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A high-speed, eight-wavelength visible light-infrared pyrometer

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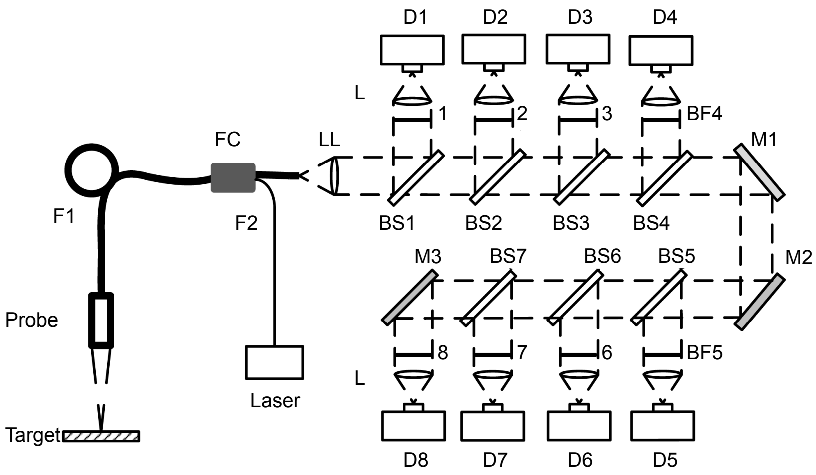

Schematic layout of the eight-wavelength pyrometer: F1-F2, fibers; LL, broadband collimating lenses; L, focusing lens; BS1~BS7, longpass dichroic beamsplitters; D1~D3, Si detectors; D4~D8, InGaAs detectors; BF1~BF8, bandpass filters; M1~M3, total reflective mirrors ; FC, fiber coupler.

Abstract: A reliable temperature measurement is a key diagnostic in many industrial and scientific applications. The temperature measurement of a sample under shock loading is of special interest. The temperature of interest in shock physics is in the range of 1500 K to 10000 K. The wavelength range of peak blackbody spectral radiance for these temperatures where signal would be maximum is from 280 nm to 1930 nm calculated by the Wien's displacement law λ_{max}=2897.7(μm·K)/T. However, as limited by the currently applicable detectors, we have developed an eight-channel, high-speed, single-fiber instrument in the spectral range of 400 nm thru 1700 nm in this work. The working wavelength of each channel is selected as 500 nm, 700 nm, 900 nm, 1100 nm, 1250 nm, 1350 nm, 1500 nm and 1600 nm. The radiation from the target in the field of view (FOV) of the system is collected by the optical probe. It passes through the fiber (F1), and then is coupled and collimated by the fiber coupler (FC) and the broadband collimating lens (LL). The collimated beam is spectrally splitted into eight beams by the long-wave-pass beam-splitters (BS1 to BS7) and three total reflective mirrors (M1 to M3) coated with golden film. The eight beams pass through eight bandpass filters (BF1 to BF8), and then they are coupled onto the eight photo detectors (D1 to D8) by independent focusing lenses (L). A laser collimation system composed of laser, fiber (F2) and fiber coupler (FC) is used for the probe alignment before experiment. The temperature from 1500 K to 10000 K is then measured by optimizing the linearity of each channel. The multilayered dichroic beamsplitters and bandpass filters are used to narrow the spectral range of each detector. The current generation of semiconductor detectors is capable of high responsivity and high speed (~10 ns rise-time) over the above wavelength range when coupled to appropriate, high-gain transimpedance amplifiers, all at a modest price. The semiconductor detectors of Si and InGaAs are used as photoelectric devices, whose bandwidths are 150 MHz. Their working wavelengths cover 400 nm~1700 nm range. By combining the high-transmittance beam-splitters and narrow-bandwidth filters, the peak spectrum transmissivity of each channel can be higher than 60%. We finished calibration of this pyrometer and get the linear constant $k(\lambda)$ by using high temperature blackbody furnace and standard opto-electronic pyrometer.

Keywords: optic pyrometer; blackbody radiation; shock physics; semiconductor detectors

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