Next-Generation Standards for High Temperatures

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A Novel Idea for a High-Temperature Fixed Point

Establishing standards for temperature, a physical quantity that is not easy to grasp, depends widely on repeatability of the temperature under which phase transitions occur in a substance. Formerly, temperature was defined on the centigrade scale, using a scale of 100 gradations from the boiling point of water to its freezing point. Today scientists use the Kelvin scale, in which the triple point of water is used to define the unit kelvin of the thermodynamic temperature. Additionally, a wide range of other fixed points, including the freezing points of pure metals, are used to realize and to disseminate the temperature scale.

Creating a fixed point, however, poses many difficulties at temperatures above 1000˚C, where matter reacts violently with other matter; the highest fixed point that can currently be used is approximately 1085˚C — the freezing point of high-purity copper. Attempts to use metals with higher melting points have failed because the graphite crucible used to contain the molten reference metal reacts with it, rendering the results unusable.

At NMIJ, we devised a new method that substitutes a metal-carbon alloy in place of a pure metal, thereby eliminating the graphite-metal reaction. By including carbon in the metal alloy at the composition known as a eutectic, the graphite-metal reaction can be prevented from proceeding further. As a result, highly reproducible melting and freezing points are obtained. NMIJ has succeeded in establishing nine distinct fixed points, from 1153˚C to 2474˚C, using carbon eutectics of a wide variety of metals. We have also demonstrated that fixed points can be obtained at temperatures above 3000˚C, using eutectics of carbon and metal carbides.

How Made-in-Japan Technologies Are Becoming World Standards

For these "made-in-Japan" standards technologies to win acceptance as true global standards, it is necessary to demonstrate temperature reproducibility and determine temperature values with high precision. These tasks cannot be achieved in Japan alone; it must be demonstrated that the temperatures can be reproduced by anyone, anywhere in the world. Worldwide agreement depends on independent verification of temperature values by the world's leading research institutes. Many of these national metrology institutes are now involved in their research activities in this field. NMIJ is actively transferring knowledge and experience to many national metrology institutes, promoting information exchange and collaborative investigation, while working to maintain its global lead.

Photo High-temperature fixed-point furnace for radiation thermometer calibration (Ru-C eutectic point)

The International Temperature Scale, the international convention on temperature standards that is revised approximately every 20 years, comes up for revision within a few years. When the International Temperature Scale is next redefined, significant changes can be expected in the upper temperature ranges, where greater precision is an urgent necessity for industries such as materials and energy.

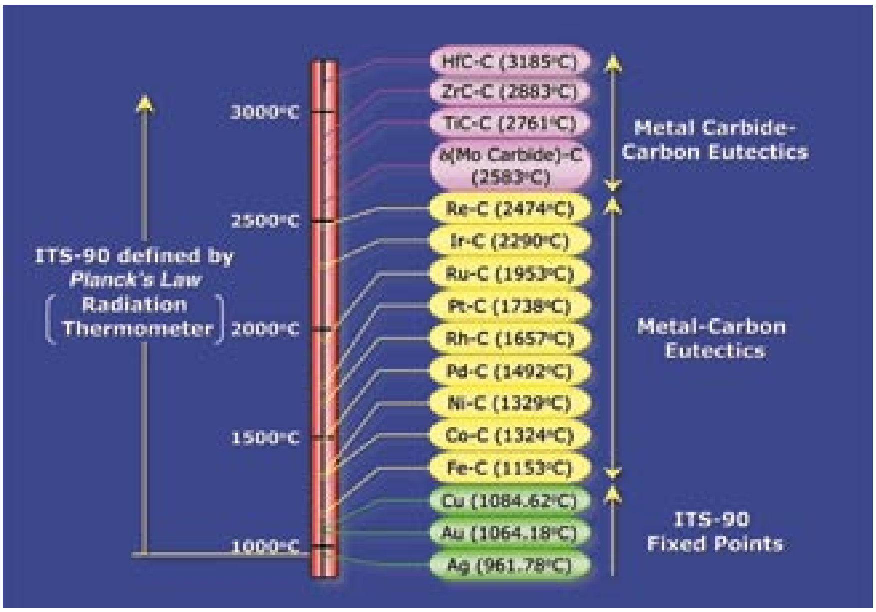

Figure High-temperature fixed points using metal (carbide)-carbon eutectics