Optical sensor based on polymer electrospun nanofibers for sensing humidity

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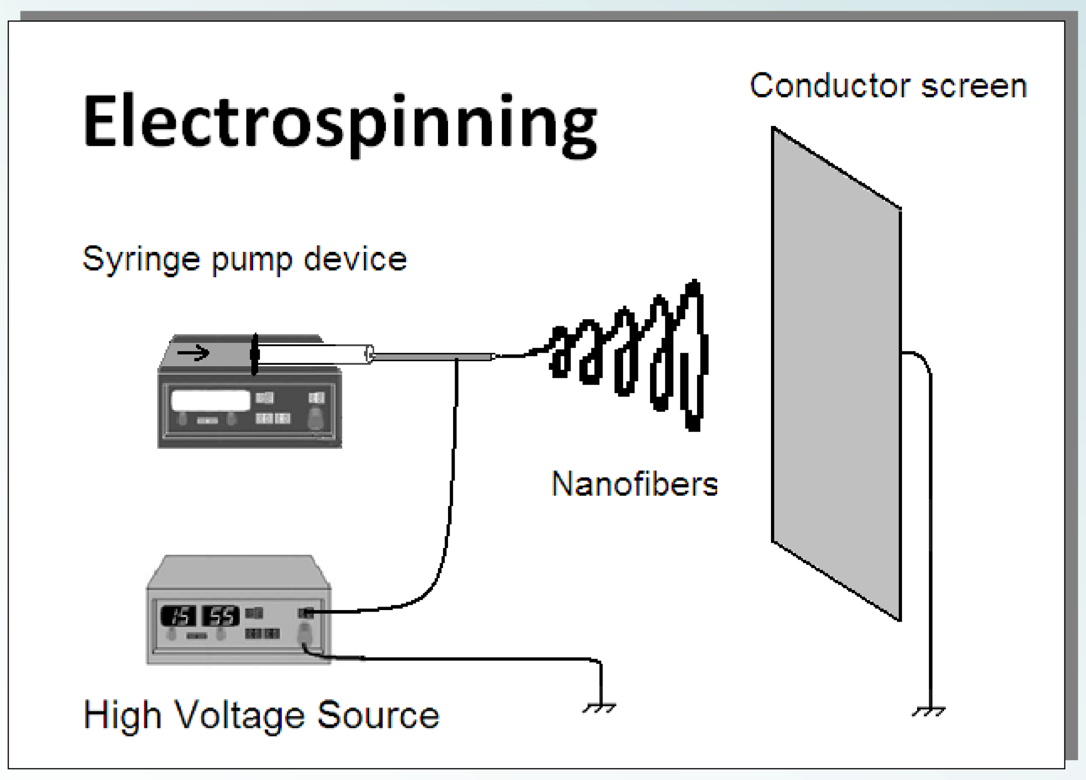
ABSTRACT

