Are ceramic-based thermal emitters a black-body source of IR radiation?

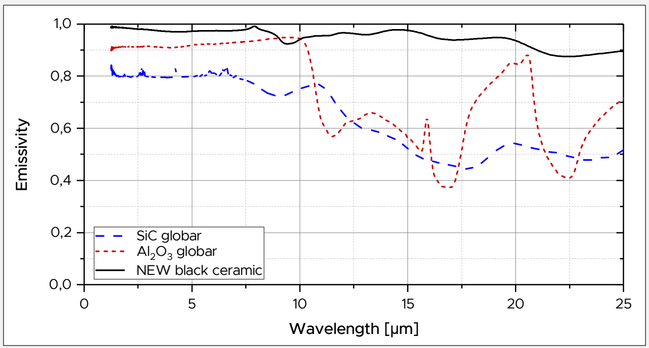

Fig. 1: Emissivity of different IR emitter ceramics.

The silicon carbide (SiC) globar

A silicon carbide (SiC) globar is the most commonly used infrared (IR) light source in measuring devices for IR spectroscopy. It features a high emissivity and operates at high temperatures typically ranging from 1200 K to 1600 K, resulting in a high optical output signal in the mid and far IR range. However, these ceramic-based IR sources are not ideal black-body emitters especially in the far IR and terahertz (THz) range with wavelengths greater than 10 µm (Fig. 1).

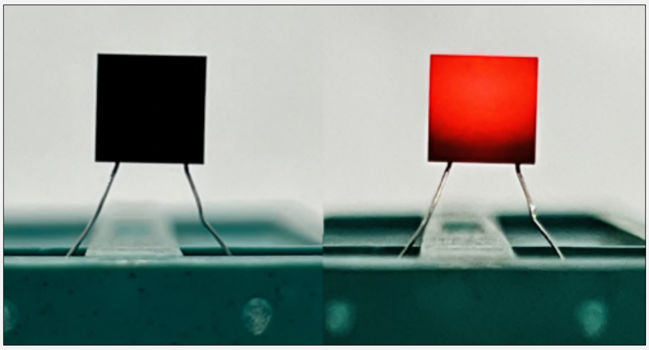

Fig. 2: Al_2O_3 ceramic with novel black coating (left) and during operation at 1200 K (right).

Black-body radiation

High optical output of an infrared emitter is achieved through a combination of high emissivity, a large emitting area, and high temperature, as outlined by the Stefan-Boltzmann law. However, it is important to note that according to Planck's law of radiation and Wien's displacement law, an increase in operating temperature results in a shift of the peak intensity of black-body radiation towards shorter wavelengths with a low impact on increasing optical output at longer wavelengths. Hence, to achieve optimal performance in the far IR and terahertz (THz) range, maximizing emissivity and ensuring a substantial radiating area are of utmost importance.

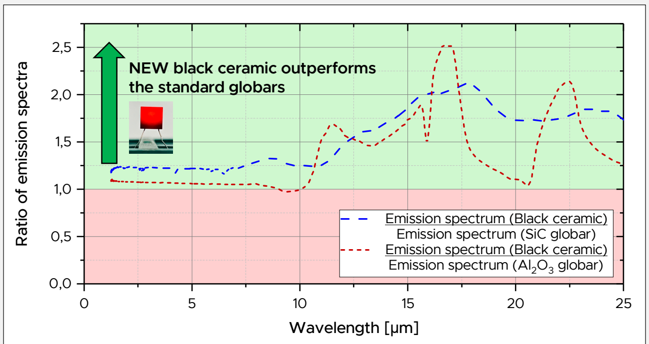

Fig. 3: Performance comparison based on calculated emission spectra for 1200 K operating temperature and measured emissivities from Fig. 1.

Al_2O_3 ceramic with black coating

In order to increase the emissivity of ceramics in the far IR and THz range a novel black coating has been developed. It can be applied on both sides of a ceramic like Al_2O_3 (Fig. 2) and features an emissivity close to that of a black-body (see Fig. 1). Operating temperatures of 1200 K and more are feasible with this black coating and will lead to higher signals compared to a standard SiC globar (Fig. 3). Additionally, the higher emissivity allows a reduction of the operating temperature which is accompanied by several benefits.

HIGHLIGHTS

- Ceramics are NOT a black-body source.
- A maximum emissivity is of utmost importance to enhance signal strength in the far IR and THz range.
- A NEW black coating for ceramics increases signal strength in the far IR and THz range.

Benefits in FT-IR spectroscopy

In measuring instruments like a FT-IR spectrometer a lower operating temperature of the IR emitter has many advantages: lower temperature drift, higher stability and lifetime, faster measurements, little-to-no risk of fire, no sample heating relevant for biological applications and many more.

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