On the need for a specified reference value for room temperature

Fengchao Liu
Department of Physics, South China Normal University, Guangzhou, 510631, China

(Received 4 January 1995; accepted for publication 9 June 1995)

This letter suggests the importance of defining a standard value for "room temperature" when reporting physical measurements. The recommendation is to designate 25 °C for this value.

"Room temperature" is commonly cited as the reference temperature for many physical property measurements without specifying an actual value (Lu *et al.*, 1994; Yu *et al.*, 1995; etc.). Because the accuracy of experimental data continues to improve in significance, there is a need to be more specific in measuring and reporting the actual temperature of all experiments. This letter considers this need and recommends that a specific value be declared a standard for physical property measurements.

In the standard equation

$$a_{t_2}=a_{t_1}[1+\alpha(t_2-t_1)], \tag{1}$$

lattice parameter a_{t_2} depends not only on the temperature t_1 and lattice parameter a_{t_1} corresponding to t_1 but also on the thermal expansion coefficient α and temperature t_2. Different values of experimental temperature t_1 have been used by various laboratories in measuring a_{t_1}. For instance, Nan and Yi-Huan (1964) used t_1=0 °C; Gibbons (1958) and Okada and Tokumaru (1984) used t_1=273.2 K (0.05 °C); White (1973) and Hartwig *et al.* (1994) used t_1=293.15 K (20 °C); Windisch and Becker (1990) used t_1=295.65 K (22.5 °C); and Klein and Croff (1967) used t_1=300 K (26.85 °C). Although the values of t_1 varied with different laboratories, if the values of t_2 are the same, and, so long as the best value of α is adopted, the different values of a_{t_2} which are obtained by various laboratories can be compared with each other.

In many papers, "room temperature" has replaced the specific value of t_2; unfortunately, experimenters have had different interpretations of what room temperature means. Yates and Panter (1962) considered room temperature as 293 K (19.85 °C); Klein and Croff (1967) used a room temperature value of 300 K (26.85 °C); and both 25 °C and 300 K were room temperature to Dutta (1962). Also, Nan and Yi-Huan (1964) used both 20 °C and 25 °C as room temperature; 298.2 K (25.05 °C) was "near room temperature" to Okada and Tokumaru (1984); and Windisch and Becker (1990) designated room temperature as 22.5 °C. Finally, Qin (1995) used 50 °C as room temperature.

From the above t_1 and t_2 values, we see that the range of experiment temperatures is from 0 to 50 °C. If we consider a more typical range of temperature in a laboratory, Δt_2, as 20 to 27 °C Δt_2 would be 7 °C. Using the differential form of Eq. (1), the lattice parameter deviation $\Delta a_{t_2}(\Delta t_2)$, which is caused only by Δt_2, is obtained as

$$\Delta a_{t_2}(\Delta t_2)=\alpha(a_{t_1})(\Delta t_2). \tag{2}$$

For silicon, a_{t_1}=5.43 Å and $\alpha=2.45\times10^{-6}$/°C (Liu, 1993, 1994), then, $\Delta a_{t_2}(\Delta t_2)$=0.00009 Å; correspondingly, the relative deviation r is (0.0009 Å)/(5.43 Å)=1.7×10^{-5}. However, 1.7×10^{-5} is larger than the relative standard deviation $r<1\times10^{-5}$ which is stipulated by the State Standard of the People's Republic of China in GB8360-87 (1987). Therefore, a specified value of t_2 is necessary to calculate a_{t_2} in Eq. (1).

The temperature t_2 was specified as 25 °C in the International Union of Crystallography, IUCr, Precision Lattice-Parameter Project which was presented by Parrish (1960). However, the lattice parameters at 25 °C quoted in this paper are based on $\alpha=4.2\times10^{-6}$/°C, and the following different temperatures: t_2=21.8 °C (Code No. 8), t_2=22.8 °C (Code No. 5), t_2=25 °C (Code Nos. 1, 11, 14, 16), $t_2=30\pm0.02$ °C (Code No. 3), t_2=31 °C (Code No. 12), t_2="room temperature" (Code Nos. 2, 6, 7). The difference between the maximum value 31 °C and minimum value 21.8 °C is Δt_2=9.2 °C; consequently, $\Delta a_{t_2}(\Delta t_2)$=(5.43 Å) ($4.2\times10^{-6}$) (9.2)=0.00021 Å. Apparently, the effect of $\Delta a_{t_2}(\Delta t_2)$ on the average a (=5.43054±0.00017 Å) of Parrish (1960) is significant; that is to say, in the range of Parrish's room temperature, the influence of the different t_2 values on the lattice parameter of silicon cannot be ignored. Therefore, to use "room temperature" to replace a specific value of t_2 is not sufficient for modern research; a standard value of room temperature must be specified.

