L.4: Fabrication of turn around point long period fiber grating by thermal relaxation of UV induced refractive index

Optical fiber gratings are important elements in many of the fiber optic sensors. A long period grating (LPG) couples co-propagating core and cladding modes resulting in a series of attenuation bands in the transmission spectrum. The multi-parameter sensing ability has led to extensive research on LPG based specific chemical and bio sensors. An LPG operating near turn around point (TAP) of the phase matching curve (wavelength vs period) is known as turn around point long period grating (TAP-LPG). TAP-LPGs possess high sensitivity but are prone to thermal degradation over time. Thermal annealing enhances the spectral stability. However, it reduces the sensitivity due to increase in separation of dual resonance band, attributed to thermal relaxation of UV induced refractive index (RI) in the fiber core. The LPG wavelength is tuned by grating period and difference in core and cladding RI. The core RI growth (Δn ~ 0.0005) by UV excitation and decay (Δn ~ 0.0003) by thermal annealing is utilized to prepare TAP-LPGs that possesses high sensitivity and higher stability simultaneously. TAP-LPGs obtained by thermal annealing of UV written LPGs of appropriate period are referred as thermal induced turn around point long period grating (TTAP-LPG). In RRCAT, a novel method was formulated to prepare TTAP-LPGs in photosensitive fibers by following three successive steps: (a) finding grating period vs writing UV fluence for TAP operation, (b) writing gratings at relatively higher period with higher fluence, and (c) controlled annealing for thermal relaxation of UV induced RI.

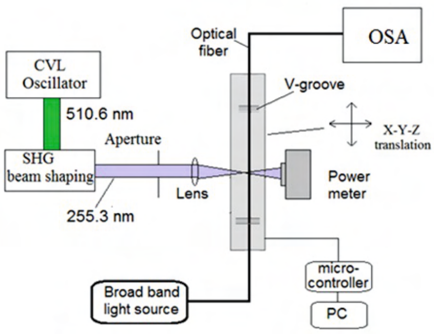

Fig. L.4.1: Schematic of LPG fabrication setup.

Figure L.4.1 shows the schematic of in-house developed LPG fabrication setup. The system uses a 255.3 nm pulsed UV beam (25 ns, 6.5 kHz), the frequency-doubled copper vapor laser (CVL) for inducing RI changes in photosensitive fiber core. The LPGs were inscribed by the point-by-point method. The UV exposure time, grating pitch and duty cycles are computer programmed. Figure L.4.2 shows the variation of grating period and wavelength with UV fluence for resonance at TAP for 12th cladding mode. As UV fluence increased from 0.2 to 1.5 kJ/cm^2, the required grating period decreased from 174 µm to 168 µm. The resonant wavelength got red shifted. Thus, writing UV fluence played a key role in selection of grating period for TAP-LPG fabrication.

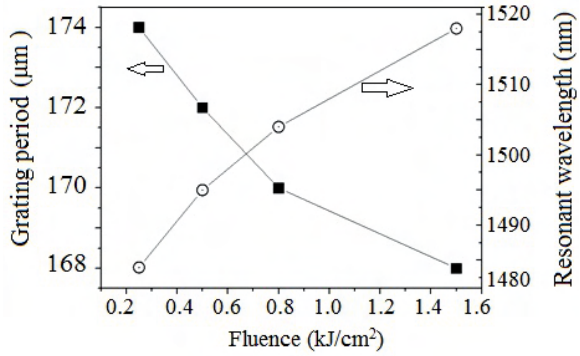

Fig. L.4.2: Variation of grating period and wavelength with UV fluence for resonance at phase matching turning point (PMTP).

As an implication of above results, LPGs of period 174 µm were first inscribed using fluence of 1.5 kJ/cm^2 (saturated). Thereafter, the inscribed LPGs were annealed at 300 °C for about 3 hours for preparation of TTAP-LPG. In Figure L.4.3, trace 1 shows the spectra of pristine LPG in which the resonance near TAP (for 12th mode) is absent. In Figure L.4.3., trace 4 shows the spectra of prepared TTAP-LPG at 25 °C. The remnant photo-induced RI after annealing was sufficient for producing resonance at phase matching turning point forming a TTAP-LPG. The traces marked as 2 and 3, in Figure L.4.3 having dual resonance, represent the LPG spectra of intermediate stages of annealing. The TTAP-LPG was stable up to 300 °C.

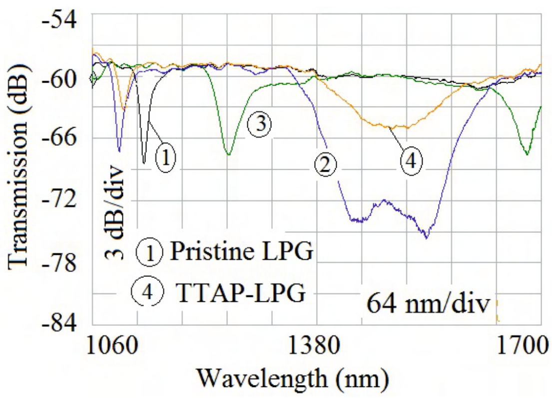

Fig. L.4.3: Spectrum of pristine LPG (trace 1) of period 174 µm written with fluence of 1.5 kJ/cm^2 and TTAP–LPG (trace 4) prepared after annealing.

The TTAP-LPG is suitable for sensing of various parameters at elevated environmental temperature. Also TTAP-LPG can be used as high sensitivity temperature sensor. Typically, the prepared TTAP-LPG of period 174 µm behaved as an amplitude sensor with average temperature sensitivity of 0.125 dB/°C in temperature interval of 30-70 °C. It behaved as wavelength encoded temperature sensor in the temperature interval of 70-240 °C with average sensitivity of 2.3 nm/°C.

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