Production of optical waveguides in planar glass substrate fabricated with Femtoprint

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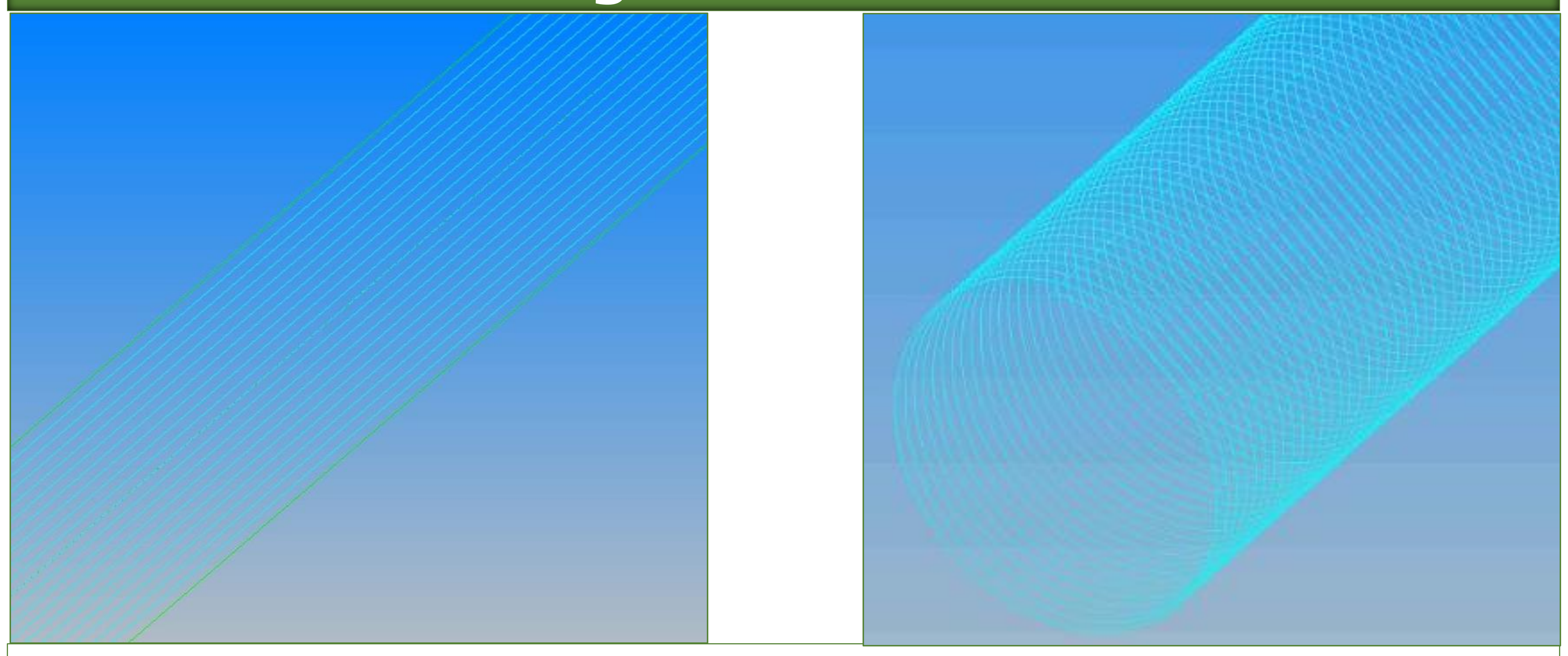
Abstract

Femtosecond laser pulses are more and more spread for the micro/nano-machining of various materials. Bragg gratings were successfully created within optical fibers using the point-by-point or line-by-line technique. The objective of our work is to produce Bragg grating sensors within planar glass substrates. To this aim, the synthesis of an **optical waveguide in a glass substrate** is a key parameter. Among the physical techniques that are available one of them is the utilization of a femtosecond laser. In this paper, we report our achievements obtained with the so-called **Femtoprint** machine, a commercial device created to engineer materials. We show the parameters that were used to produce waveguides in planar substrates. We show the characterization set-up that was implemented and report the first experimental results that were obtained.