People feel comfortable at 25 °C in daily life, and many publications do use t_2=25 °C in Eq. (1). The IUCr specified t_2=25 °C in the IUCr Precision Lattice-Parameter Project (Parrish, 1960), and the State Standard of the People's Republic of China (No. GB8360-87, 1987) is t_2=25 °C. Additionally, some physical constants are obtained at 25 °C in the recommended consistent values of fundamental constants which were published by the Fundamental Constants Task Group of the Committee on Data for Science and Technology in 1986. At present, I have only found one reference which states that "standard temperature is 0 °C" in *A New Dictionary of Physics* (Gray and Isaacs, 1975). That book does not specify a value for "room temperature." Therefore, I would like to suggest in this letter that 25 °C be used as the standard value for room temperature. I would also like to invite the readers of this publication to respond with their thoughts on this idea.

ACKNOWLEDGMENT

This work is supported by the Natural Science Foundation of Guangdong Province.

Dutta, B. N. **(1962)**. "Lattice Constants and Thermal Expansion of Silicon up to 900 °C by X-ray Method," Phys. Status Solidi **2**, 984–987.

GBB860-87 **(1987)**. The State Standard of the People's Republic of China No. GB8360-87.

Gibbons, D. F. **(1958)**. "Thermal Expansion of Some Crystals with the Diamond Structure," Phys. Rev. **112** (1), 136–140.

Gray, H. J., and Isaacs, A., Eds. **(1975)**. *A New Dictionary of Physics* (Longman Group Limited, 1975, London).

Hartwig, J., Bak-Misiuk, J., Berger, H., Bruhl, H. G., Okada, Y., Grosswig, S., Wokulska, K., and Wolf, J. **(1994)**. "Comparison of Lattice Param-

 0885-7156/95/10(3)/225/4/$6.00

eters Obtained from an Internal Silicon Monocrystal Standard," Phys. Status Solidi A **142**, 19–26.
Klein, P. H., and Croft, W. J. **(1967)**. "Thermal Conductivity, Diffusivity, and Expansion of Y_2O_3, $Y_3Al_5O_{12}$, and LaF_3 in the Range 77–300 K," J. Appl. Phys. **38** (4), 1603–1607.
Liu, F. C. **(1993)**. "Confirmation of the New Technique for Measuring the Linear Thermal Expansion of Silicon," Powder Diffr. **8**, 36–38.
Liu, F. C. **(1994)**. "Influence of Thermal Expansion Coefficient on the Lattice Parameter of Silicon," Powder Diffr. **9**, 260–264.
Lu Z. C., Xian Y. Z., and Shen B. G. **(1994)**. "Thermal Expansion Properties of Fe-based Nanocrystalline Alloys," Acta Physica Sinica **43** (5), 799–802.
Nan, S., and Yi-Huan, L. **(1964)**. "X-ray Measurement of the Thermal Expansion of Germanium, Silicon, Indium Antimonide, and Gallium Arsenide," Acta Phys. Sinica **20** (8), 699–703.
Okada, Y., and Tokumaru, Y. **(1984)**. "Precise Determination of Lattice Parameter and Thermal Expansion Coefficient of Silicon between 300 and 1500 K," J. Appl. Phys. **56** (2), 314–320.
Parrish, W. **(1960)**. "Results of the I.U.Cr. Precision Lattice-Parameter Project," Acta Crystallogr. **13**, 838–850.
Qin, X. Y. **(1995)**. "Thermal Expansion Behavior of Nanocrystalline Ag at High Temperature," Acta Phys. Sinica **44** (2), 244–250.
White, G. K. **(1973)**. "Thermal Expansion of Reference Materials: Copper, Silica, and Silicon," J. Phys. D **6**, 2070–2078.
Windisch, D., and Becker, P. **(1990)**. "Silicon Lattice Parameters as an Absolute Scale of Length for High Precision Measurements of Fundamental Constants," Phys. Status Solidi A **118**, 379–388.
Yates, B., and Panter, C. H. **(1962)**. "Thermal Expansion of Alkali Halides at Low Temperature," Proc. Phys. Soc. London **80**, 373–382.
Yu, C. W., He, P. M., Xu, Y. B., Qi, Z. F., and Li, W. Z. **(1995)**. "Growth of C_{70} Single Crystals with a Linear Temperature Gradient," Acta Phys. Sinica **44** (3), 488–491.