Study on the performance of fiber cladding diameter to humidity sensor

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-Abstract-

Reducing the diameter of FBG cladding by hydrofluoric acid can improve the sensitivity and response speed of humidity sensor, and has little effect on repeatability and stability.

-The Fabrication Of Sensors-

Experiments have found that the fiber diameter has a linear relationship with the corrosion time, as shown in Figure 1. Using this feature, gratings FBG1-4 with diameters of 125μm，85μm，73μm and 53μm were prepared respectively.

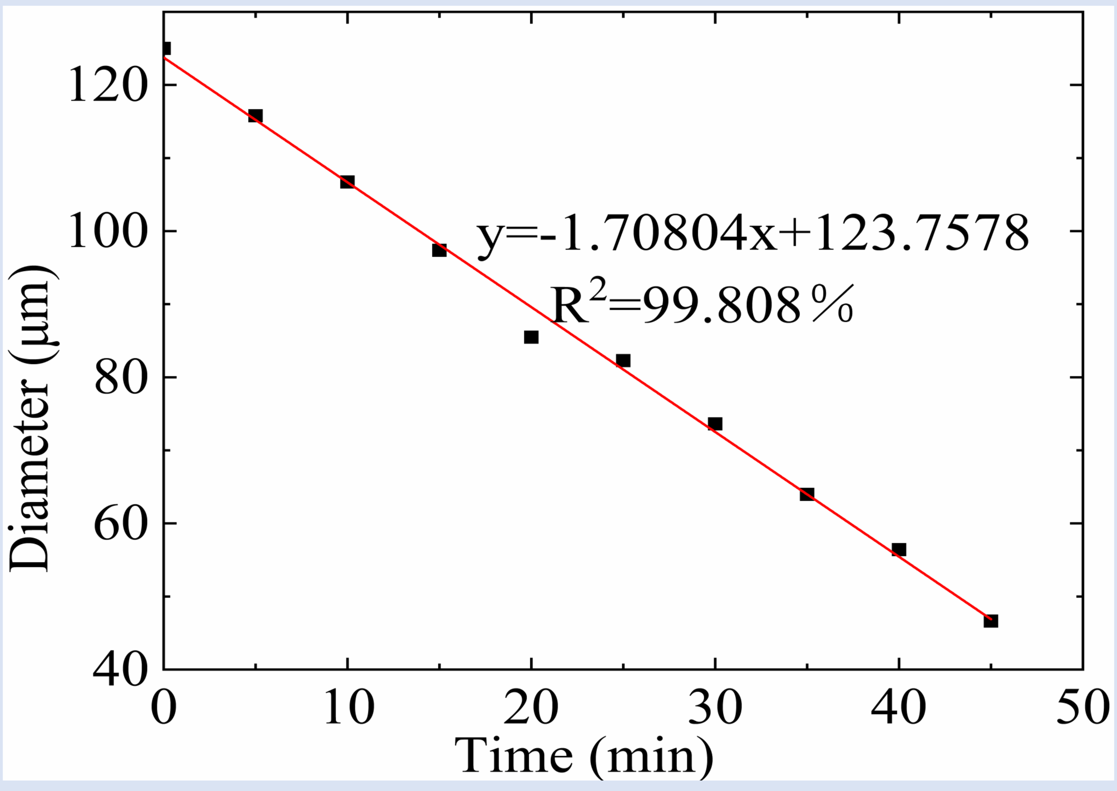

Figure 1. Relationship between fiber diameter and corrosion time

PI solution was ZKPI-305IIE (cp:5000-6000, solid content:12%-13%) produced by Beijing Pome.Use HO-TH-02B pull coating machine to coat the fiber grating. Set the pulling speed to 100mm/min, dip it in PI solution for 1 minute and put it in a drying oven at 120° C for 5 minutes. Repeat the above steps 4-5 times to ensure consistent coating thickness. After forming a uniform PI film on the surface of the grating, the grating was cured at 180℃ for 120 minutes in the drying oven. Sensor probes with different cladding diameters were recorded as FBG1-4 and observed under a ZYGD-300 optical microscope, as shown in Figure 2.

