BoKoMaT

28.09. – 29.09. 2023

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Vortragssprache: EN

Emissivity measurements of thin NiTi shape memory alloy wires by comparing them with a black body cavity

The shape memory effect and superelasticity of NiTi alloys make them unique for their applications in actuators and elastocaloric cooling technologies [1]. These distinct properties are induced in NiTi alloys by reversible phase transformation from martensite to austenite, which can be triggered through temperature change or stress. It is extremely challenging to measure the temperature of thin NiTi wires during operation without disturbing their phase transformation parameters with conventional contact thermometry. However, a possible solution is contactless infrared thermography for which accurate emissivity data are mandatory. Here, we present an apparatus for measuring the emissivity of metals on a microscopic level, covering the temperature range from 308 K to 423 K. This apparatus consists of three principal components, i.e., a state-of-the-art infrared camera, a reference quality black body cavity [2], and contact thermometry calibrated on ITS-90. In the present work, the emissivity of NiTi samples having rough, slightly oxidized, and heavily oxidized surfaces was measured with an expanded combined uncertainty of 0.015 at a confidence level of 95%. It is investigated that with the increase in temperature, the emissivity increases rapidly in the martensite phase, while it decreases slowly in the austenite phase. We hypothesize that this behavior is due to the temperature-dependent change in microstructure on the sample surface. Moreover, it will be presented that the average emissivity is as low as 0.25 for a shiny rough surface, and it increases with the thickness of the oxidation layer, e.g., to 0.33 for slightly oxidized and to 0.45 for heavily oxidized surfaces.

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