

Optical fiber Surface Plasmon Resonance-based temperature sensor

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Abstract

We propose and demonstrate a novel, compact and simple-to-construct optical fiber thermometer based on Surface Plasmon Resonance (SPR) phenomenon, its temperature sensitivity is -3066 pm/°C and it was tested from 10°C to 40°C.

1.- Introduction

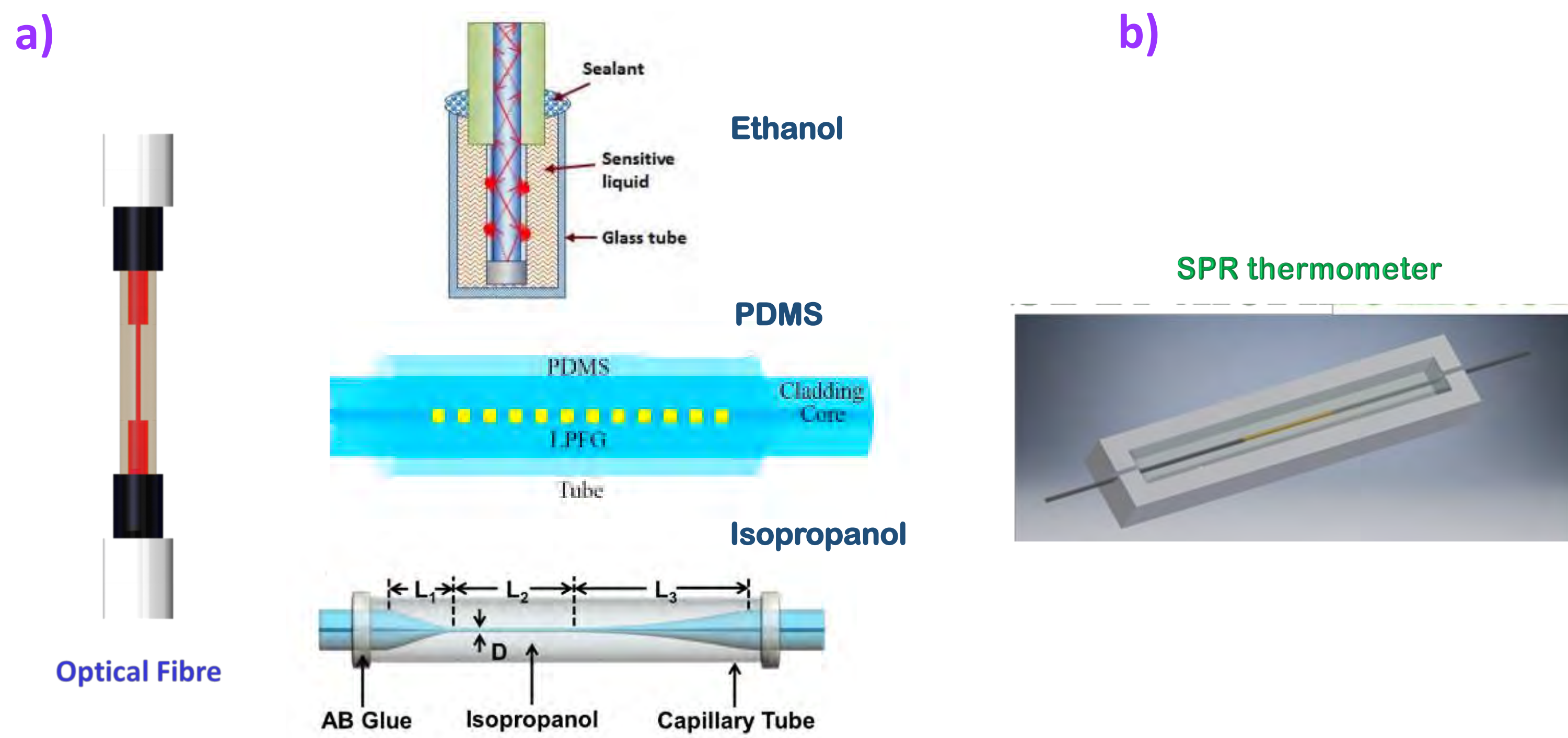


Fig. 1. Temperature Sensors: a) A single refractive index sensor can become a thermometer sensor adding a thermoresponsive materials [1-3], and b) sketch of the final structure of the proposed sensor head.

