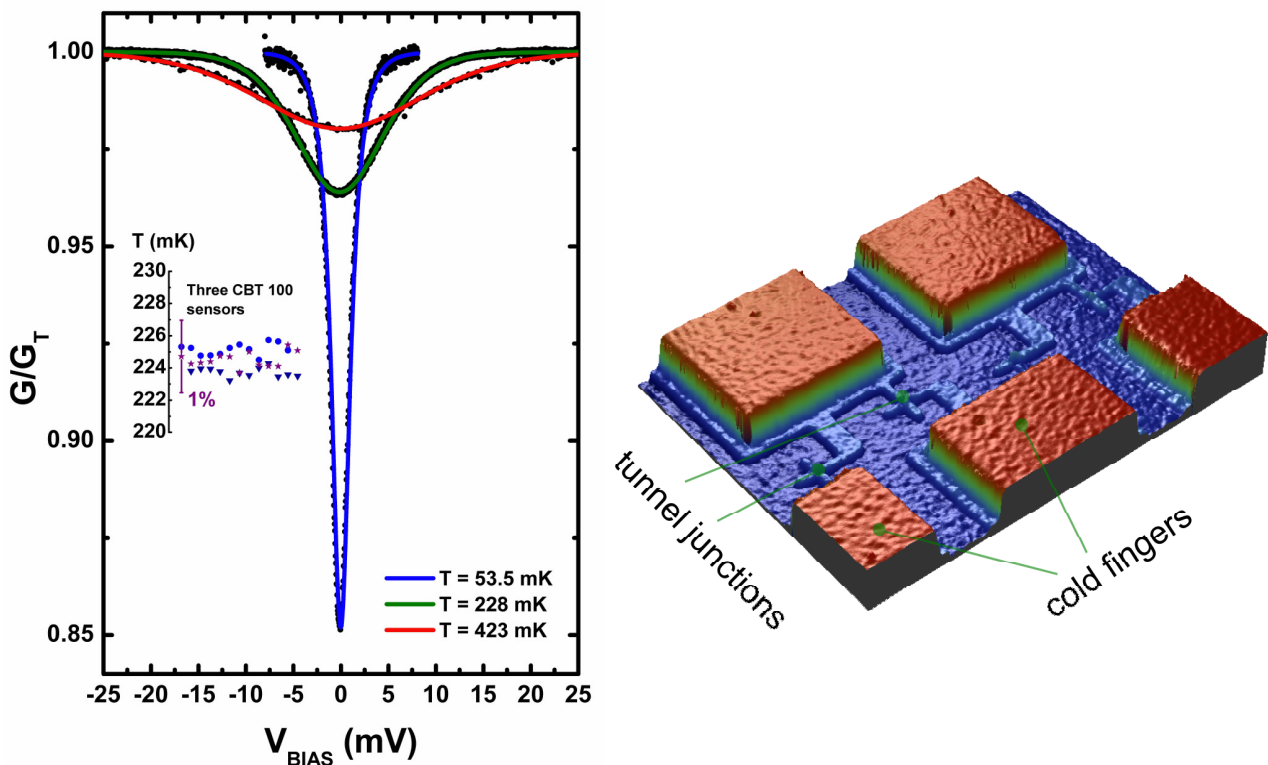


Figure 1: Left panel: Differential conductance as a function of bias voltage of CBT sensor measured at three different temperatures. $G_T^{-1}=47600$ Ohm. Solid line is a fit to theoretical formula [1] with two parameters. The full-width at half maximum FWHM depends only on temperature T . The depth of the conductance dip depends on temperature T and charging energy E_c , which can be calculated once T is known from FWHM. Small insert shows readings of three different sensors measured taken from several subsequent measurements. Right panel: Pseudo-color image of CBT tunnel junction array. Courtesy of VTT Technical Research Center of Finland.

Coulomb blockade thermometers offer several advantages:

- **simple resistance measurement using two or four wires**
- **primary measurement mode does not need calibration**
- **fast zero-bias resistance measurement mode using e.g. standard lock-in amplifier**
- **operates at high magnetic fields (up to 27 T, ref. [2])**

[1] J. Pekola et al, Physical Review Letters, 73, 2903 (1994)

[2] J. Pekola et al, J. of Low Temp. Phys., 128, 263 (2002)

Aivon Oy offers CBT sensor chip C1 designed for primary thermometry in temperature range 40 mK – 1 K. At lower temperatures, the self-heating of the present sensor starts to affect on electron temperature causing uncertainty. At temperatures higher than 1 K, almost flat conductance curve decreases the reliability of the temperature measurement.

Figures 2 and 3 show images and dimensional drawings of CBT sensors H3L3 and H3L3m. Bobbin B1 is also shown in the figure. Twisted pair sensor wire can be wound around a bobbin to improve thermal anchoring at lowest temperatures. The sensor package and the bobbin can be mounted into cryostat using copper screw M4 included. The sensor H3L3m houses a strong permanent magnet to suppress superconductivity of Al-based sensor below 1K. For measurements at high magnetic fields, the sensor can be ordered without magnet (H3L3).



Figure 2: From left to right: Uncovered CBT sensor (holder/lid type H3L3), H3L3 as normally delivered, strong permanent magnet is glued on top of the lid (H3L3m), and bobbin B1 for thermal anchoring of the wire.

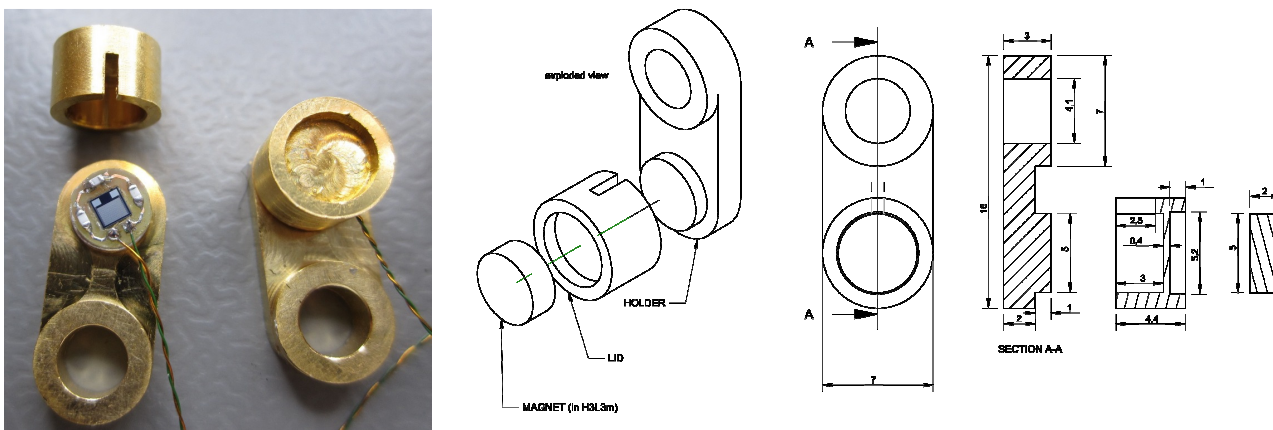


Figure 3: Left: Top view of sensor H3L3 as uncovered and covered with lid. Right: Dimensional drawing of the holder, lid and magnet.

Please do not hesitate to contact Aivon if you find CBT sensors interesting. Further information in Aivon web pages: <http://www.aivon.fi/products-and-services/coulomb-blockade-thermometer/>