



SUSPENDED-WEB MICROSTRUCTURED FIBERS FOR SENSING APPLICATIONS

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UNIVERSIDADE DO PORTO

Outline

1. Spatial optical filters

- Hollow core tube (MMI)
- Silica rod (Fabry-Perot)

2. Suspended-web microstructured fibers

- Mach-Zehnder interferometer
- Multimodal interferometer
- Sensing applications

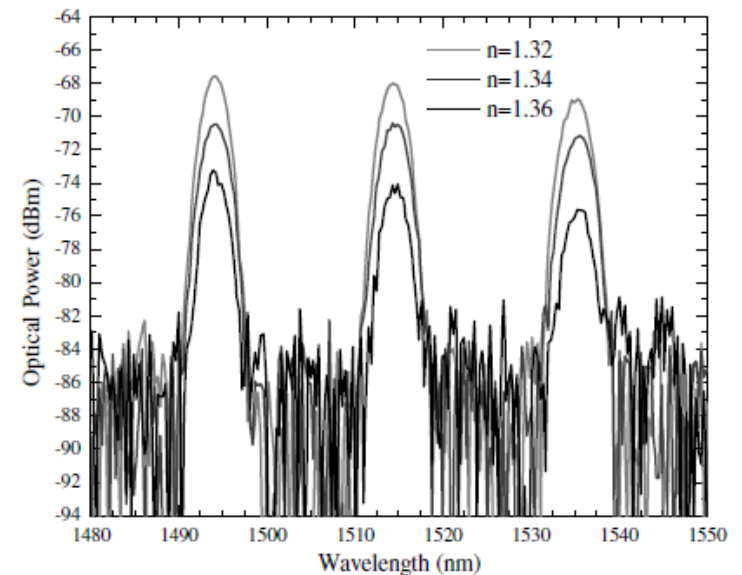
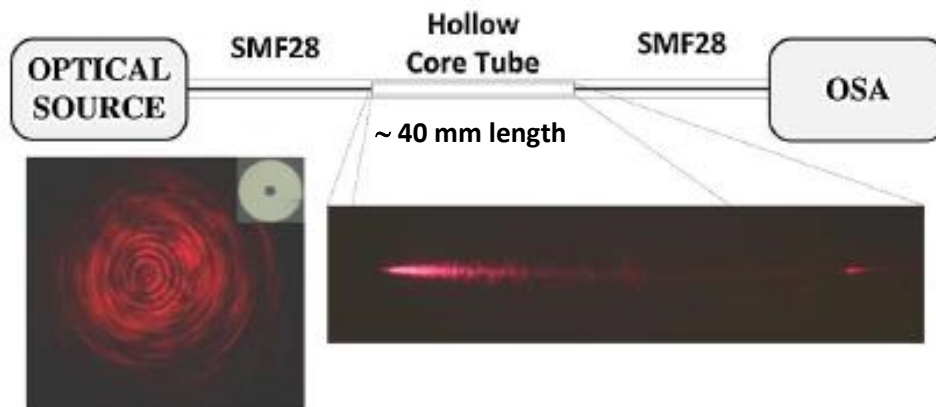
3. Conclusions

1. Spatial optical filters - Hollow core tube

Hollow core tube (IPHT)