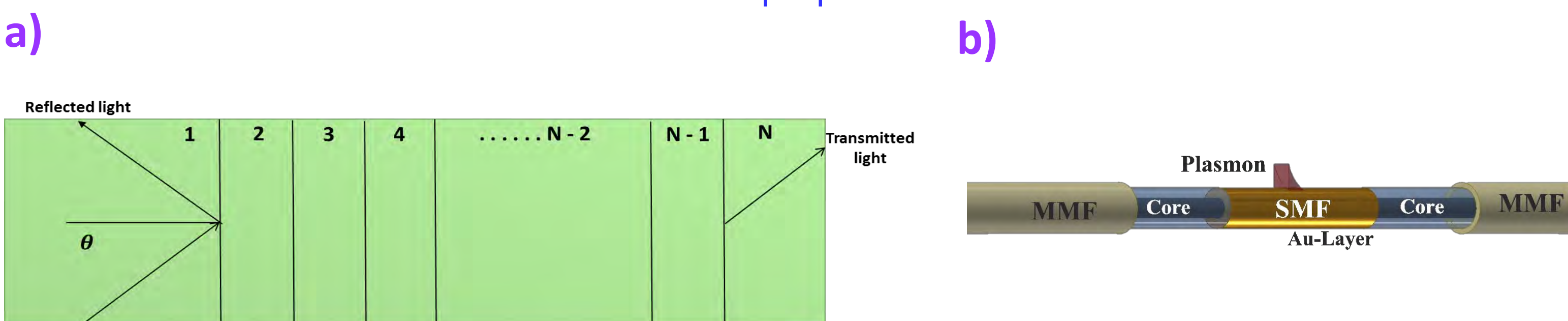


Fig. 2. a) Multilayer model for the calculation of reflection coefficient (R_p) [3], b) a representation of the hetero-core structure coated with gold layer and SPR phenomena.

Transmitted power

$$P = \frac{\int_{\theta_c}^{\pi/2} R_p^{N_{ref}(\theta)} \left(\frac{n_1^2 \sin \theta \cos \theta}{(1 - n_1^2 \cos^2 \theta)^2} \right) d\theta}{\int_{\theta_c}^{\pi/2} \left(\frac{n_1^2 \sin \theta \cos \theta}{(1 - n_1^2 \cos^2 \theta)^2} \right) d\theta}$$

