Radiance Temperatures at 1500 nm of Niobium and Molybdenum at Their Melting Points by a Pulse-Heating Technique

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Radiance temperatures at 1500 nm of niobium and molybdenum at their melting points were measured by a pulse-heating technique. The method is based on rapid resistive self-heating of the strip-shaped specimen from room temperature to its melting point in less than 1 s and measuring the specimen radiance temperature every 0.5 ms with a high-speed infrared pyrometer. Melting of the specimen was manifested by a plateau in the radiance temperature-versus-time function. The melting-point radiance temperature for a given specimen was determined by averaging the measured values along the plateau. A total of 12 to 13 experiments was performed for each metal under investigation. The melting-point radiance temperatures for each metal were determined by averaging the results of the individual specimens. The results for radiance temperatures at 1500 nm are as follows: 1983 K for niobium and 2050 K for molybdenum. Based on the estimates of the uncertainties arising from the use of pyrometry and specimen conditions, the combined uncertainty (two standard-deviation level) in the reported values is ±8 K.

KEY WORDS: emissivity (normal spectral); high-speed pyrometry; high-temperature reference points; melting; molybdenum; niobium; radiance temperature.

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1. INTRODUCTION

Melting-point radiance temperatures, and related normal spectral emissivities, of selected pure metals have been suggested as possible candidates for high temperature references for use in relation to optical temperature measurements [1]. The successful utilization of this scheme requires an accurate knowledge of the wavelength dependence of the radiance temperatures, and normal spectral emissivities, of the selected metals. In the past two decades, extended measurements in the wavelength range 500–1000 nm have been made at the National Institute of Standards and Technology (NIST) in the United States and at the Istituto di Metrologia “G. Colonnetti” (IMGC) in Italy [1].

The objective of the present paper is to report extension of the radiance temperature measurement capabilities to longer wavelengths, 1500 nm. In order to achieve this, a high-speed infrared pyrometer was constructed. The pyrometer incorporates an InGaAs photodiode as the detector. It has been shown [2] that this type of detector has a satisfactory level of linearity and stability. In the present work, radiance temperatures at 1500 nm of niobium and molybdenum at their respective melting points were measured.

2. MEASUREMENT SYSTEM

A functional diagram of the high-speed system that is used for performing measurements at high temperatures is shown in Fig. 1. The specimen was heated from room temperature to its melting point in less than 1 s by the passage of a high-current pulse through it. The heating rate of the specimen was adjusted by adjusting the voltage of the battery bank and the Inconel resistor in series with the specimen. The switch and the electronic equipment were controlled by time-delay pulse generators. Details concerning the construction and operation of the pulse heating system are given in earlier publications [3, 4].

The high-speed radiance temperature measurements were made with a two-wavelength pyrometer, operating at 1500 and 651 nm. The 651-nm channel was used for calibration and control purposes. The pyrometer’s achromatic lens system focuses the radiance from a circular target area (0.2-mm diameter) on the specimen onto the head of a fiber-optic bundle, which is randomly bifurcated in order to distribute nearly equal fractions of the measuring pyrometer.

Radiance temperature (sometimes referred to as brightness temperature) of the specimen surface at a given wavelength is the temperature at which a blackbody at the same wavelength has the same radiance as the surface. The wavelength is the effective wavelength of the measuring pyrometer.