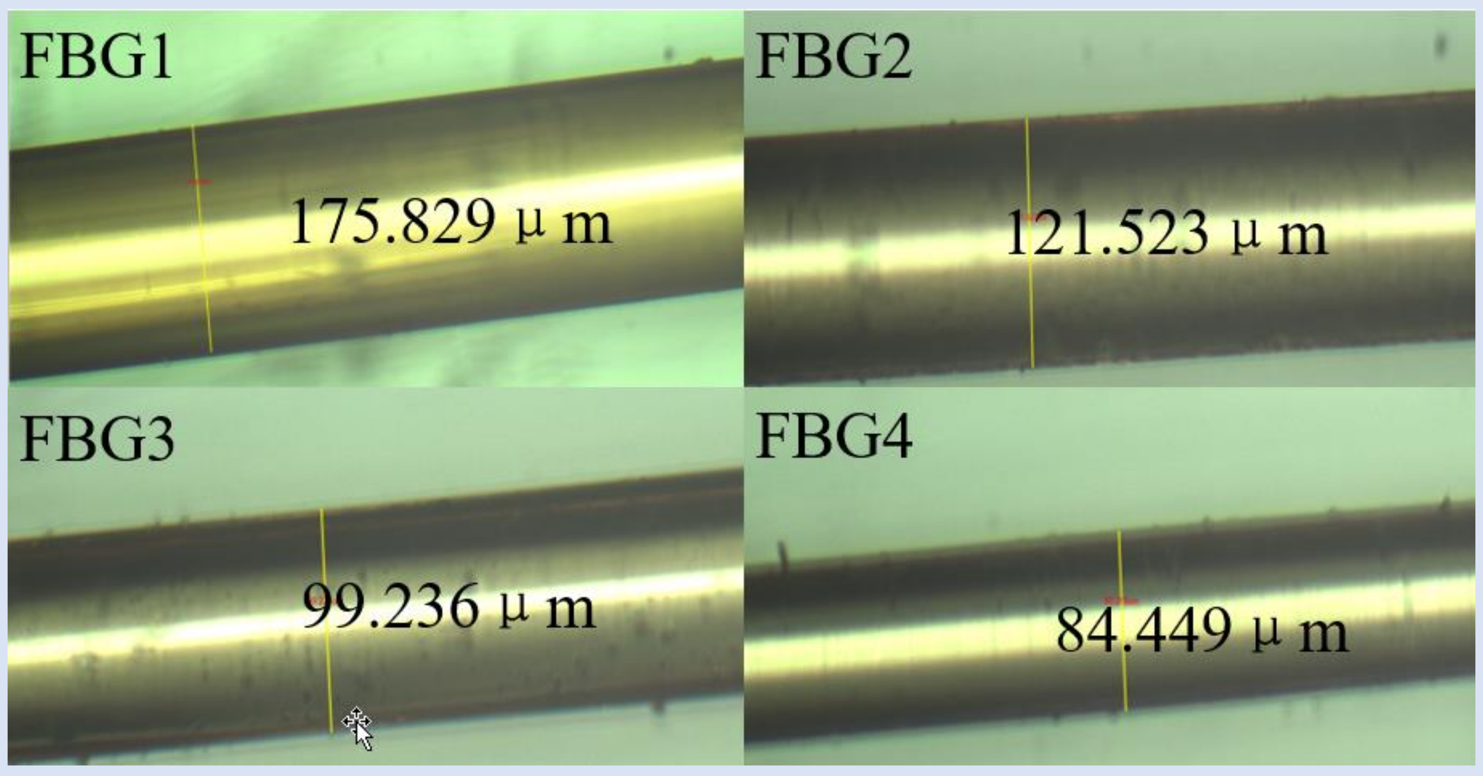

Figure 2. Optical micrograph of FBG1-4 after coating

-Test-

Fix the FBG sensors in the cavity of the cf-1000 temperature and humidity generator. Set the temperature to a constant 23° C, adjust the relative humidity from 8%RH, 30%RH, 50%RH, 70%RH to 90%RH, and record the corresponding wavelength value after each state is stable for 1.5h. Humidity characteristics of FBG1-4 and Relationship between sensitivity and cladding diameter were shown in figure 3. The sensitivity of FBG1-4 is 4.4pm/%RH and 5.8pm/%RH, 6.3pm/%RH and 6.9pm/%RH in the process of rising humidity of 10-90%RH, the linearity reached 99.68%, 99.88%, 99.93%, 99.84%, respectively. Besides, as the cladding diameter decreases, the relative humidity sensitivity of the sensor will increase linearly.