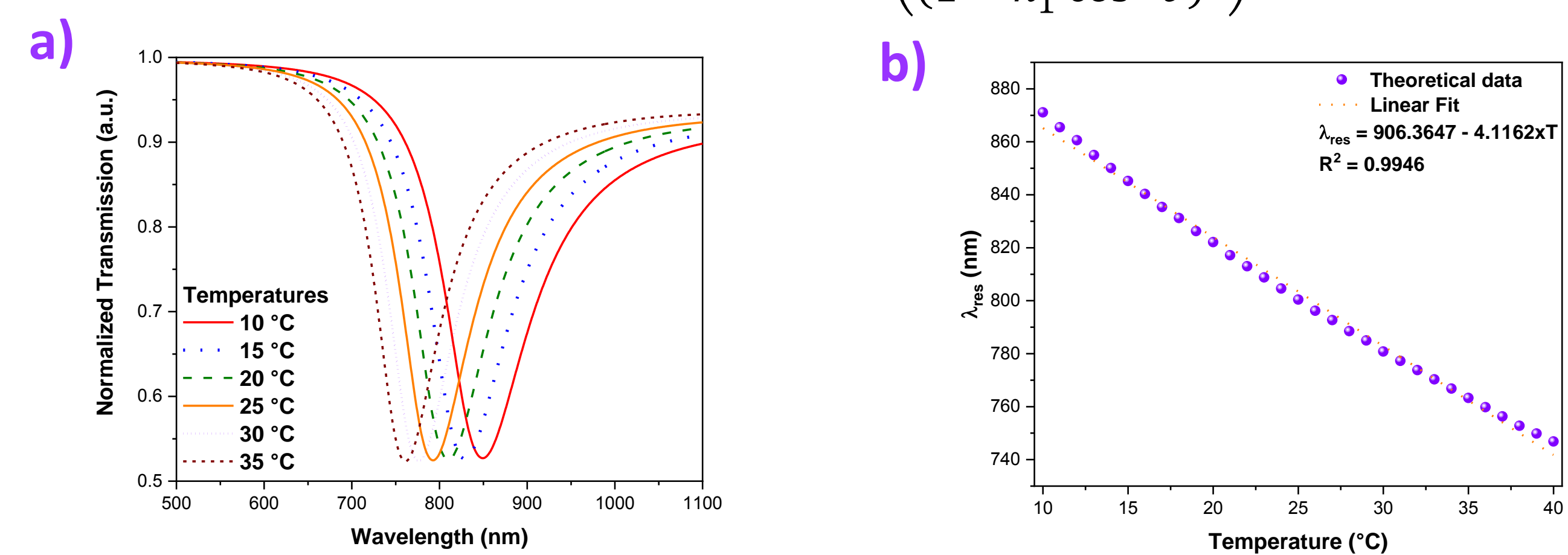


Fig. 3. Theoretical: a) Reflection spectra at different values of T and b) Calibration curve of the sensor.

2.- Fabrication Process by SLA

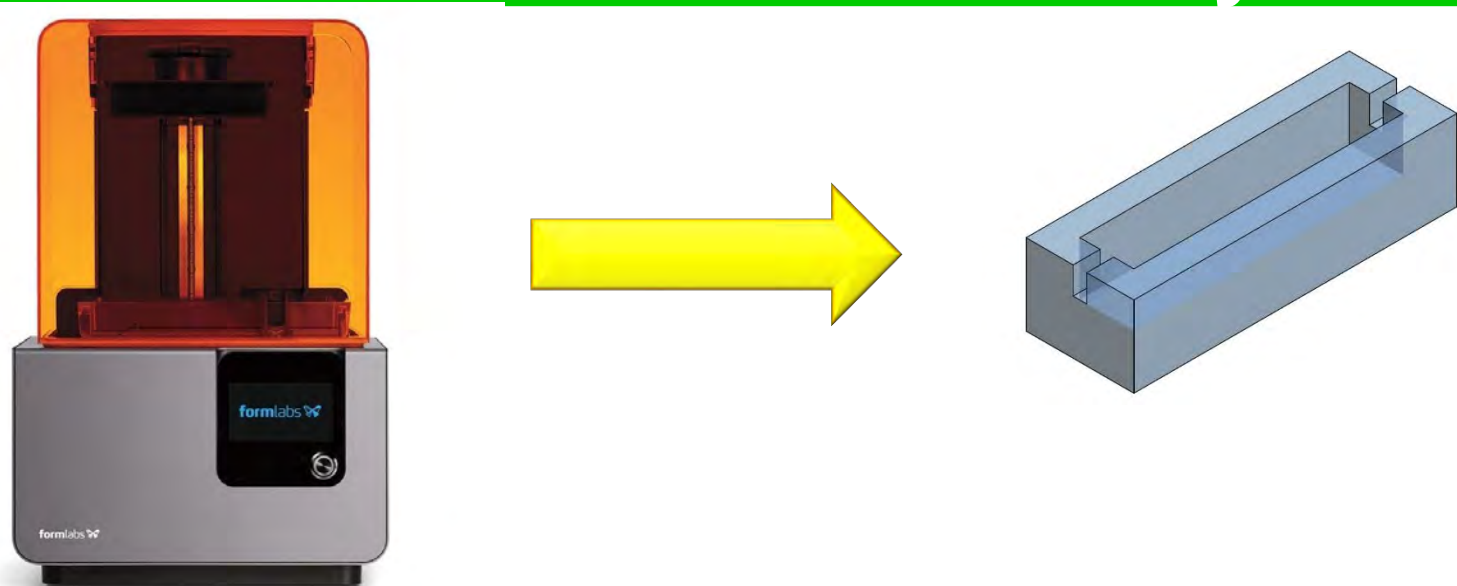


Fig. 4. Rectangular container printed by stereolithography 3D printer (Form2, Formlabs).