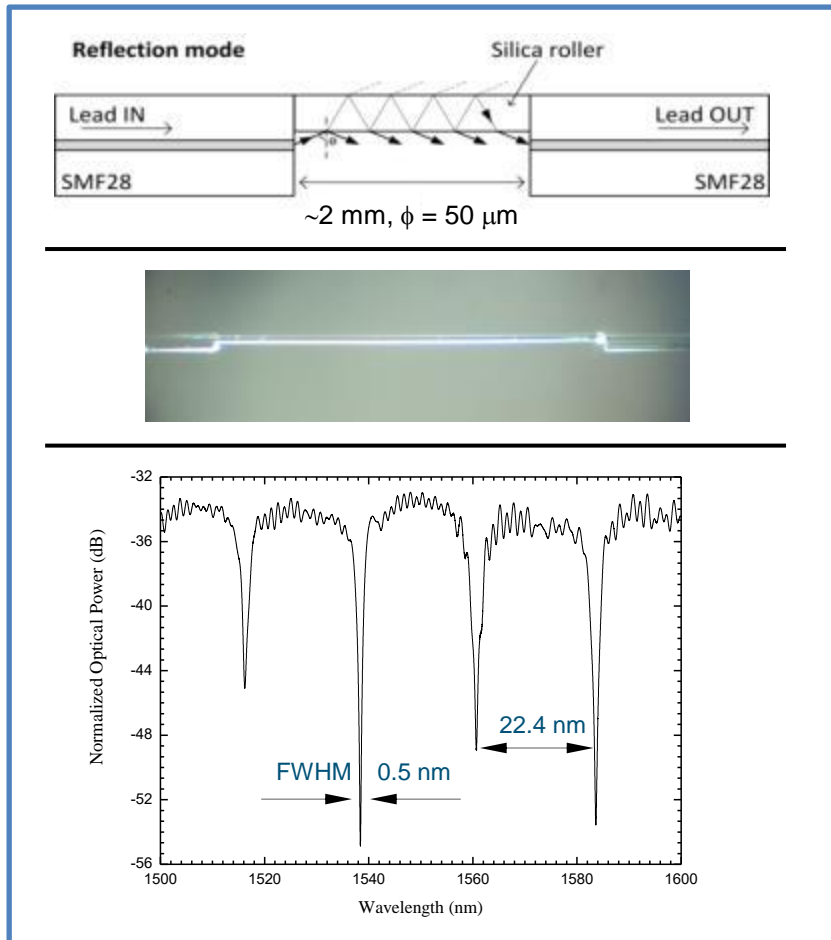


Outer diameter: 125 μm
Core diameter: 20 μm

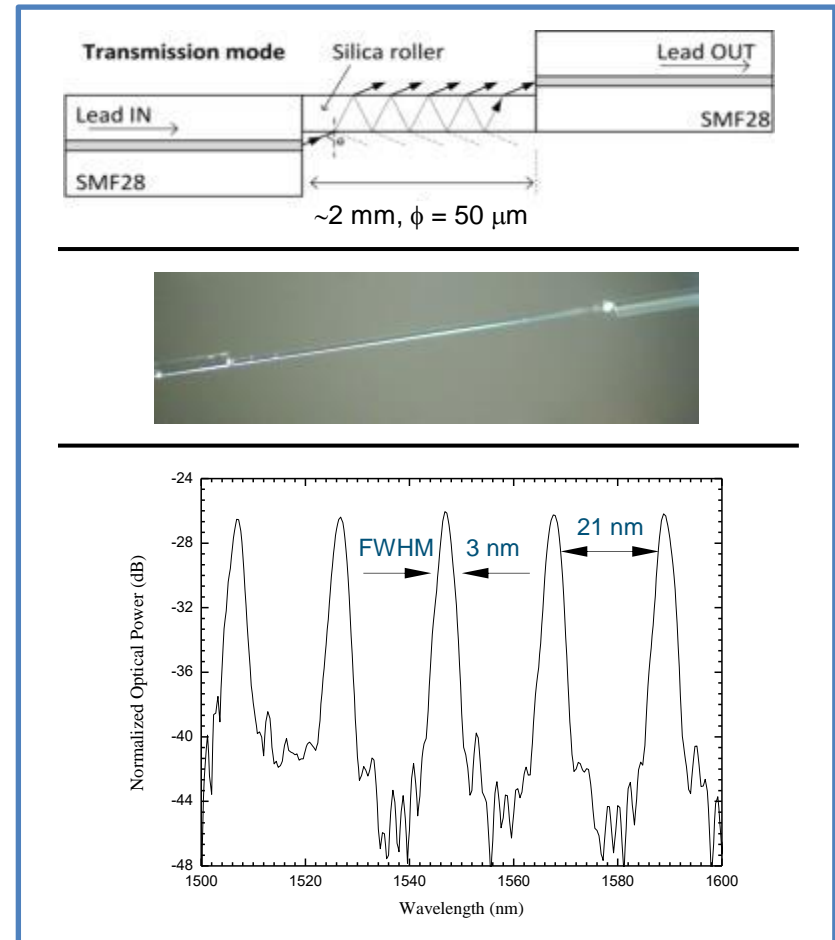


1. Spatial optical filters – Silica rod

Band-rejection filter

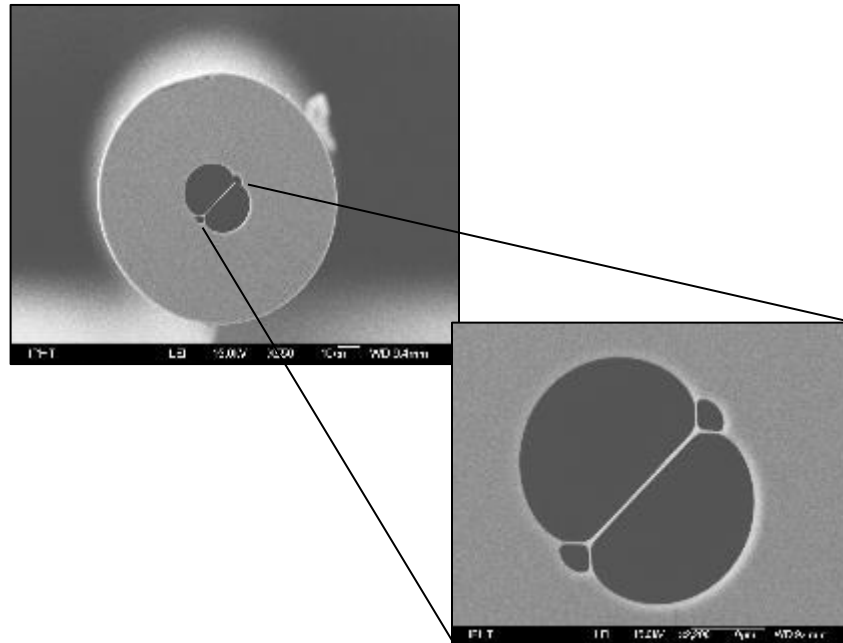


Bandpass filter



2. Suspended-web microstructured fibers for sensing applications

Suspended-web fiber (574b4)