1. Design of the structure



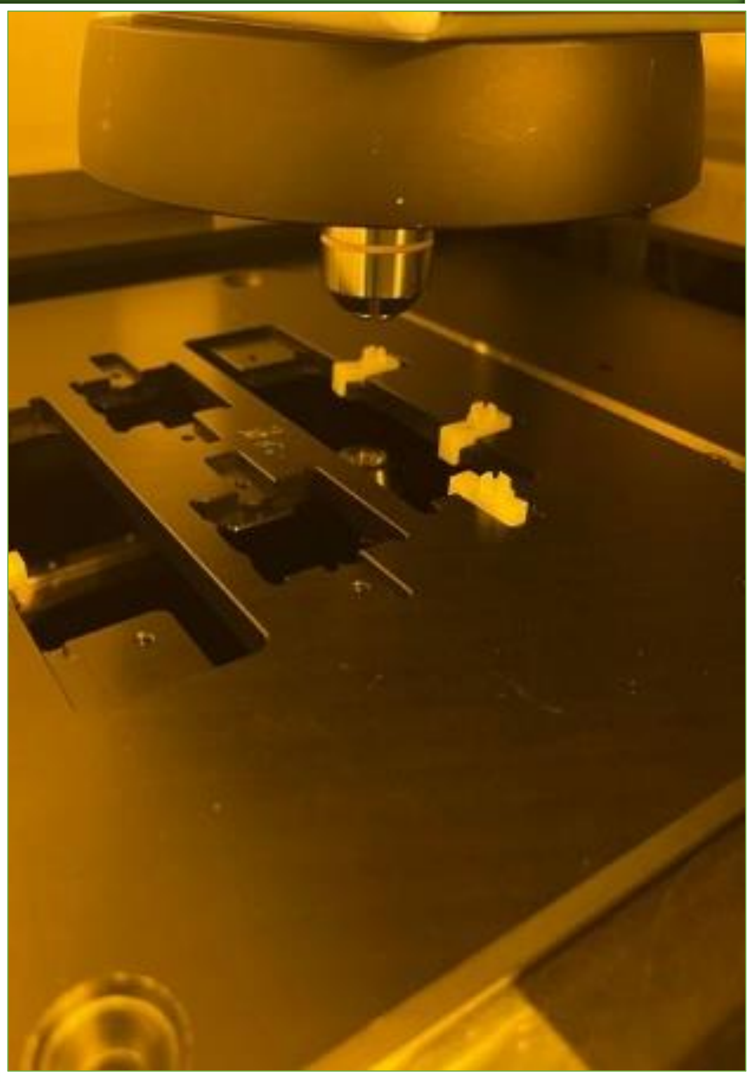
Femtoprint Machine

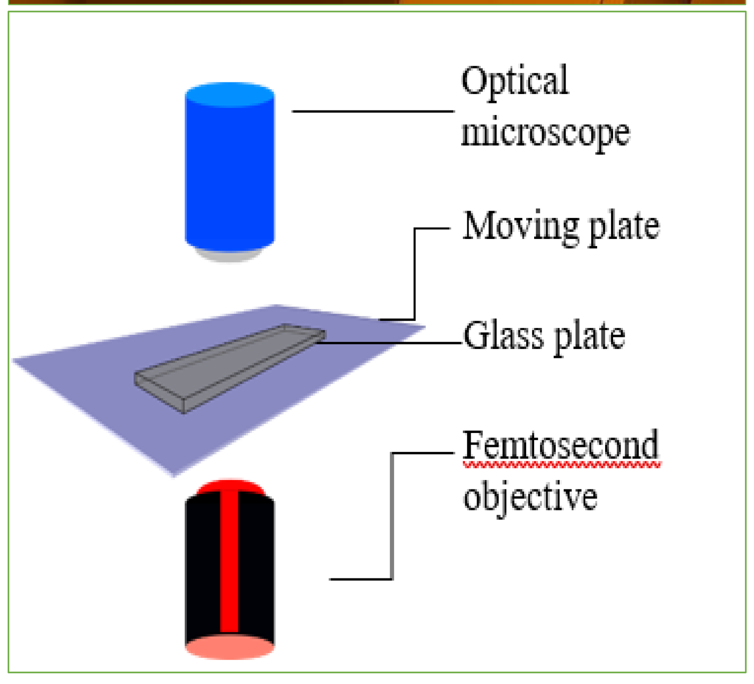
- **Alphacam** is the software where the laser path will be defined. Two choices of laser path the pocketing (planar operation) and the rough (vertical operation)
- In these laser paths each parameter can be previously defined, such as the **Energy pulse** (E_p), **Repetition rate** (f), and **translation** (v). It can be noticed in the equation of surface energy below (ω_{nl}: nonlinear beam waist)

