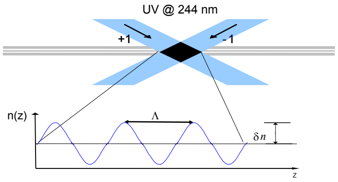
Induced-Birefringence Effects on Superimposed FBGs: Analysis and Proposal of Reduction

V. García-Muñoz, C. Caucheteur
victorgm@tfo.upm.be
POLYTECH.MONS

Superimposed Fiber Bragg Gratings (SIFBGs) are multiple passband filters written at the same location of an optical fiber. They are often used in Wavelength Division Multiplexing (WDM) optical communications systems and in optical sensor devices. For both applications, it has become of high importance to study the grating polarization properties such as Differential Group Delay (DGD) and Polarization Dependent Loss (PDL) since they affect the data transmissions but they can be advantageously used for sensing applications. We investigate a writing technique to reduce DGD and PDL induced by the inscription of SIFBGs.

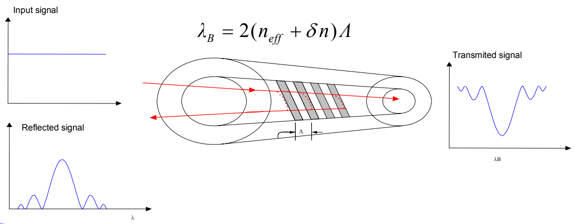
Operating principle of FBGs

Fiber Bragg Grating (FBG): Local periodic modulation of the core refractive index of an optical fiber created by interference of UV light.



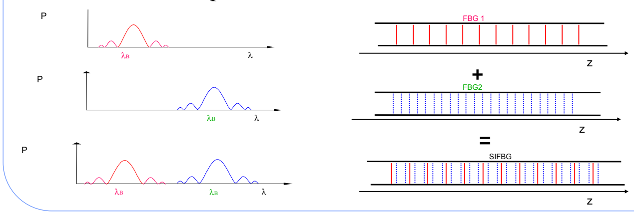
Fiber Bragg Grating (FBG) are selective frequency filters with central wavelength λ_B related to the pinch of the refractive index modulation Λ, the effective refractive index and the index modulation δn.

$$\lambda_B = 2(n_{eff} + \delta n)\Lambda$$

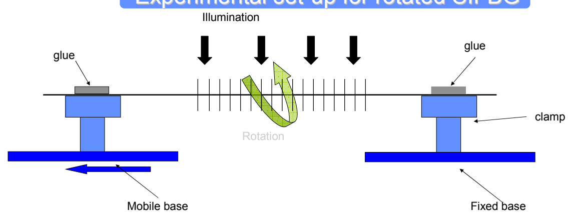


Superimposed FBGs (SIFBGs)

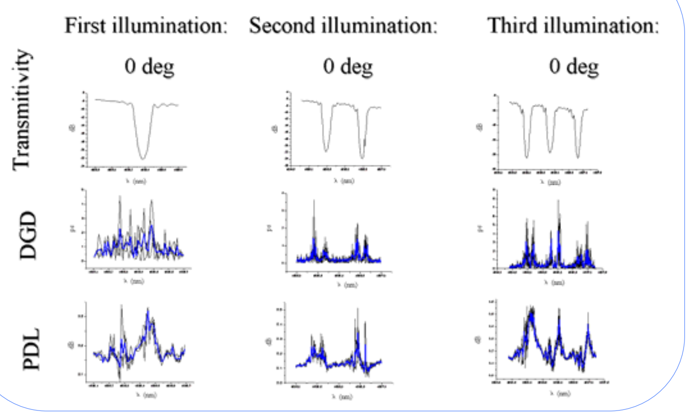
Superimposed Fiber Bragg Grating (SI-FBG): Several FBGs with different modulation period fabricated in the same location of the fiber.



Experimental set-up for rotated SIFBG

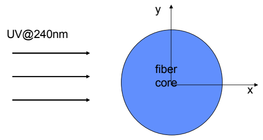


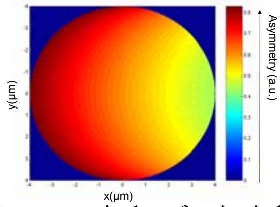
Experimental Results: Non Rotated SIFBG



Side writting and birefringence

FBGs are fabricated by illuminating one side of the core fiber.





Side written fabrication process causes an asymmetry in the refractive index profile in the plane transversal to the optical axis.

Asymmetry in the refractive index profile leads to birefringence. The electric field is separated in two polarizations along the x and the y axes with different effective index, then for FBGs the spectrum is composed of two overlapping resonant peaks whose central wavelengths are:

$$\lambda_{B,x(y)} = 2(n_{eff,x(y)} + \delta n)\Lambda \quad \text{where} \quad n_{eff,x(y)} = n_{eff} \pm \frac{\Delta n}{2} \quad \text{and } \Delta n \text{ is the fiber birefringence}$$

The spacing between the two peaks is given by $\Delta\lambda_B = 2\Delta n\Lambda$.

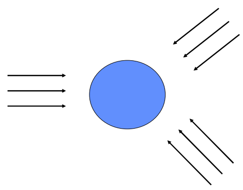
Δn induces Polarization Dependent Losses (PDL) and Differential Group Delay (DGD).

PDL: Maximum change in the transmitted spectrum when the input state of polarization is varied over all polarization states.

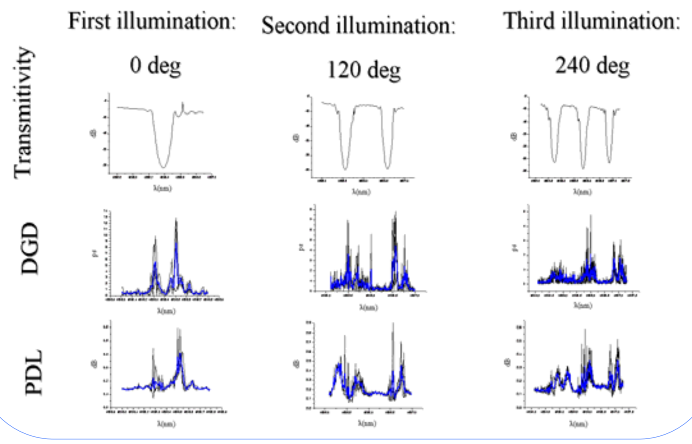
DGD: Difference in the group delay between the two eigenmodes.

Symmetrization process for SIFBGs

Several illuminations in the same place provide an increase of the profile asymmetry, then of the PDL and DGD. We propose the rotation by a fixed angle of the fiber after each illumination in order to reduce the induced birefringence.



Experimental Results: Rotated SIFBG



Conclusions

We have studied the case with no rotation and the case with 120 degrees rotation angle (three gratings) after each illumination. Measurements of DGD and PDL were performed after each inscription for the standard case and for the rotated case in order to observe the evolution of the polarization properties. The DGD and PDL dependency with wavelength was obtained using the Jones matrices method with the aid of a tunable source. We demonstrate that a reduction of the polarization effects is observed after each inscription in the rotated case, contrarily to the non rotated case.