Cross-section of the suspended-web fiber achieved after fabrication.

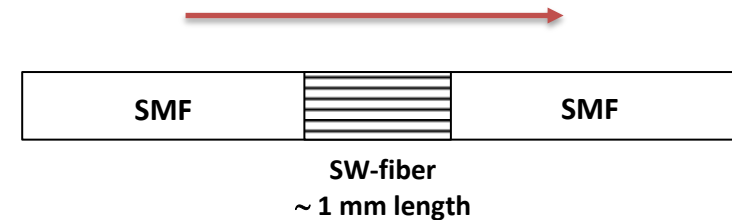
Outer diameter: 123 μm

Holes diameter: $\sim 17 \mu\text{m}$

Holes crossing: 35 μm

Core: rectangular shape suspended by four bridges (thickness of 0.4 μm each)

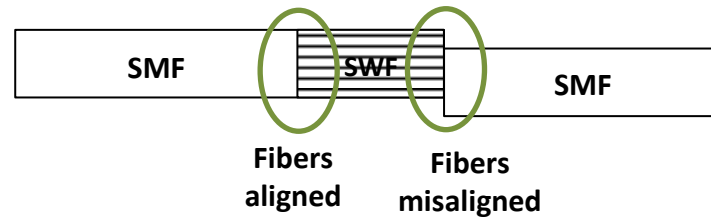
Core dimensions: 23 μm and 0.41 μm in length and thickness, respectively.



