ABSTRACT

The Effect of Anisotropy on Emissivity

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The correlation of structural anisotropy with normal spectral emissivity has been investigated experimentally and theoretically. Data on anisotropic materials include pyrolytic graphite, pyrolytic boron nitride, and single crystal beryllium at temperatures near 800°C over a wavelength range from visible to near infrared (0.60 - 11μ) in both purified hydrogen and argon atmospheres. Photomicrographs (up to 1000X), interference photographs, and X-ray orientation patterns were taken of all surfaces before and after the experiments to insure that no surface changes had taken place.

The probing technique was employed[1] to measure normal spectral emissivity which avoided complicated optics and separation of blackbody cavity and specimens from the same heating conditions. Thermocouple temperature measurements of specimen surfaces and blackbody cavity were made directly. A convenient correction for temperature difference between blackbody cavity and specimens was achieved by means of a macroscopic thermal relation involving the Planck Radiance.

The ability to control emissivity by controlling crystallographic orientation was demonstrated by measuring the normal spectral emissivity of C-face (c-axis perpendicular to the surface) pyrolytic graphite specimens as a function of deposition temperature. Variation of the electrical conductivity parallel to the C-face, which corresponds to a normal spectral emissivity perpendicular to this face, was achieved by depositing the pyrolytic graphite at different temperatures ranging from 1800 to 2200°C. These experimental results for C-face pyrolytic graphite, which is metallic in its emissive characteristics due to this high electrical conductivity parallel to this face, have yielded a qualitative comparison to the Hagen-Rubens relation developed for metals in the infrared.

The degree of anisotropy required to significantly effect the emission of radiant energy was demonstrated by comparing polarized light emissivity measurements of the A-faces (c-axis parallel to surface) of pyrolytic graphite and pyrolytic boron

[1] Autio, G. W. and Scala, E., Carbon 4, 13 (1966).

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nitride to that of a less anisotropic material such as single crystal beryllium. A comparison with theory was made to determine whether the minimum polarized emissivity for the A-face orientation of a particular material was equivalent to that of the unpolarized emissivity of the corresponding C-face. Polarized light emissivity studies have provided a measure of the preferred orientation in pyrolytic materials.

Attempts to compare theory with experiment have been made based on band structure calculations and optical constants measurements. Relating the normal spectral emissivity to other physical properties was achieved by coupling the electrical properties, conductivity and dielectric constant, with the optical properties, index of refraction and extinction coefficient. The comparison of theory with experiment depended on such practical considerations as surface preparation, degree of preferred orientation, and temperature. In the Hagen-Rubens range of wavelengths ($\gtrsim 5\mu$), the anisotropy in emissivity is predicted to a great extent by the observed anisotropy of dc electrical conductivity along the major crystallographic directions.