- [1] Zhao, Z. Deng and H. Hu, "Fiber-Optic SPR Sensor for Temperature Measurement," in IEEE Transactions on Instrumentation and Measurement, vol. 64, no. 11, pp. 3099-3104, Nov. 2015.
- [2] Qi Wang, Chao Du, Jiaming Zhang, Riqing Lv, Yong Zhao, "Sensitivity-enhanced temperature sensor based on PDMS-coated long period fiber grating", Optics Communications, Volume 377, 2016, Pages 89-93
- [3] Y. Xue, Y. Yu, R. Yang, C. Wang, C. Chen, J. Guo, X. Zhang, C. Zhu, and H. Sun, "Ultrasensitive temperature sensor based on an isopropanol-sealed optical microfiber taper," Opt. Lett. 38, 1209-1211 (2013).
- [4] Sharma, A.K., and Gupta, B.D., Nanotechnology, 2006, 17, (1), pp. 124-131.

3.- Fabrication Process and Experimental Setup

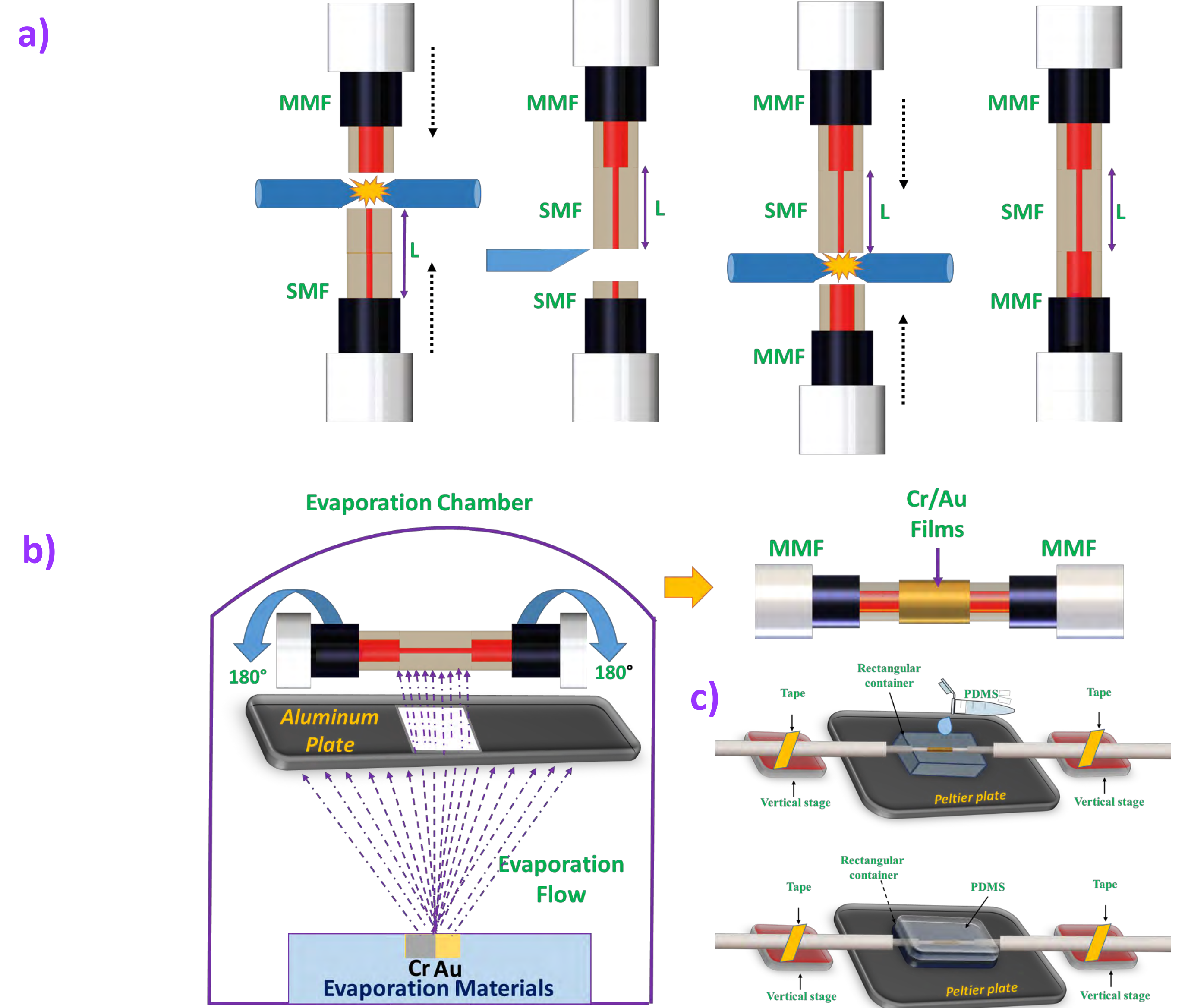


Fig. 5. Fabrication process: a) MMF-SMF-MMF structure, b) Metal layer deposition, and c) temperature sensor head.