$$\Phi_d = \frac{4E_p}{\pi\omega_{nl}}\left(\frac{f}{v}\right)$$

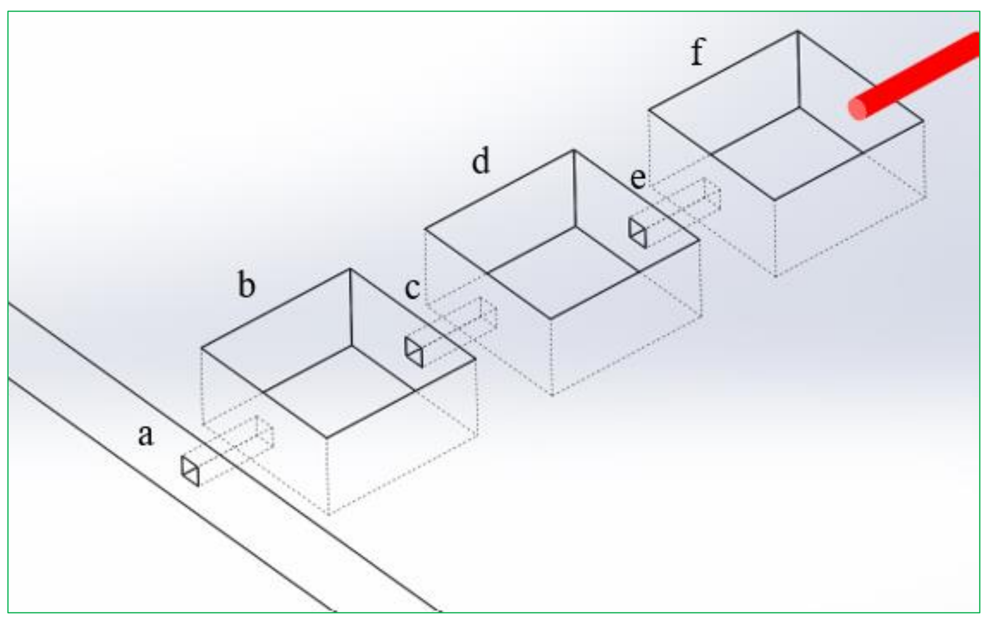
- This step is finished when the structure is designed and is **compiled** in the software. This is the first step

