

High-Temperature Thermometer Using Cr-Doped GdAlO₃ Broadband Luminescence

Intense high-temperature luminescence enables this thermometer to operate in high thermal radiation backgrounds.

John H. Glenn Research Center, Cleveland, Ohio

A new concept has been developed for a high-temperature luminescence-based optical thermometer that both shows the desired temperature sensitivity in the upper temperature range of present state-of-the-art luminescence thermometers (above 1,300 °C), while maintaining substantial stronger luminescence signal intensity that will allow these optical thermometers to operate in the presence of the high thermal background radiation typical of industrial applications. This objective is attained by using a Cr-doped GdAlO₃ (Cr:GdAlO₃) sensor with an orthorhombic perovskite structure, resulting in broadband luminescence that remains strong at high temperature due to the favorable electron energy level spacing of Cr:GdAlO₃.

The Cr:GdAlO₃ temperature (and pressure) sensor can be incorporated into, or applied onto, a component's surface when a non-contact surface temperature measurement is desired, or alternatively, the temperature sensor can be attached to the end of a fiber-optic probe that can then be positioned at the location where the temperature measurement is desired. In the case of the fiber-optic probe, both the

pulsed excitation and the luminescence emission travel through the fiber-optic light guide. In either case, a pulsed light source provides excitation of the luminescence, and the broadband luminescence emission is collected. Real-time temperature measurements are obtained using a least-squares fitting algorithm that determines the luminescence decay time, which has a known temperature dependence established by calibration. Due to the broad absorption and emission bands for Cr:GdAlO₃, there is considerable flexibility in the choice of excitation wavelength and emission wavelength detection bands.

The strategic choice of the GdAlO₃ host is based on its high crystal field, phase stability, and distorted symmetry at the Cr³⁺ occupation sites. The use of the broadband emission for temperature sensing at high temperatures is a key feature of the invention and is novel since broadband luminescence emission normally shows severe thermal quenching. The tightly bound AlO₆ octahedra in GdAlO₃ results in a larger energy barrier to nonradiative decays than in other materials and therefore makes using broadband emission for temperature sensing

possible at high temperatures. This approach results in a substantial increase in temperature capability. For example, the most commonly used Cr-doped crystal used for luminescence-based temperature measurements, ruby, has only been demonstrated up to 600 °C, whereas the Cr:GdAlO₃ optical thermometer under development has already been shown to exhibit useful luminescence up to 1,300 °C. Because GdAlO₃ is non-reactive and is stable in harsh, high-temperature environments, sensors composed of Cr:GdAlO₃ will be very well suited for remote high-temperature measurements in engine or industrial environments where its intense high-temperature luminescence will stand out above significant thermal radiation background levels.

This work was done by Jeffrey Eldridge of Glenn Research Center and Matthew Chambers. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18614-1.

Metrology Arrangement for Measuring the Positions of Mirrors of a Submillimeter Telescope

This system is applicable to any submillimeter radio telescope.

NASA's Jet Propulsion Laboratory, Pasadena, California

The position of the secondary mirror of a submillimeter telescope with respect to the primary mirror needs to be known ≈0.03 mm in three dimensions. At the time of this reporting, no convenient, reasonably priced arrangement that offers this capability exists. The solution proposed here relies on measurement devices developed and deployed for the GeoSAR mission, and later adapted for the ISAT (Innovative Space Based Radar Antenna Technology) demonstration. The measurement arrangement consists of four metrology heads, located on an optical bench, attached to the secondary mirror. Each

metrology head has a dedicated target located at the edge of the primary mirror. One laser beam, launched from the head and returned by the target, is used to measure distance. Another beam, launched from a beacon on the target, is monitored by the metrology head and generates a measurement of the target position in the plane perpendicular to the laser beam.

A 100-MHz modulation is carried by a collimated laser beam. The relevant wavelength is the RF one, 3 m, divided by two, because the light carries it to the target and back. The phase change due to travel to the target and back is meas-

ured by timing the zero-crossing of the RF modulation, using a 100-MHz clock. In order to obtain good resolution, the 100-MHz modulation signal is down-converted to 1 kHz. Then, the phase change corresponding to the round-trip to the target is carried by a 1-kHz signal. Since the 100-MHz clock beats 100,000 times during one period of the 1-kHz signal, the least-significant-bit (LSB) resolution is LSB = 0.015 mm.

This work was done by Alex Abramovici and Randall K. Bartman of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47530