Reticoli a passo lungo in fibra ottica con differenti passi reticolari sovrapposti: teoria, fabbricazione ed applicazione per la rivelazione simultanea di più parametri

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An Optical fiber long period grating (LPG) is a permanent periodic modulation of the core refractive index of a photosensitive single-mode fiber, generally photo-induced by means of ultraviolet (UV) irradiation: characterized by a grating period of several hundred microns, it can couple light from forward-propagating core mode to forward-propagating cladding modes, so that its transmission spectrum consist of a series of loss peaks. The central wavelength of each attenuation band, called resonance wavelength, is not arbitrary but it must fulfil a phase matching condition and it depends on the grating pitch, on the amplitude of the induced index modulation and on the order of the cladding mode itself.

More complex index perturbations, composed of spatially superimposed gratings of different periods, imply the presence in the transmission spectrum of various attenuation bands associated to cladding modes of very different orders that would never be adjacent in a single LPG spectrum. Superimposed long-period gratings (SLPGs) can perform new and interesting applications but their fabrication is not trivial due to the nonlinear response of photosensitive core to UV irradiation. In this work a novel flexible writing technique has been designed and developed to efficiently superimpose long period gratings having arbitrary periods: it is is based on a custom UV exposure schedule that, through a computer-controlled manufacturing system, can induce point-by-point a discretized index pattern of arbitrary shape. The efficiency and flexibility of this novel method have been experimentally demonstrated with the superimposition of two sinusoidal gratings with pitches $\Lambda_1 = 425\ \mu m$ and $\Lambda_2 = 255\ \mu m$: two resonance peaks, associated to LP_{06} and LP_{09} cladding modes, have been approached in a chosen wavelength range (1500-1600 nm) and minimum transmittances about equal to -20 dB have been achieved by careful design.

Such manufactured SLPG has been proposed as a sensor to measure simultaneously temperature and surrounding refractive index (SRI) changes: the two closely resonance peaks shift as these measurands change and, thanks to a proper experimental setup, their individual responses to temperature and SRI have been evaluated at calibration level. The choice of suitable operating ranges allows to neglect both non-linear and cross-sensitivity effects then, from the measurement of the wavelength shifts, the simultaneous changes of measurands can be extrapolated by solving a linear system (dual wavelength technique). The proposed dual-parameter sensor system works with aqueous solutions in the near infrared with operating ranges from 19 to 26 °C for temperature and from 1.3164 to 1.3315 RIU for refractive index. Its performance is good in terms of resolutions, 0.45 °C and $1.8 \cdot 10^{-3}$ RIU; the maximum deviation between the extrapolated values and the "true" values is about 0.12 °C for temperature changes and $6 \cdot 10^{-4}$ for RI changes.