Study on the effect of roughness on the cryogenic emissivity of copper

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Abstract

In a cryogenic vacuum environment, radiative heat transfer is a significant means of heat transfer, characterized by the important parameter of cryogenic emissivity. However, cryogenic surface emissivity varies with changes in surface condition, exerting a significant influence on heat transfer. In this study, a systematic investigation was conducted on the cryogenic surface emissivity of copper samples with different roughness under vacuum conditions, with a spectral range of 2 um to 12 um and a temperature range of 200–300 K. A custom-built device was used to study the emissivity, investigating the effects of temperature and roughness on surface emissivity. The results showed that at low temperatures, emissivity increases with rising temperature and with increasing surface roughness. A modified emissivity model based on the Agababov roughness function was established to fit the relationship between emissivity, temperature, and roughness, enabling the prediction of low-temperature surface emissivity for samples with different roughness levels. Different laser-etched structures were designed on the surface of copper samples. Through simulation and measurement verification, the cryogenic surface emissivity of the samples was improved to over 0.5. This study promotes understanding the mechanism of cryogenic spectral emissivity varying with roughness.

Keywords: cryogenic emissivity, roughness, laser-etched