Research and Development

Extended Abstract

Nanomedicine 2017: Gradient optical filters for medical applications-Anna Sobczyk-Guzenda-Lodz University of Technology, Poland

Abstract

Low energy light has been continuously gaining importance in medical practice. Its pain-relieving as well as regenerating and microcirculation enhancing activity are well recognized. It has also been shown that polarized light exhibits bio-stimulating properties. Light utilizing techniques require optical filters with their aim being a removal of unwanted wavelengths from the spectrum emitted by the source. Interference filters are constructed as stack multilayer systems composed of alternated films of high and low refractive index materials. Frequently, low adhesion between these materials causes destruction of the filters and physical effects on interphase boundaries makes them difficult to manufacture. This work introduces a novel attitude towards optical filters. A manufacture of filters with a gradient change of refractive index is presented. This gradient results from periodic change of the coating composition, predetermined in the phase of filter design. In the filter realization phase, two materials are deposited. One is silicon dioxide with refractive index of 1.45, while the other comprises silicon nitride with refractive index equal 2.20, changing their proportions in a continuous and periodic manner results in a gradient periodic change of material refractive index. The technology comprises radio frequency plasma enhanced chemical vapor deposition with a use of tetramethyldisilazane as precursor. A use of nitrogen as a reaction medium leads to silicon nitride coatings, while an application of oxygen results in silicon dioxide films. When the process is carried out in a mixture of nitrogen and oxygen, a material with predetermined value of its index of refraction is deposited.

FOSs can be realized with a working principle primarily based on a large wide variety of interferometric configurations, e.g., Sagnac interferometer, Michelson interferometer, Mach-Zehnder interferometer, and Fabry-Perot interferometer. Typically, these methods exhibit an extremely excessive sensitivity even though cross-sensitivity represents a substantial drawback: first of all the have an impact on of temperature may also introduce quite high size uncertainties (Grattan & Sun, 2000). These FOSs can be designed as intrinsic sensors, the place the sensing component is the fiber itself, or as extrinsic sensors, the place a small measurement sensing component is connected at the tip of an optical fiber. The most common configuration is the second, the place the sensing element, positioned at the tip of the optical fiber, reasons adjustments of mild parameters in a ordinary relation with the measurand. In this case, the optical fiber is employed to transmit the radiation emitted by means of a light supply (e.g., laser or diode) and to transport the radiation, modulated through the measurand, from the sensing thing to a photodetector (e.g., an optical spectrum analyzer). Thanks to this solution, the sensor can be used additionally for invasive measurements, as the largest phase of the measurement device (light supply and photodetector) can be placed a ways from the miniaturized sensing element, due to the very confined electricity losses of light in the fiber.

In scientific applications, commonly committed to pressure and strain monitoring (Rolfe et al., 2007), the most frequent sketch is based totally on the interferometer configuration proposed by using Fabry and Perot (Fabry & Perot, 1898), additionally acknowledged as multi-beam interferometer due to the fact many beams intervene in one resonator. A standard cognizance is composed of two parallel high reflecting mirrors placed at distance. If distance is variable, the instrument is known as a Fabry-Perot interferometer. If d is fixed, whereas the incident mild perspective varies, the instrument is referred to as a Fabry-Perot etalon. The Fabry-Perot interferometer lets in to distinguish very shut radiation wavelengths. The Fabry-Perot cavity is normally utilized as secondary aspect of the sensor. Its output is an electromagnetic radiation with a wavelength that is feature of d. In order to have high performances a dimension gadget primarily based on Fabry-Perot interferometer wishes a photodetector discriminating radiations with very close wavelengths. The working precept can be described as follows. When a mild beam, emitted by way of a mild supply (e.g., a laser), enters between the two mirrors, a more than one reflections phenomenon takes place. The electromagnetic waves in the cavity can interact constructively or destructively, depending on if they are in phase or out of section respectively. The condition of positive interference, corresponding to a peak of transmitted light intensity, occurs if the difference of optical route length between the interacting beams is an integer a couple of of the mild wavelength.

Other methods applied to the sketch of intensity-modulated FOSs are based on the mild coupling of two fibers. In this configuration, schematically reported in determine 4, the radiation emitted via a light source is conveyed within a fiber optic, whose distal extremity is positioned in front of another fiber. The intensity of the light transmitted into the second fiber, and measured by using a photodetector positioned at its distal tip, is associated to the distance (d) between the two fiber tips: the transmitted intensity decreases when d increase.

About thirty years have passed considering the fact that the introduction of fiber Bragg grating (FBG) sensors, when Hill et al. located the phenomenon of photosensitivity (Hill et al., 1978). They discovered that an optical fiber with a germanium-doped core can show a light-induced permanent alternate in the core's refractive index thanks to an electromagnetic wave with high depth and a precise wavelength. An optical fiber core characterised by means of periodic refractive index adjustments constitutes a FBG. Only eleven years later, a milestone find out about describing a FBG-based sensor was once posted (Meltz et al., 1989). The development of such sensors was mainly delayed due to the excessive cost and the attention difficulties, that only throughout the nineties showed a vast reduction. Nowadays, there are two primary techniques to recognise fiber grating: interferometric and segment masks method. These strategies enable for the manufacturing of some unique kinds of grating labeled as: FBG; long-period fiber grating; chirped fiber grating; tilted fiber grating; and sampled fiber grating (Lee, 2003). The gratings are referred to as fiber Bragg gratings (FBGs) if the grating spatial length has the order of magnitude of hundreds of nanometers, or lengthy duration gratings (LPGs) if the spatial length has the order of magnitude of hundreds of micrometers. Application-oriented customizations, reduced costs and robust designs are essential for the business success of such sensing technology, especially for the scientific market.

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