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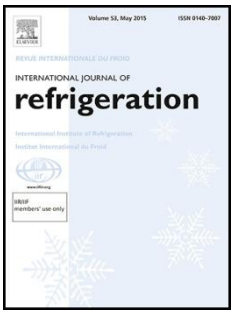

Title: Low temperature thermal radiative properties of gold coated metals

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Low temperature thermal radiative properties of gold coated metals

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Highlights

- emissivity and absorptivity of Ti-6Al-4V, Cu and various Au layers are investigated
- Au layer reduces large emissivity/absorptivity difference between Ti alloy and Cu
- sputtered Au layer has the lowest emissivity/absorptivity among deposited samples
- thermal radiative properties of gold layers strongly depend on purity of the gold

Abstract

In order to assess the effect of gold deposition on thermal radiative properties of metallic materials, we measured total hemispherical emissivity and absorptivity of Au layers with a minimal thickness of 1 µm in dependence on the temperature T_R of thermal radiation (from 20 K up to 320 K). Technically pure copper or titanium alloy (Ti-6Al-4V) was used as substrate while three types of Au layers were deposited by a sputtering process or a galvanic method. Emissivities among samples with Au layers ranged from 1.8% to 3.9% at room temperature. Galvanic deposition of pure Au lowered the original emissivity of Ti-6Al-4V alloy at 300 K from 15.8% to 3.4%, whereas the same deposition on mechanically polished Cu resulted in increase of emissivity by a factor of three, up to 3.2%. Absorptivity of each sample with Cu or Au surface was lower than its emissivity and showed a weaker dependence on T_R.

Keywords: gold films, heat transfer, thermal radiation, cryogenics

1. Introduction

Emissivity of a real surface is a ratio of thermal radiation energy emitted by the surface and by the black (100% absorbing) surface at the same temperature. When a body is irradiated, the absorbed fraction of the energy of thermal radiation impacting its surface is defined as absorptivity (Howell et al., 2010).

Thermal radiative properties, i.e. emissivity and absorptivity, generally depend on the used material, treatment of bulk material as well as on surface finish (Sabuga and Todtenhaupt, 2001; Musilova et al., 2005; Kralik et al., 2014). Thermal radiation interacts with the given material in a "skin depth", i.e. in a very thin surface layer of a metal, and due to the interaction with free electrons it is related to electrical resistivity of the material near the surface. For instance, the skin depth calculated for a gold coating at 35 K is only about 0.06 µm (Tuttle et al., 2016). Furthermore, the emissivity is a material property dependent on the material temperature while the absorptivity generally depends on both the temperature of the material and the spectrum of the thermal radiation (temperature of the source of thermal radiation). Both the emissivity and absorptivity of metallic materials generally increase with increasing temperature of the sample, and the character of such dependence mainly results from increasing metal resistivity (Musilova et al., 2005; Kralik et al., 2016).