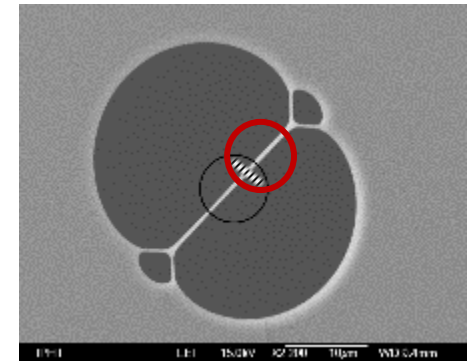
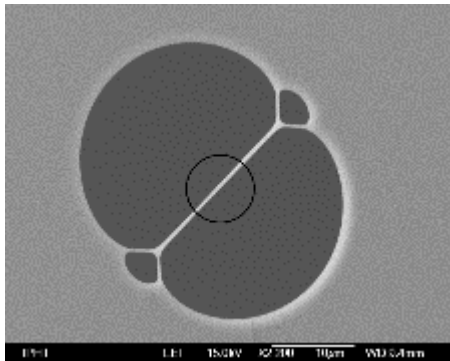
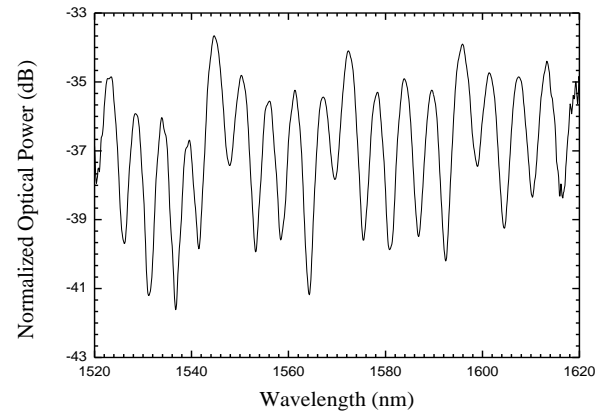
2. Suspended-web microstructured fibers for sensing applications

Splice Process – Manual operation

$\Delta\lambda = 5.2 \text{ nm}$
 $\Delta n = 0.44$
SWF length (estimated) $\approx 1.1 \text{ mm}$

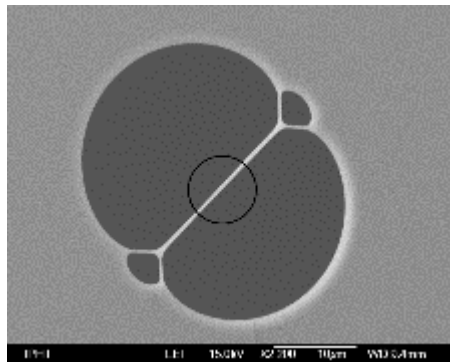
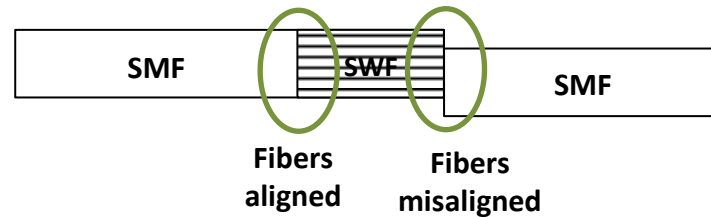


Mach-Zehnder Interferometer

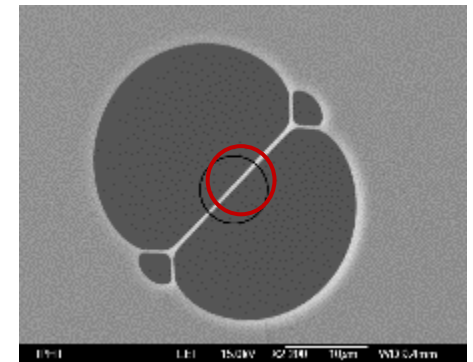
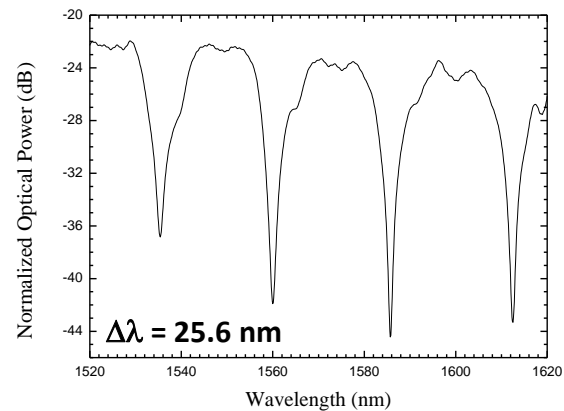