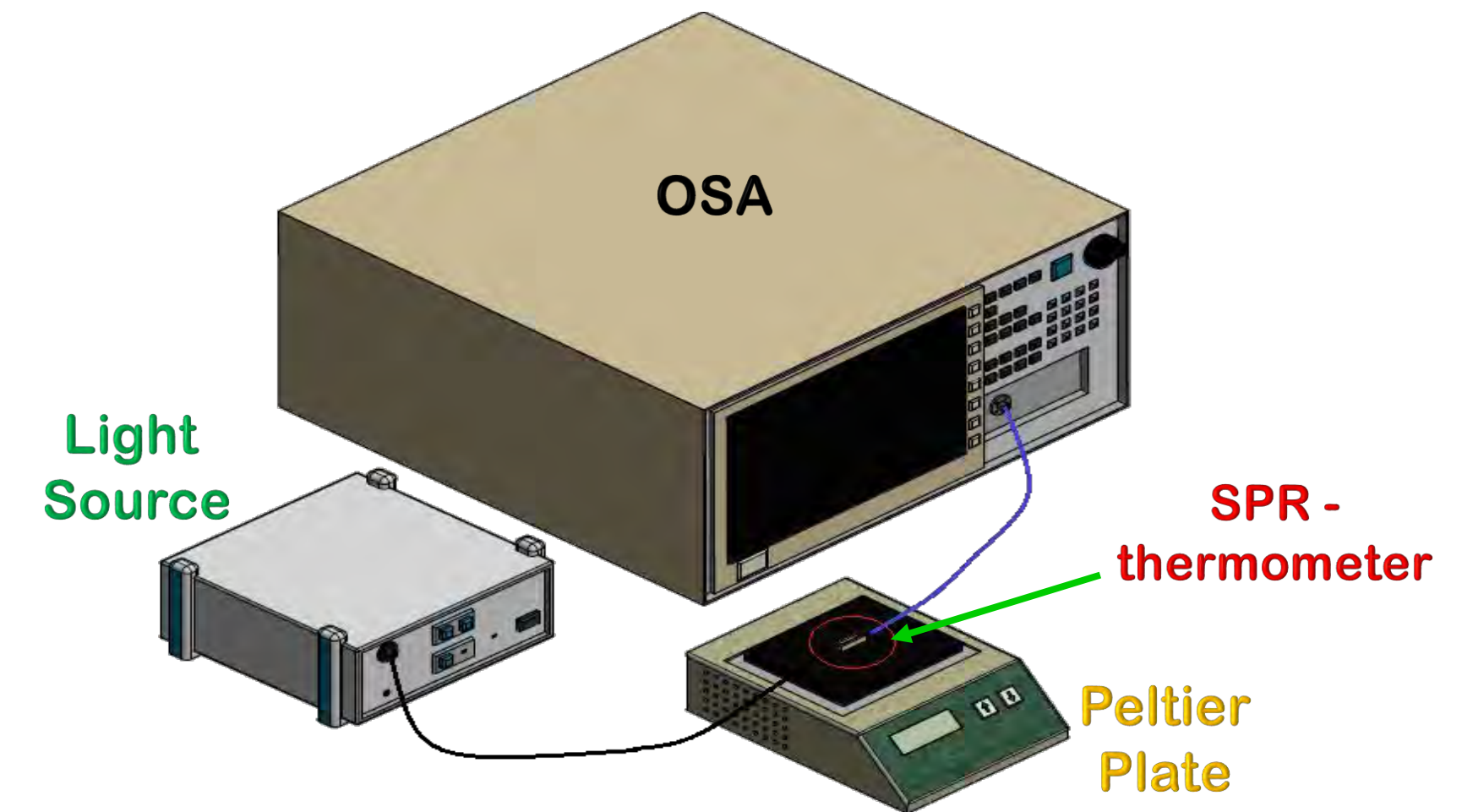


Fig. 6. Experimental Setup.

4.- Experimental Results

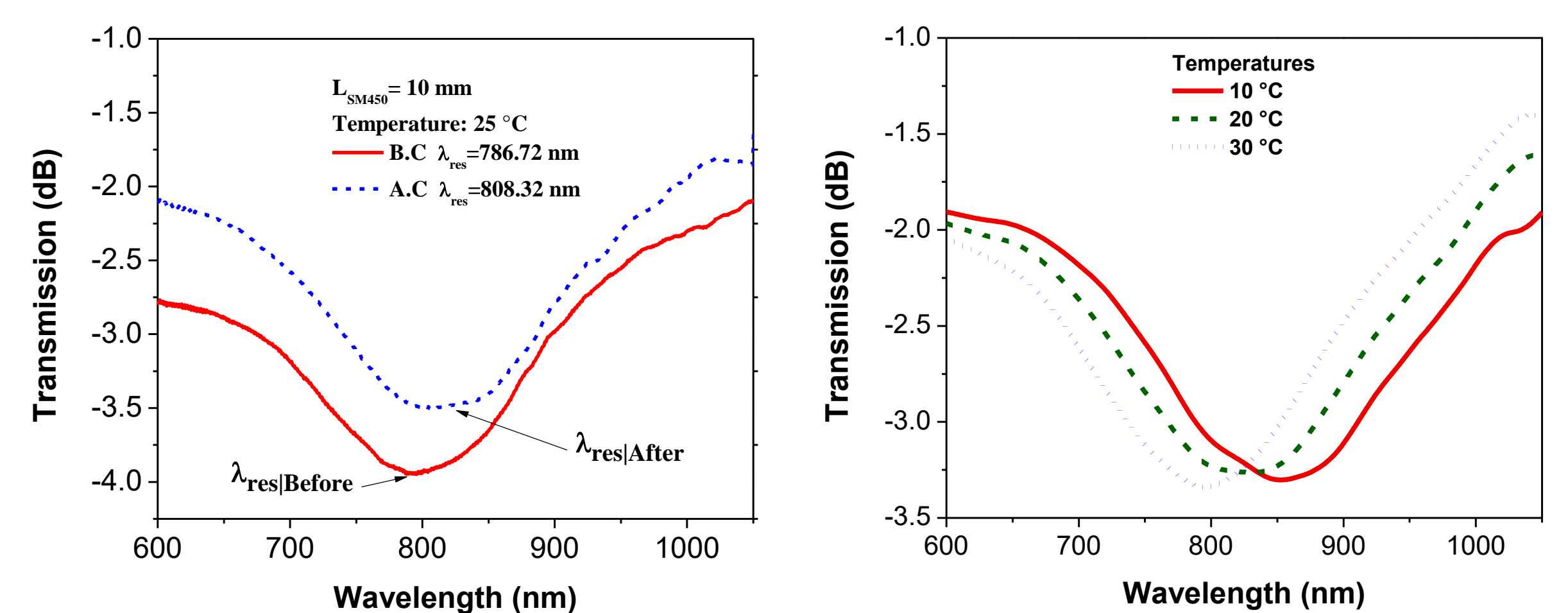


Fig. 7. Experimental reflected spectra of fiber SPR sensor: a) Before and after curing the PDMS, b) Different Temperatures.