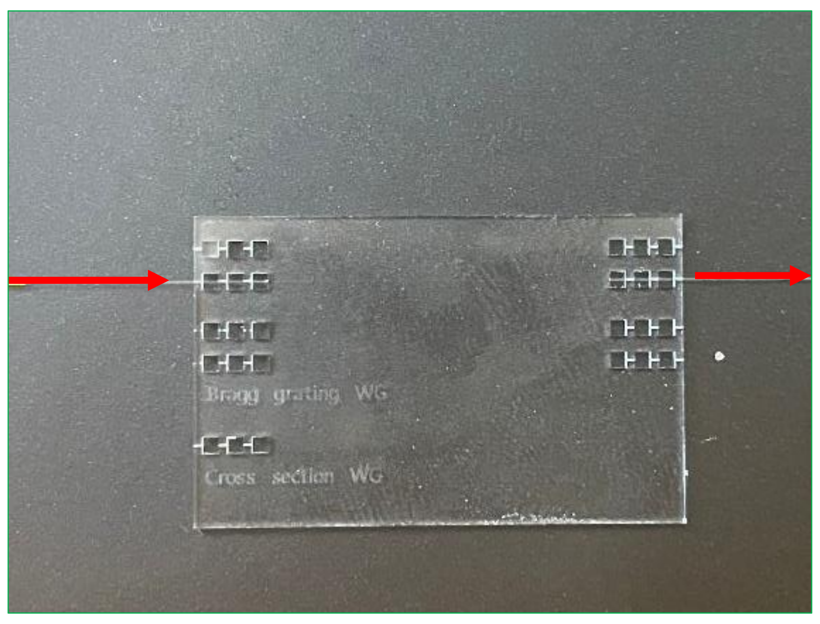
2. The FemtoPrint Machine





3. Experimental set-up



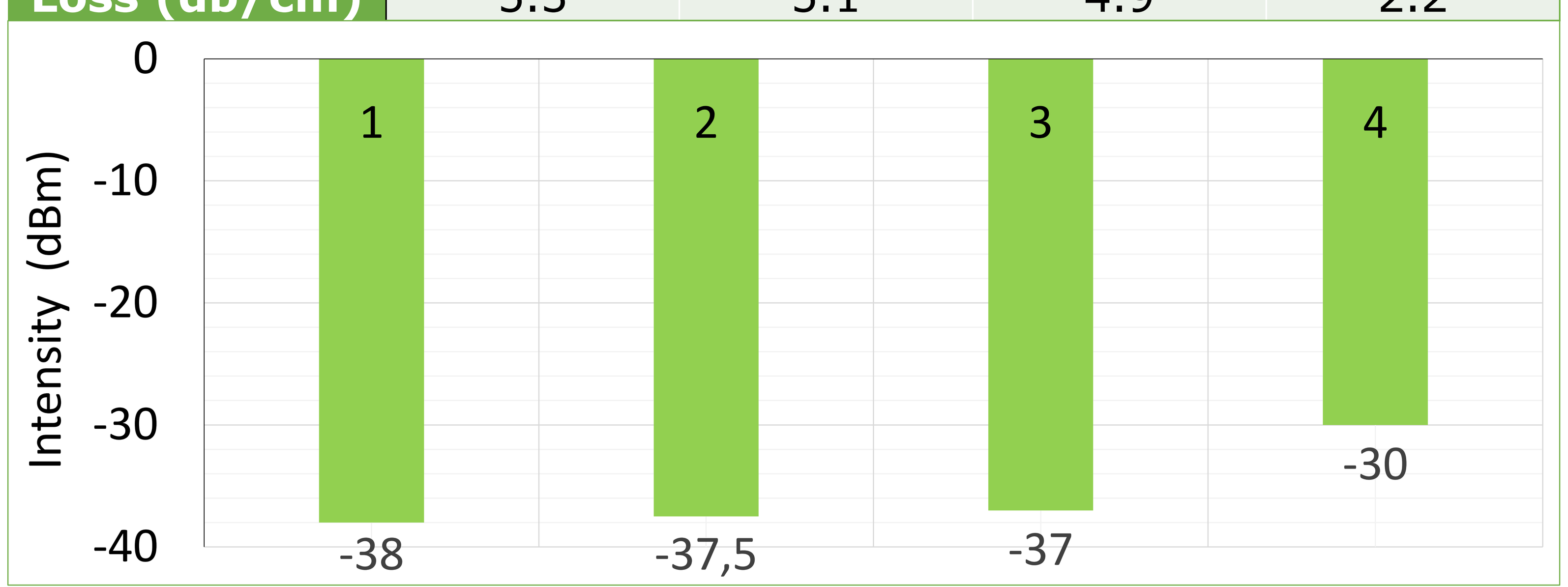


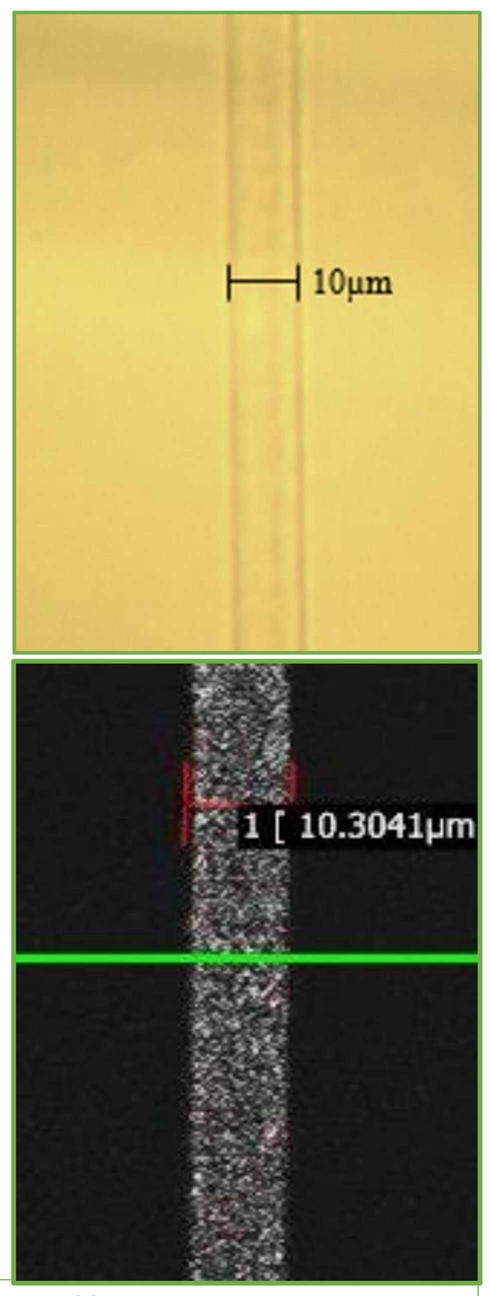
The set-up pictured here is a transmission set-up put in place at the University of Mons.