2. Suspended-web microstructured fibers for sensing applications

Splice Process – Manual operation

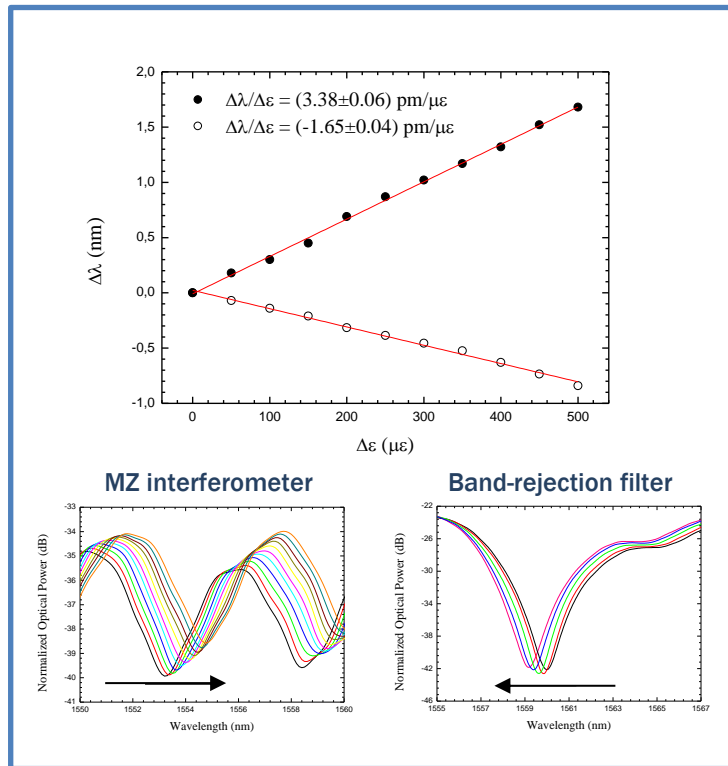


Band-rejection filter

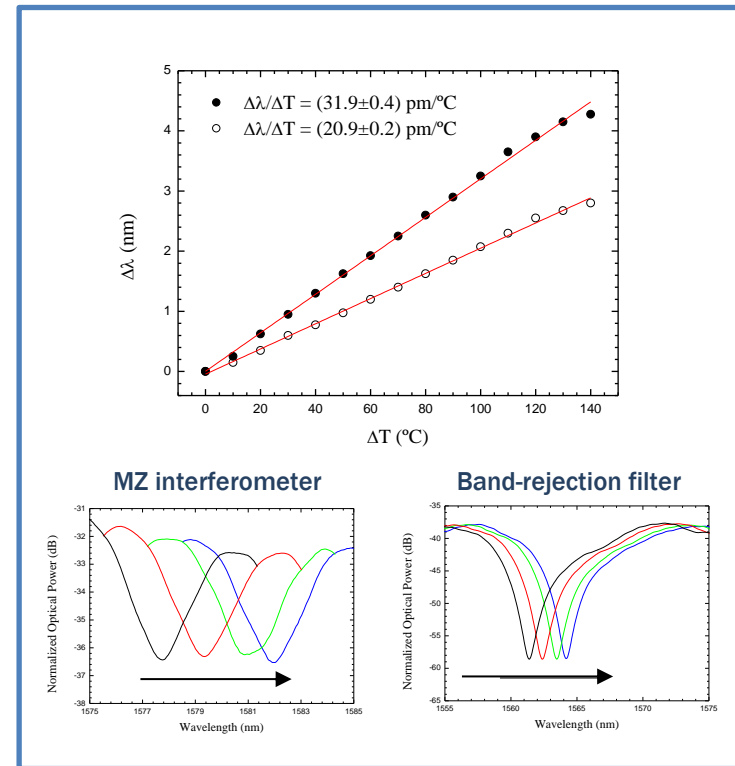


2. Suspended-web microstructured fibers for sensing applications

Strain Sensing



Temperature Sensing



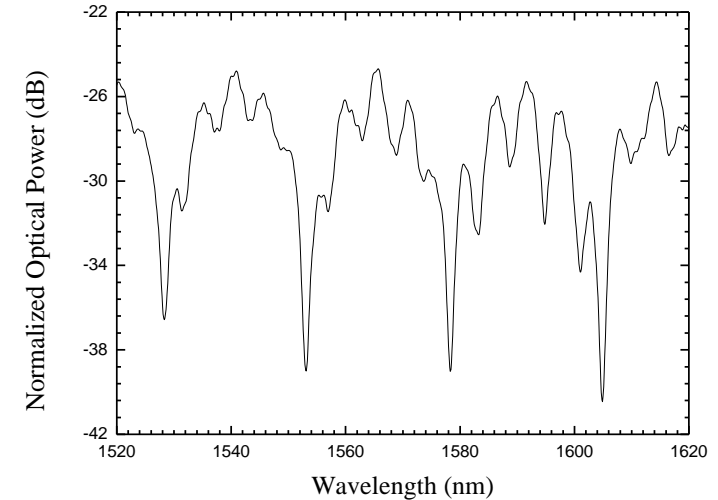
2. Suspended-web microstructured fibers for sensing applications

Splice Process



Fibers
aligned

Fibers
misaligned



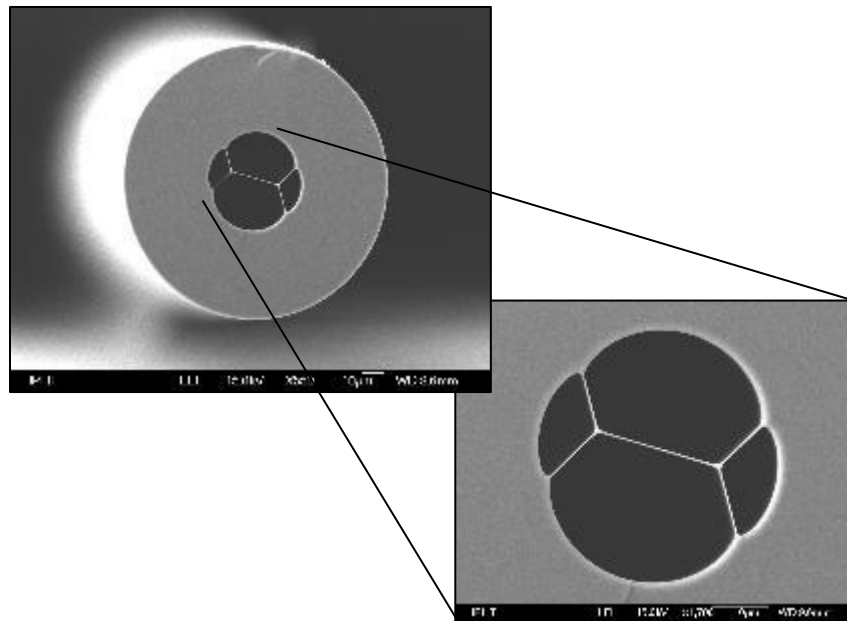
Simultaneous measurement of strain and temperature

$$\begin{bmatrix} \Delta\lambda_1 \\ \Delta\lambda_2 \end{bmatrix} = \begin{bmatrix} K_{T_1} & K_{\varepsilon_1} \\ K_{T_2} & K_{\varepsilon_2} \end{bmatrix} \begin{bmatrix} \Delta T \\ \Delta\varepsilon \end{bmatrix} \Rightarrow \begin{bmatrix} \Delta T \\ \Delta\varepsilon \end{bmatrix} = \begin{bmatrix} K_{\varepsilon_2} & -K_{\varepsilon_1} \\ -K_{T_2} & K_{T_1} \end{bmatrix} \begin{bmatrix} \Delta\lambda_1 \\ \Delta\lambda_2 \end{bmatrix}$$

$$\begin{bmatrix} \Delta T \\ \Delta\varepsilon \end{bmatrix} = -\frac{1}{123.28} \begin{bmatrix} -1.65 & -3.38 \\ -20.9 & 31.9 \end{bmatrix} \begin{bmatrix} \Delta\lambda_1 \\ \Delta\lambda_2 \end{bmatrix}$$

2. Suspended-web microstructured fibers for sensing applications

Suspended-web fiber (574b1)



Cross-section of the suspended-web fiber achieved after fabrication.

