Self-validating thermocouples based on metal-carbon eutectic fixed points

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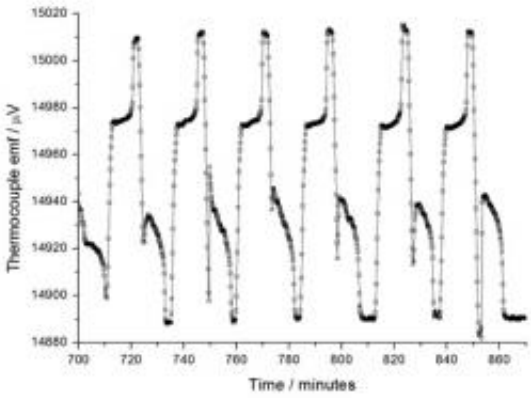

Typical melts and freezes of the Co-C alloy as demonstrated by the self-validating thermocouple.

When used at high temperatures (above 1100 °C) thermocouples are prone to substantial calibration drift. To gauge the extent of the drift, for example, in an industrial setting, it is highly desirable for the thermocouple to be calibrated regularly in-situ.

The temperature group at the National Physical Laboratory, UK, has developed a self-validating thermocouple technology, whereby temperature fixed points comprising metal-carbon eutectic alloys [1] form an integral part of the thermocouple.

The novelty consists of employing a graphite crucible, containing the

fixed point material, to form the measuring junction [2]. The thermocouple wires are attached to either end of the cylindrical graphite crucible, so the graphite crucible provides the electrical connection between the two thermoelements.

The high electrical and thermal conductivity of the graphite ensure the good electrical and thermal response of the thermocouple, and also that the melting and freezing plateaux of the eutectic alloy are observable as a 'hesitation' in the thermocouple emf as the temperature of the measuring junction passes through the fixed point temperature.

NPL is currently applying this technique of self-validation to Pt/Pt-Rh thermocouples (Types R, S, and B), Pt/Pd thermocouples, and W-Re thermocouples (Type C). The thermocouples developed so far include the metal-carbon eutectics Co-C and Pt-C. Nonetheless all metal-carbon eutectic alloys and metal (carbide)-carbon eutectic alloys can be used as the fixed point. Also under development are multiple fixed points in the same crucible, so that self-calibration can be performed at a series of temperatures. For example, a measuring junction comprising four fixed points Zn, Ag, Co-C, Pd-C will enable self-calibration up to 1500 °C.

More information:

[1] "Radiometric observation of melting and freezing plateaus for a series of metal-carbon eutectic points in the range 1330 °C to 1950 °C", Y. Yamada, H. Sakate, F. Sakuma, and A. Ono, *Metrologia* 36, pp. 207-209 (1999)
[2] "Miniature thermoelectric fixed points (MTFP) for thermocouple calibration", M. Tischler and M.J. Koremblit in *Temperature: its measurement and control in science and industry* 5, pp. 383-390 (1982)

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