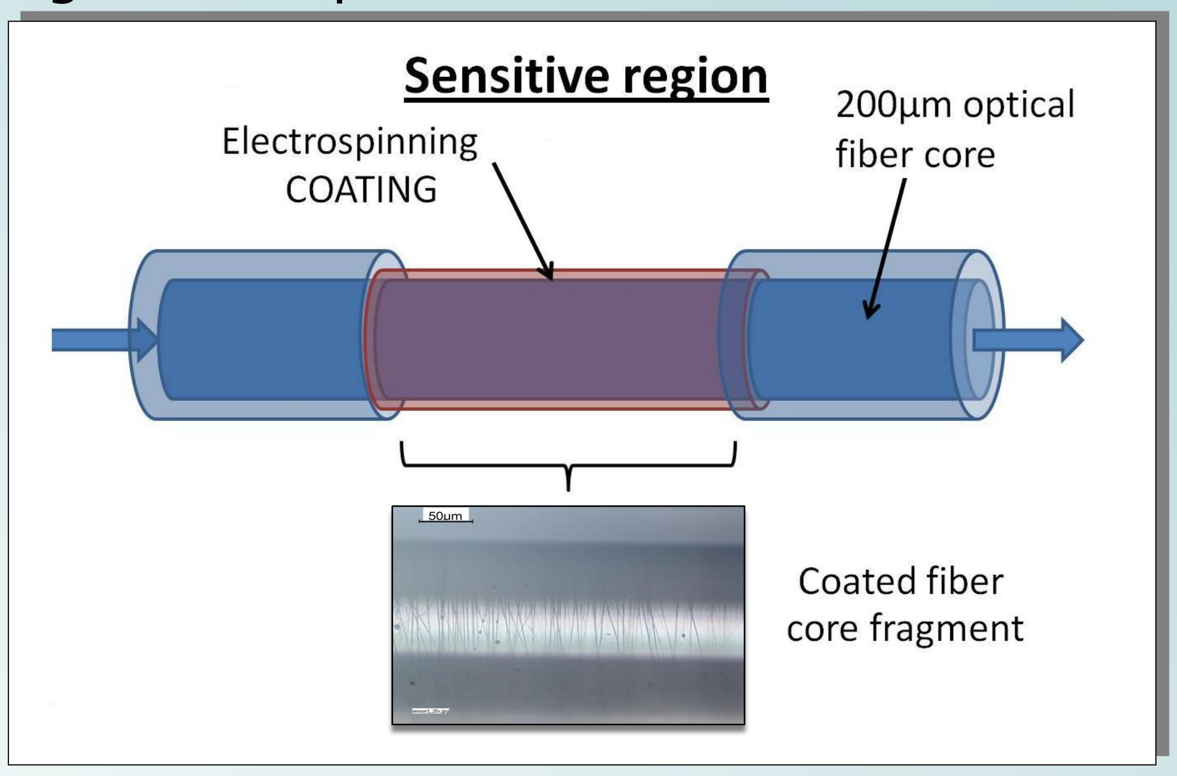
A novel humidity sensor based on polymer electrospun nanofibers coating onto an optical fiber is proposed in this work. The coating is composed of poly(acrylic acid), and its fabrication was performed by the electrospinning technique using an optical fiber core as substrate. This technique allows the fabrication of sensitive films with high surface area in a fast and simple way compared to other overlay fabrication techniques. The sensor was tested in a programmable temperature and humidity climatic chamber. Relative Humidity (RH) was varied in the range from 20%RH to 80%RH at room temperature. The results showed a monotonic variation of the absorbance spectra to RH changes, thus obtaining a successful humidity sensor.

SENSOR FABRICATION

◇ A 3cm fragment of 200μm optical fiber core was prepared by removing the cladding. The fragment was coated by electrospinning for 20 min.

◇ The electrospinning solution is prepared using 2g. of PAA loaded into a syringe. The distance between the anode (syringe) and the cathode (conductor screen) is 20 cm. The voltage was kept constant to 20 kV.