- Part a, c, and e are **square tunnels of 126µm length**. They are directly aligned with the waveguide location.
- Part b, d, and f are open cavities of 1 mm in length. They are here to faster the KOH etching and help in case of fiber breaking
- The optical fiber of 125 µm are put in the cavity of the glass plate on each sides with matching gel at the end of each of it

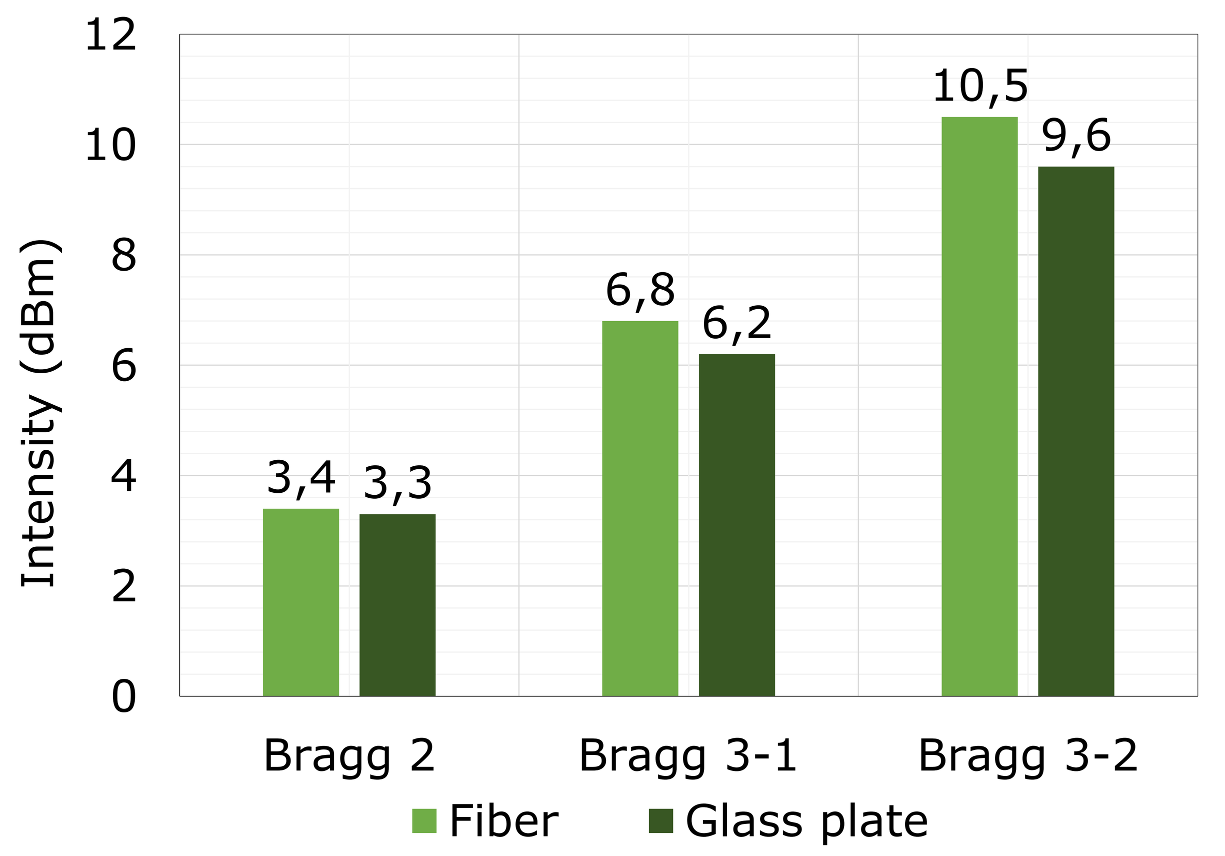
4. Results

Label of structure	#1	#2	#3	#4
Pulse energy	130 nj	130 nj	130 nj	130 nj
Repetition rate	1 MHz	1 MHz	1 MHz	1 MHz
Type of inscription	Helicoidal	Planar	Planar	Planar
Speed of inscription	1 mm/min	1 mm/min	5 mm/min	20 mm/min
Space between laser paths	0.5 µm	0.5 µm	0.5 µm	0.5 µm
Loss (db/cm)	5.3	5.1	4.9	2.2





- The table is showing the different waveguides created as well as the different associated parameters.
- The graph shows the transmission signal obtained for each waveguide.
- The microscope picture is representing the waveguide observed in transmission or under He-Ne gas laser



This experiment Bragg grating was added in the optical fiber

Goal: Measure the quality of the transmission of the Bragg grating signal through the waveguide

It can be seen that at least 90 % of the signal in transmission is obtained through the waveguide.