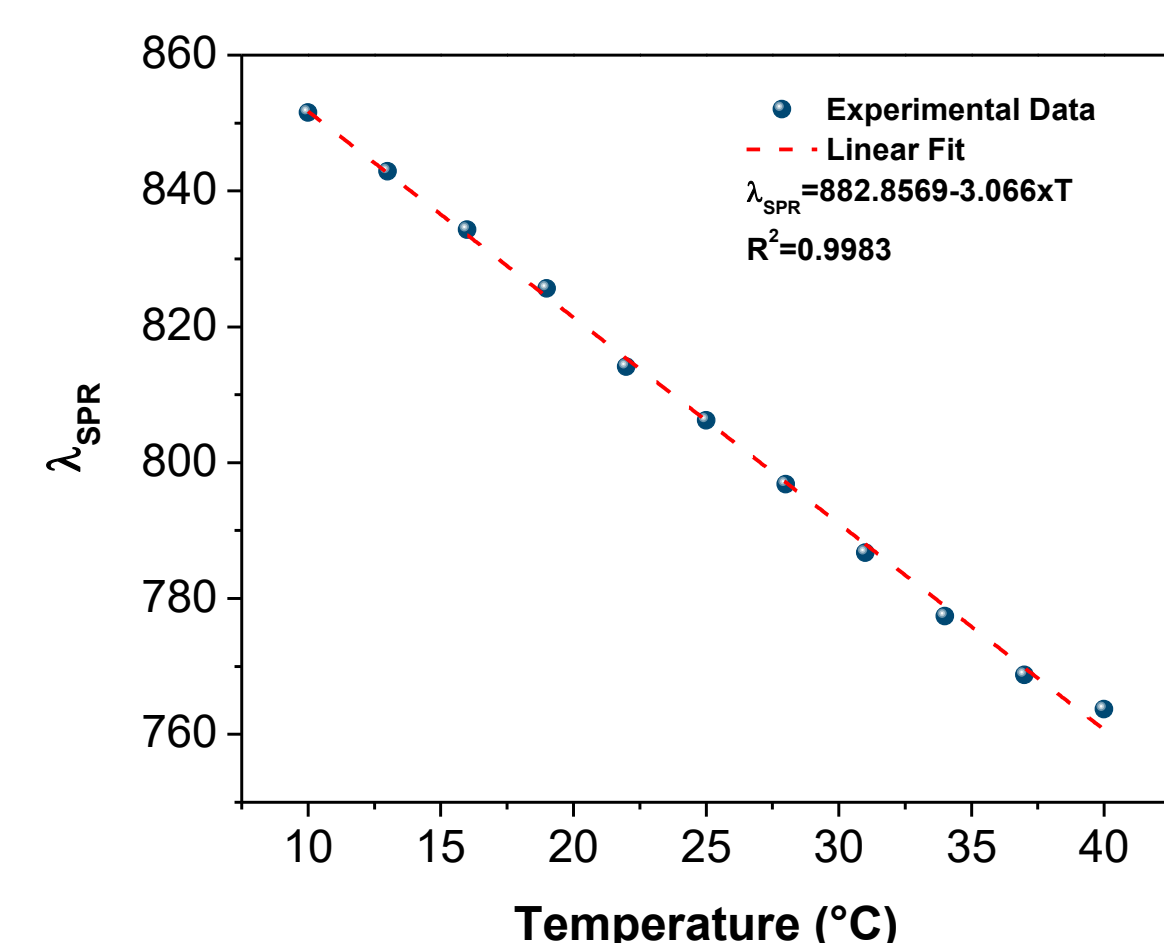


Fig. 8. Experimental calibration curve.

4.- Conclusions

We proposed and demonstrated a novel, compact and simple-to-construct optical fiber thermometer based on Surface Plasmon Resonance (SPR) phenomenon. From the experimental calibration curve, a temperature sensitivity of -3066 pm/°C was found with good linear response in the temperature range from 10°C to 40°C. We can speculate that the temperature detection resolution is around 0.5°C, assuming the resolution of the OSA is 0.1 nm and the sensitivity reached.

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