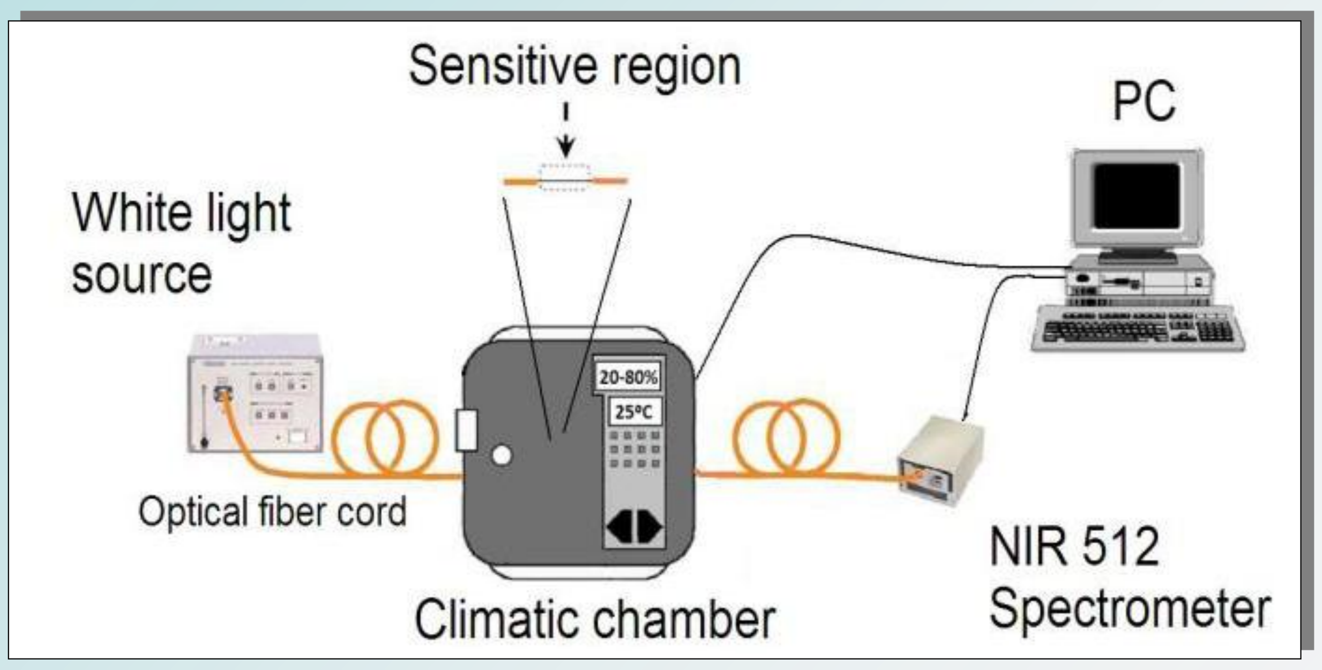




◇ The optical fiber fragment was placed and rotated 2cm above the collector screen and perpendicularly to the syringe jet direction thus obtaining the sensitive region.

SET-UP

◇ An end of the optical fiber was connected to a broadband light source while the other end was connected to a spectrometer to register the transmission spectrum of the sensor.



◇ A programmable climatic chamber was used to expose the sensor to Relative Humidity variations from 20% to 80% and vice versa at 25ºC.