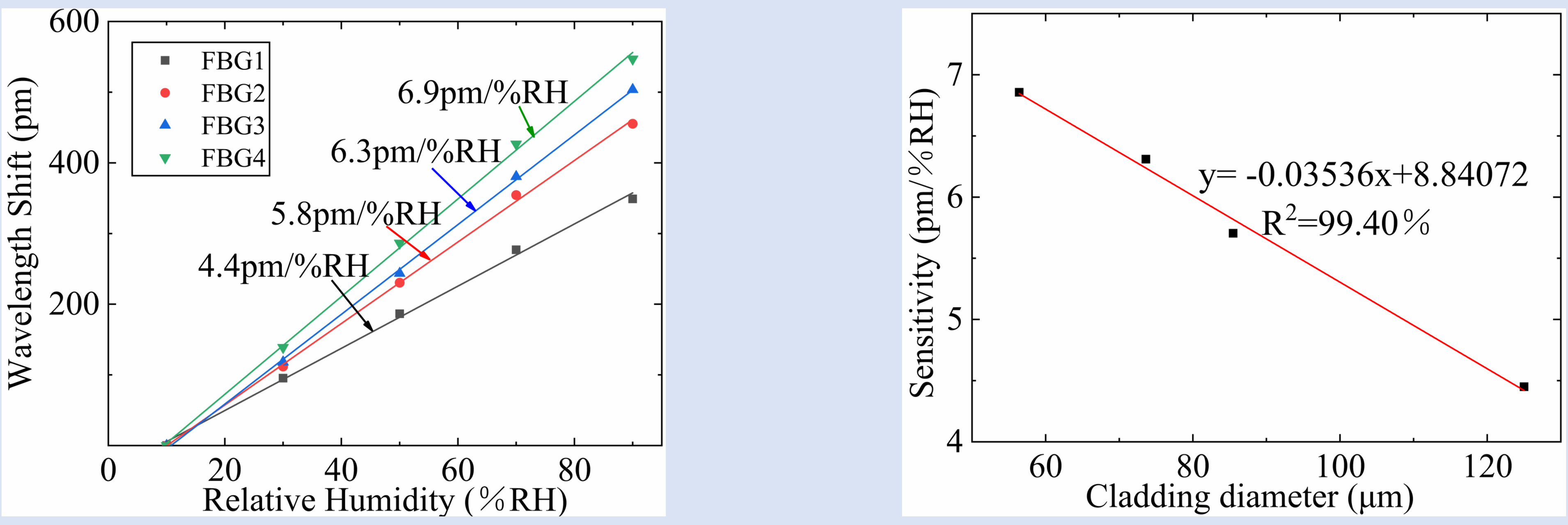

Figure 3. Humidity characteristics of FBG1-4 and relationship between sensitivity and cladding diameter

Saturated LiCl solution (11.3%RH) and saturated K_2SO_4 solution (97.3%RH) were selected as the rapidly switching humidity environment. And 63% of the total wavelength change was taken as the response time of humidity sensor , denoded as T_{63}. The response time curve of FBG1-4 is shown in Figure 4. The experiment show that the response time of FBG1-4 is 5.38min, 3.38min, 2.55min and 2min respectively. As can be seen from the figure, the response time of the sensors decreases with the decrease of the fiber cladding diameter.

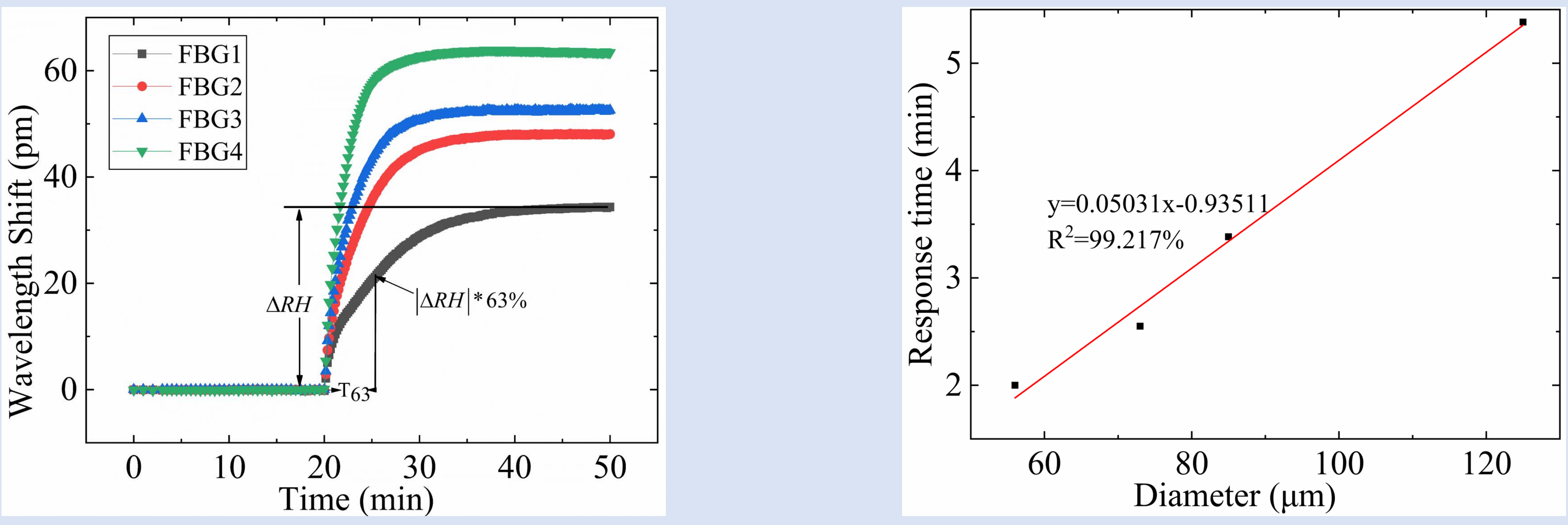

Figure 4.Response time of FBG humidity sensors

-Conclusion-

Reducing the grating diameter can improve the sensitivity of the FBG to humidity, reduce the response time, and has almost no effect on the stability, thereby improving the performance of the sensor. However, practice shows that as the diameter of the optical fiber decreases, the mechanical strength of the FBG also decreases, causing the sensor probe to become more fragile.