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A Novel approach on detailed analysis of half-etched fiber Bragg grating for sensing purpose

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Article

Fiber optics has proven its best applications in the long-distance telecommunication and high-speed data transfer with secure features of the optical signal . Due to light weight, tiny hair like structure, compact size, high sensitivity, immune to electromagnetic interference and remote sensing features of the optical fiber bring forward its candidature became significant for the sensing applications. Evanescent-field-based fibre optic sensors in which a portion of the fibre cladding has been removed, became very attractive in chemical and biochemical applications where higher sensitivity, simplicity and the robustness are of the paramount importance . Removal of the fibre cladding layer pave the way of interaction between the evanescent field of the propagating mode (or modes) and the surrounding medium. Furthermore, thinned optical fibres and fiber Bragg gratings (FBGs) are of interest for wavelength tuning. In addition, in the last few years, several interrogation methods have been proposed. The principle of operation of these sensors rely on dependence of the Bragg wavelength on effective refractive index and the grating pitch. However, if the cladding diameter is reduced along the grating region, the effective refractive index is significantly affected by the external refractive index, which in turn shift the Bragg wavelength combined with the modulation of the reflective amplitude. Chemical etching using hydrofluoric acid (HF) is one of the most effective approaches in shaping the structure of the fibre to achieve the desired broadband spectra . Here, a detailed study on the effect of the diameter of the fiber due to etching has presented. The single reflection peak of the FBG splits into two separate wavelengths due to the half-etching. The axial tension applied on the half etched FBG (HEFBG) is the key factor in determining the peak-to-peak distance between the two lobes of the grating. Due to the reduction in diameter, there will be a considerable change in the effective refractive index which in turn affects the sensitivity of the gratings. As a result, higher sensitivity is observed. Experimental set-up and details Figure 1 shows the schematic diagram of the experimental set-up. Light from a broadband SLD source coupled with the directional 3dB coupler. The reflected light from the half-etched FBG through the coupler is monitored using an Optical spectrum analyser. Schematic diagram of the experiemntal set-up To etch the fibre along the length of the grating, the half of the grating is dipped into the 40% HF solution. For controlling the etching effectively a dozens of fiber were immersed into the HF solution, taken out every 5 minutes and teh diameter of teh etched portion was measured uding the optical microscopy after careful cleaning and drying. It is found that teh etching rate was 1.61 µm/min at the room temperature. With knowledge of the etching rate, we then repeated the etching on the gratong of length 1 cm. The main factors to get the ideal diameter are the concentration of the HF solution and the room temperature. The etching rate will be faster for increasing those parameters. The whole length of the sensor and robustness are almost unchanged. When we etched the FBG partially to remove the cladding part adequately from the fiber and in this way, we pave the way to strengthen the "Evanescent field wave (EFW)" . Once EFW strengthens, the sensitivity of the device increases. Thus, the enhancement of the sensitivity is expected. As expected, the peak of the FBG splits exactly into two lobes due to the half-etching which depicted in and the reflected spectrum is shown in the detection.. Applied tension on the FBG is the key factor in determining the difference between the peaks of the etched FBG. One lobe having the original Bragg wavelength is due to un-etched grating region, whereas, the other one corresponds to another wavelength which is due to etched region. This is due to the changes of effective refractive index of the fiber which affects the Bragg wavelength of the gratings.. Schematic of half-etched FBG Result and Discussions shows the variation of tempearture sensitivity with the different diameters of fibers. To observe the effect of the reduction in diameter on the sensitivity, we have investiagted mainly five different diameters of fibers i.e., 7,10,15,30,60,90 and 125 µm over the ranges from 25 to 100 °C. From the figure it can be inferred that, as the diameter reduces, there was no remarkable changes upto 20µm. But a sudden increase in sensitivity was observed below 15µm diamter. A large change in temperature sensitivity below 15µm is observed due to the change in thermal expansion coefficient and thermo-optic coefficient. A decrease in the Young's modulus of the etched fiber increases its thermal expansion co-efficient which have a considerable influences on the thermal sensitivity of the sensor and also when the cladding is reduced adequately, the effective refractive index of the fundamental mode decreases which leads to decrease the thermo-optic coefficient of the fiber, as a result higher temperature sensitivity is observed . To evaluate the strain sensitivity, those three different diameters were taken into consideration over the range from 100 to 1000 µƐ. A linear increases in the strain sensitivity is ovserved as expected in Temperature and strain sensitivity with different diameters of fibers. We can find that, highest temeparture and strain of around 22.40 pm/°C and 4.25 pm/µƐ for the lowest diamter i.e., 7 µm have been achieved. The highest temperature sensitivity is double to the conventional value of 10 pm/°C for 125 µm fiber. The strain sensitivity of 4.25 pm/µƐ is three times to the conventional value i.e., 1.12 pm/µƐ. Significantly, the half-etched FBG sensor can be used for the simultaneous measurement of temeperature and strain with enhanced sensitivity.

Biography

Mr. Koustav Dey, has completed his M.Sc in Physics from Vidyasagar university, India. Currently he is pursuing Ph.D in the field of Photonics at NIT Warangal (an institute of national importance), TS,India. He is an active member of many international and national organizations like IEEE, OSA, SPIE, OSI and ILA. Currently he is holding the position of treasurer of NITW SPIE Chapter and President of NITW OSA Chapter. He has received several national awards.

Speaker Publication

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