RESULTS

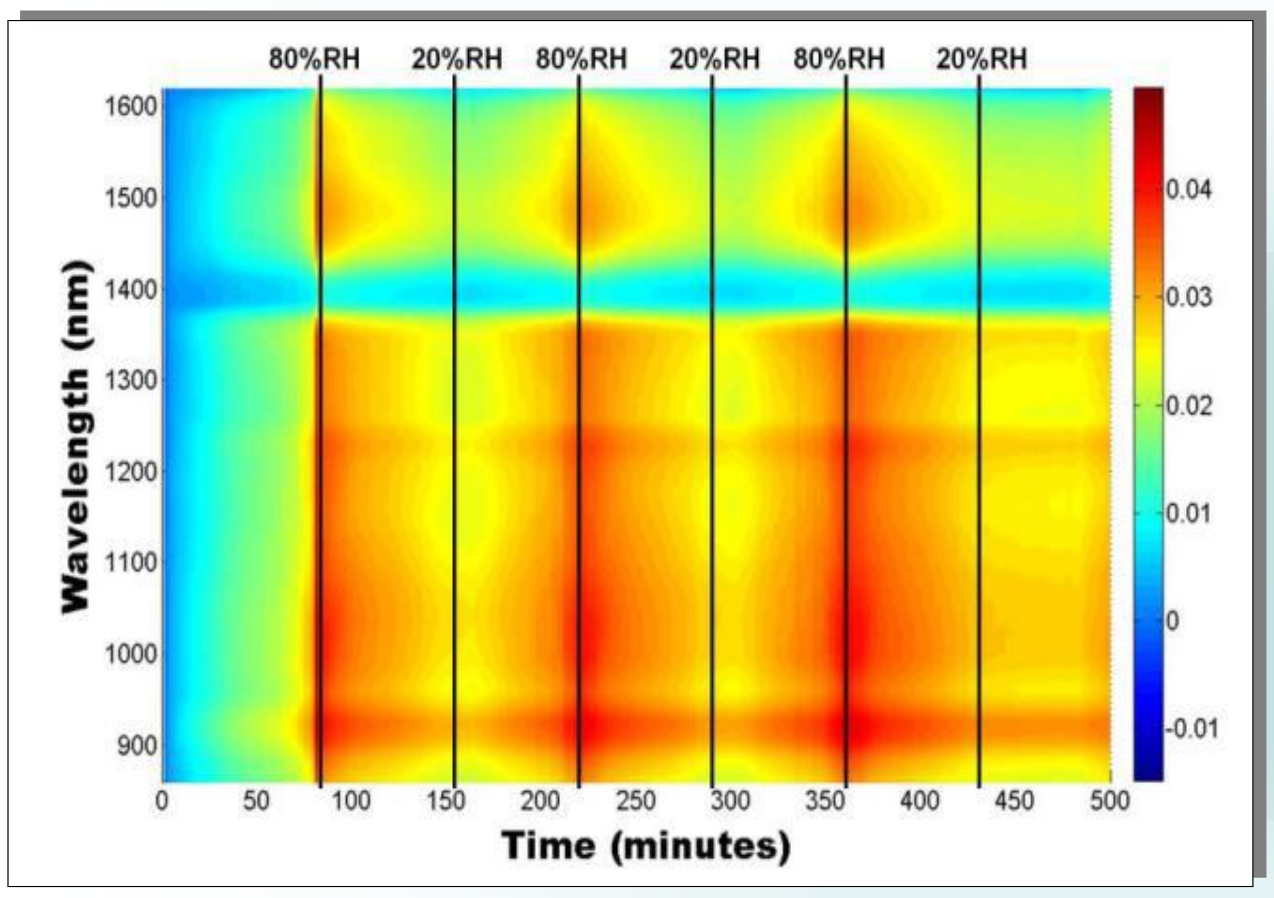


Figure 1

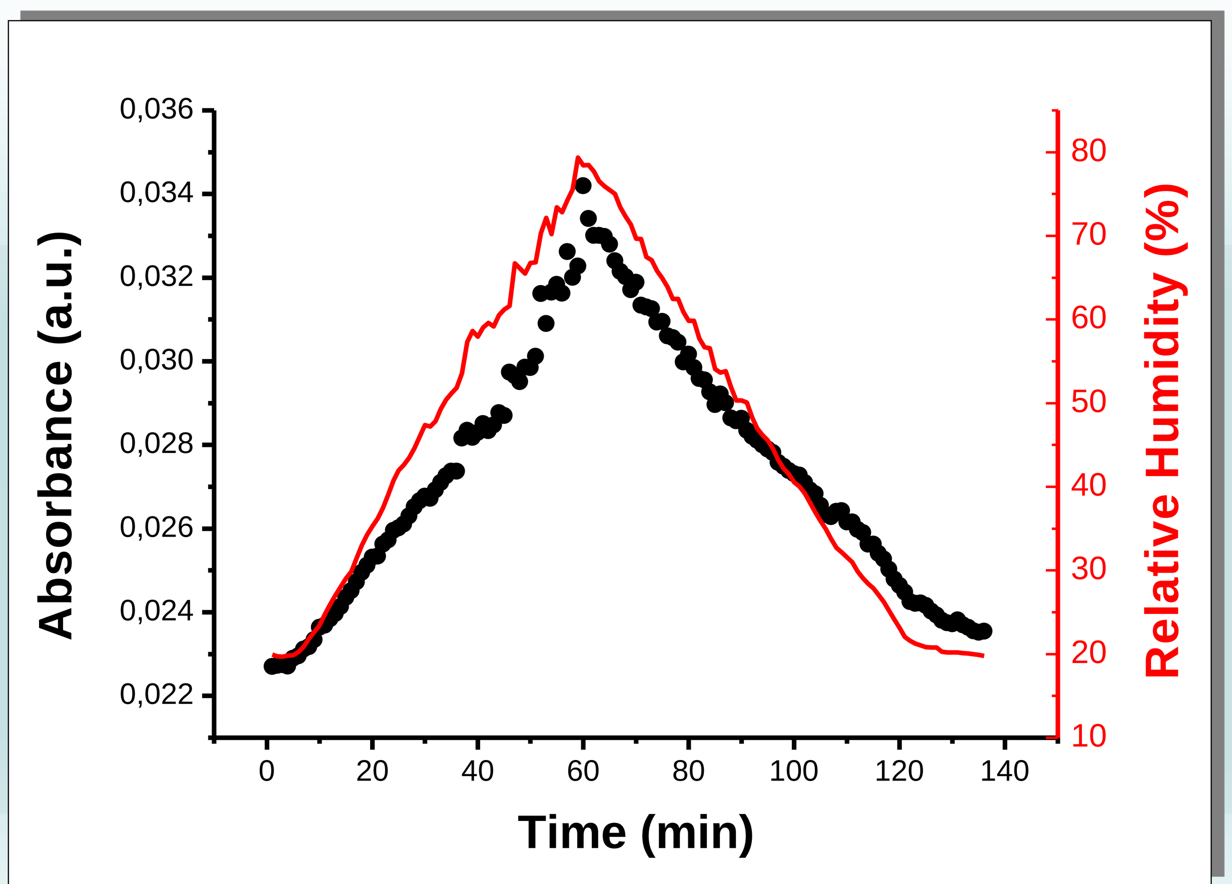


Figure 2

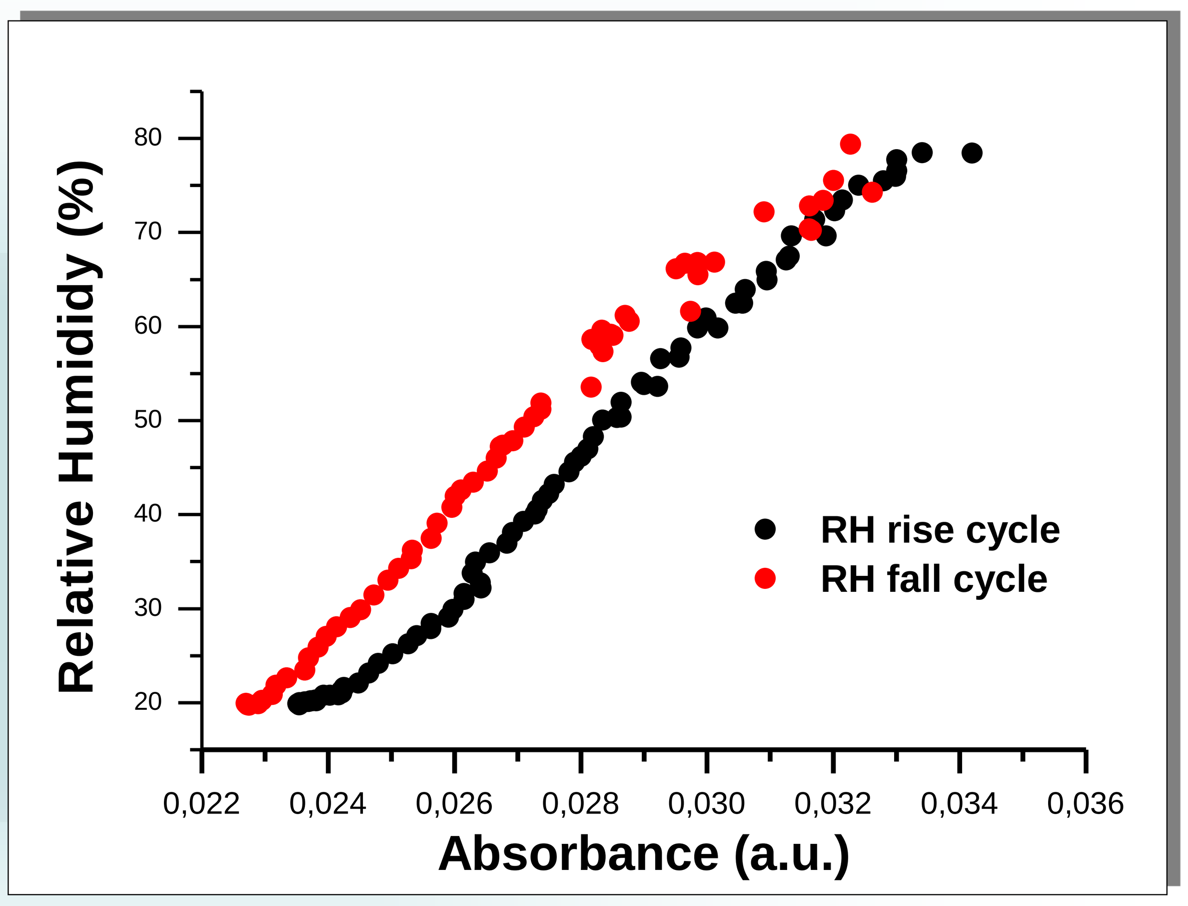


Figure 3

Figure 1: Monitoring of the absorbance of the sensitive region in 3 RH cycles.
Figure 2: Climatic chamber RH electronic sensor (red line) compared with the optical fiber sensor response for a wavelength of 1300nm (black dots).
Figure 3: Transfer function of the device for a 20%RH-80%RH-20%RH cycle.

CONCLUSIONS

- ❑ A new RH sensor based on a electrospun nanofibers mat fabricated directly onto an optical fiber core is presented.
- ❑ The sensitive region was fabricated using electrospinning, which provides a simple and fast fabrication step compared with other time consuming techniques. The nanofibers have been successfully placed onto the fiber core with a predominant orientation which provides a quasi-periodic surface morphology.
- ❑ The sensitive region changes the refractive index surrounding the optical fiber as a function of the relative humidity and, therefore, the absorbance spectra changes depending on this parameter from at least 20%RH to 80%RH. The sensor has shown a high repeatability and an acceptable low hysteresis of 4.1%.
- ❑ This device represents the first RH optical fiber sensor based on polymeric electrospun nanofibers as the sensitive coating.

ACKNOWLEDGMENT

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