Chapter 42
Fiber Optic Interferometric Method for Registration of IR Radiation

Fiber Optic Interferometric Method

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Abstract A high sensitivity speckle based fiber-optic method for registration of low intensity IR radiation is described. The method is based on the effect of variation of the speckle pattern in the far-field of a multimode fiber. IR radiation that falls on a lateral surface of the fiber leads to variation of the speckle image. Computer processing of the speckle image provides information on the amplitude of perturbation that interacts with the fiber. An algorithm was developed for processing of the speckle image and determining of the intensity of IR radiation. The results of the computer simulation correlate well with the experimental ones.

Keywords Multimode fiber • Speckle pattern • Modal interference • CCD • IR

42.1 Introduction

When injecting a coherent light beam into a multimode optical fiber the light is guided in a determined number of propagation modes. Each of these modes has a specific propagation constant, spatial field distribution, and polarization. The number and the shape of confined modes are a function of the index of refraction, the diameter of the fiber core, and the wavelength of light. At the exit end of the fiber the propagation modes interfere in the far field producing a random interference image – the speckle pattern. This pattern is highly sensitive to external perturbations and carries information on the conditions of light propagation in the fibers. The changes in the speckle pattern produced by external perturbations may

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be determined by variation in the optical path length due to changes in the index of refraction, geometrical path, and the propagation constants of each fiber mode. This effect is laid dawn on the basis of a measurement technique that employs modal interference in an optical fiber [1]. Speckle-based methods are widely used for registration of physical parameters [2–4]. These methods have been extensively used for industrial applications in measurements of deformation and displacement, object shape, vibrations, etc. [5, 6]. Electronic speckle interferometry combined with PC processing technique offer powerful tools for registration of physical quantities and industrial control. In a previous paper [1] we have reported a fiber optic method for registration of low intensity infrared (IR) radiation based on the effect of interference of propagation modes in the far field of a multimode fiber. In this paper we present new results and details on the method.

42.2 Experimental Set-Up

The experimental set-up is represented in Fig. 42.1. It consists basically of a multimode optical fiber coupled to a coherent light source, a CCD detector, and a PC for processing of the speckle image. The probing light from the coherent light source is injected into the input face of the fiber and at the output end of the fiber in the far-field the modal distribution of the probing light intensity (the speckle image) is registered. When a physical perturbation hits the fiber, the speckle pattern changes. The CCD is used for registration of the variations of the speckle pattern of the multimode fiber for subsequent PC processing.

The probing light source was a HeNe Laser at 633 nm. A segment of multimode commercially available optical fiber with a parabolic index profile and the core/cladding diameter 50/125 μm was used as sensing element. A common electrical heater was used as IR radiation source. Variation of the intensity of IR radiation was performed by variation of the distance between electrical heater and optical fiber. The speckle pattern in the far field of the fiber was registered with a HDCS-1020 CMOS image sensor with the pixel size 7.4 × 7.4 μm and image array sizes VGA 640 × 480. The full frame video rate at 8-bit resolution was 30 fps.

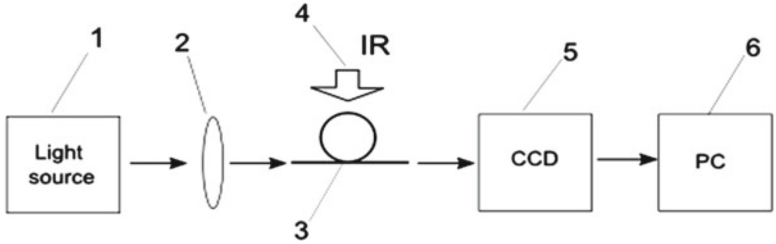

Fig. 42.1 Schematic representation of the method: *1* – a coherent light source; *2* – microscope objective; *3* – multimode optical fiber; *4* – IR radiation source; *5* – CCD detector; *6* – computer