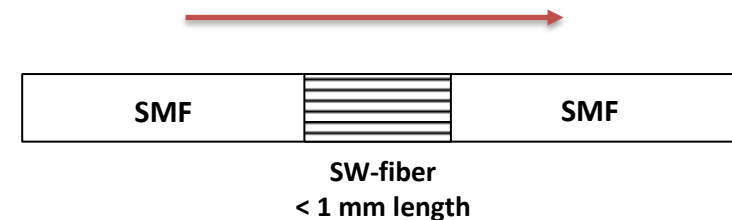
Outer diameter: $\sim 123 \mu\text{m}$

Holes diameter: $\sim 33 \mu\text{m}$

Holes crossing: $44 \mu\text{m}$

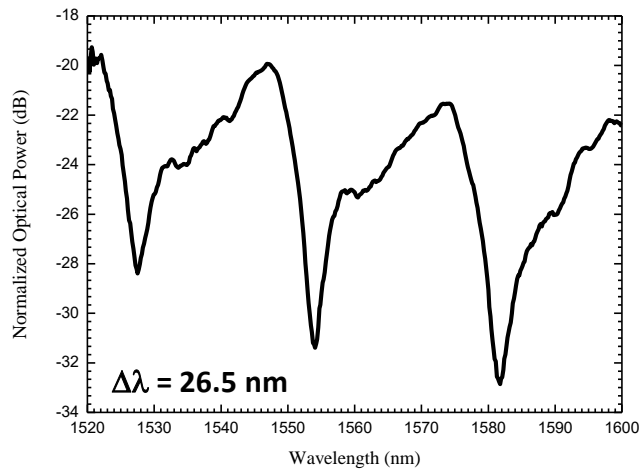
Core: rectangular shape suspended by four bridges (thickness of $0.35 \mu\text{m}$ each)

Core dimensions: $23 \mu\text{m}$ and $0.35 \mu\text{m}$ in length and thickness, respectively.

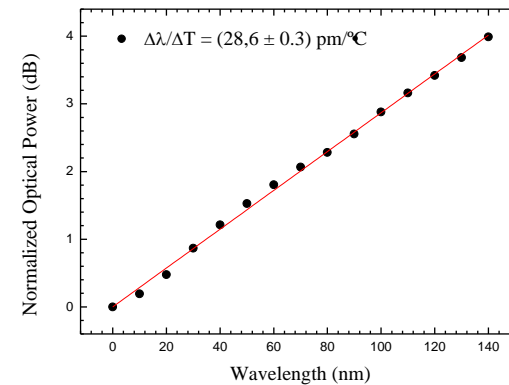


2. Suspended-web microstructured fibers for sensing applications

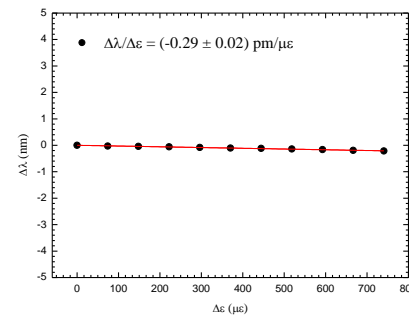
Band-rejection filter



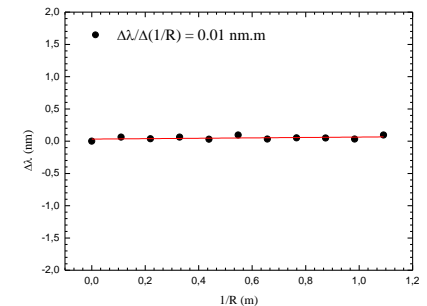
Temperature Sensing



Strain Sensing



Curvature Sensing



3. Conclusions

- Development of two distinct sensor behaviors with SW fibers: MZI and band rejection filter.
- SW fibers suited for sensing physical parameters.
 - High sensitivity to temperature ~ 30 pm/°C with low sensitivities to strain and curvature
 - Simultaneous measurement of strain and temperature
- **Future work:** Fabrication of microstructured fibers with 3 or more suspended-web cores. Sensing applications and fiber lasers.



THANK YOU



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Spatial optical filters – Silica rod

