Broadband radiation source for infrared and terahertz spectroscopy

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Abstract: New developments towards miniaturized and powerful infrared spectrometers are limited by the availability of appropriate components. A novel black-body radiation source with broadband emissivity in the infrared range is presented and compared to state-of-the-art sources.

1. Introduction and motivation

Infrared (IR) spectroscopy holds significant untapped potential for material analysis but new developments towards miniaturized and powerful systems are mainly limited by the availability of appropriate components [1], like the IR radiation source. A silicon carbide (SiC) globar is the most commonly used 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 infrared (FIR) and terahertz (THz) range with wavelengths greater than 10 µm (Fig. 1) [2-4].

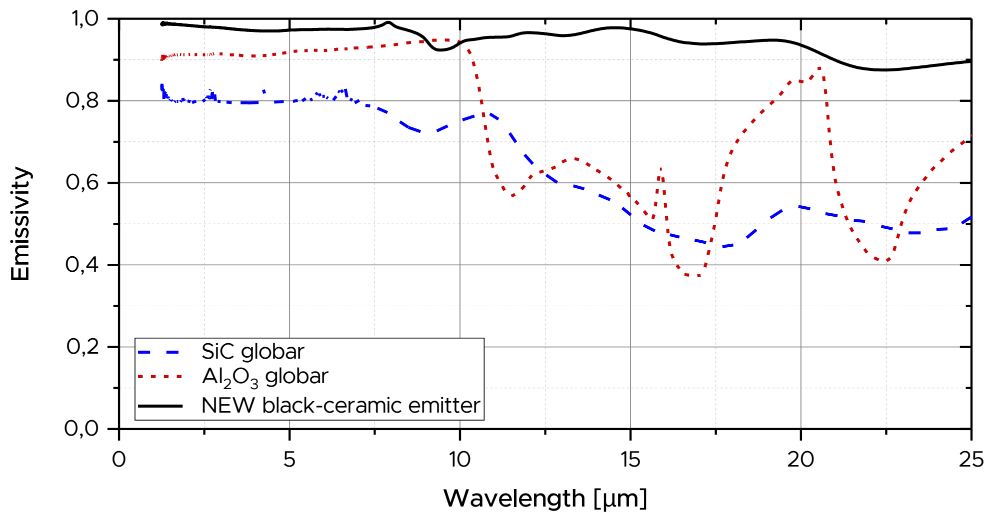

Fig. 1. Emissivity of different IR emitter ceramics measured at room temperature.

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 range, maximizing emissivity and ensuring a substantial radiating area are of utmost importance.

2. Results and conclusions

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 (compare Fig. 1). Operating temperatures of 1200 K and more are feasible with this black coating and result in higher signals compared to a standard SiC globar (Fig. 3). The emitter size and geometry can be tailored to customer- or application-specific needs. Finally, the higher emissivity allows a reduction of the operating temperature of the radiation source which is accompanied by several benefits. 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, lower electrical power consumption, faster measurements, little-to-no risk of fire, no unwanted sample heating relevant for biological applications and many more.

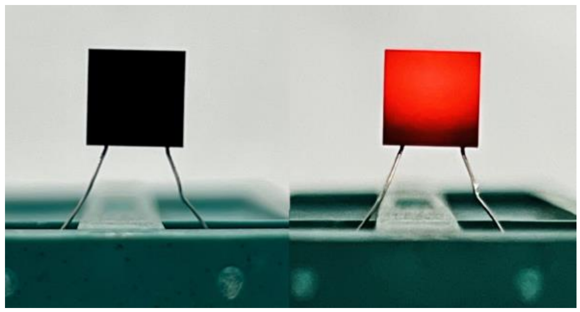

Fig. 2. Al_2O_3 ceramic (5x5 mm²) with novel black coating (left) and during operation at 1200 K (right).

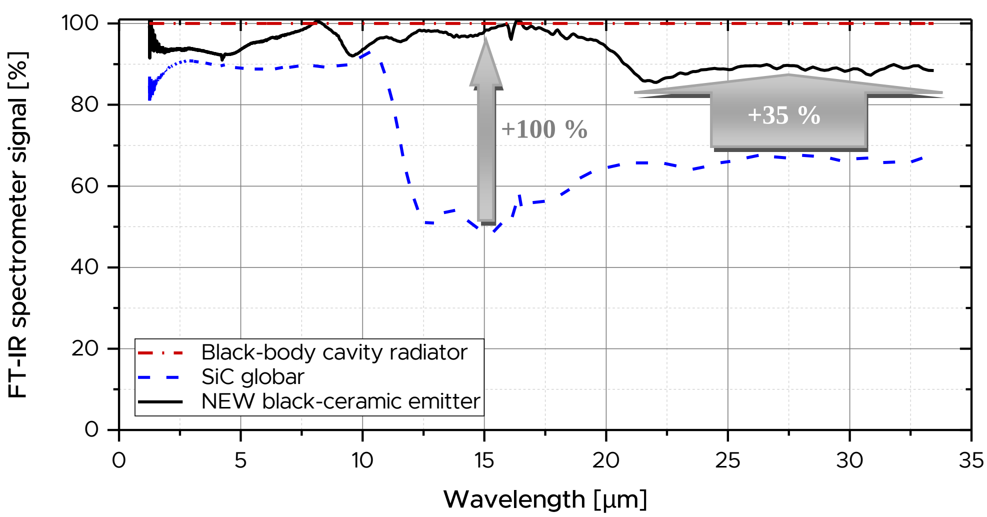

Fig. 3. Performance of a state-of-the-art SiC globar and the novel black-ceramic IR emitter compared to a black-body cavity radiator all operating at 1200 K temperature. The emitted radiation was coupled into a Bruker Vertex 70v FT-IR spectrometer to measure the signal strengths as a function of the wavelength.

3. References

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