Refractive index and temperature sensor based on no-core fiber and few-mode fiber coupling

Yeming Zhao*, Zhengrong Tong *, Weihua Zhang, Jietong Zhang
Engineering Research Center of Optoelectronic Devices and Communication Technology, Ministry of Education, Tianjin Key Laboratory of Film Electronic and Communication Devices, School of Integrated Circuit Science and Engineering, Tianjin University of Technology, Tianjin, China, 300384

ABSTRACT: An interferometric fiber optic sensor based on no-core fiber (NCF) is proposed, and small sections of few-mode fiber (FMF) are fused to each end of the NCF to enhance the sensitivities of the sensor. The refractive index sensitivities of this structure are 171.29 nm/RIU from 1.35 to 1.41 and 892.56 nm/RIU from 1.41 to 1.43, respectively. The temperature sensitivity is 0.06684 nm/°C from 30°C to 90°C. The proposed sensor has the advantages of simple structure, low cost and anti-electromagnetic interference, which can be widely used in biological and chemical fields.

Sensor structure

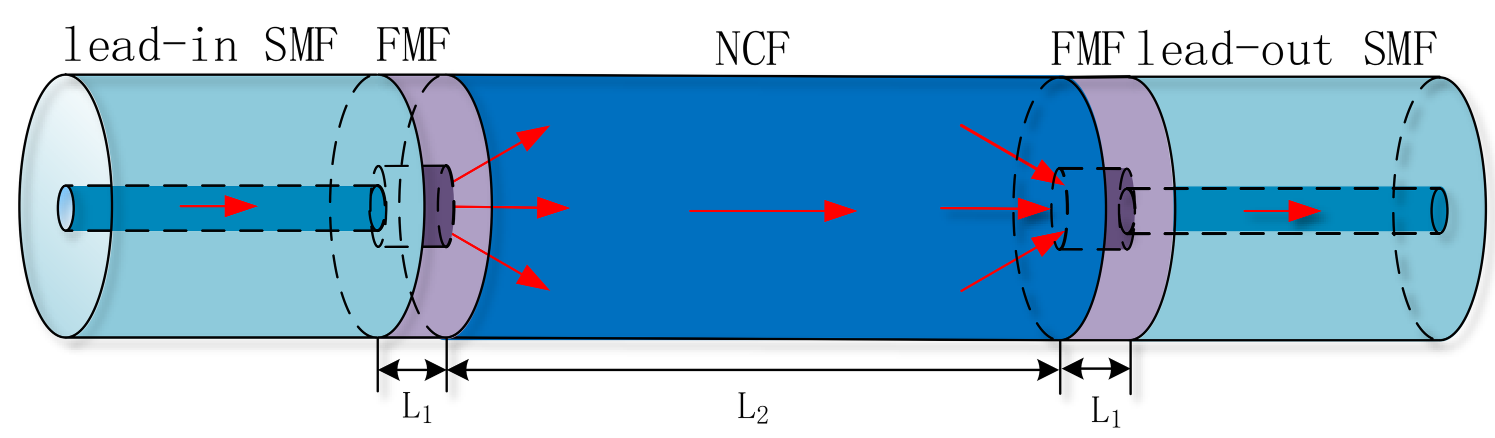

Fig.1 Sensing structure

Two small sections of FMF (L_1=0.2cm) and one section of NCF (L_2=2.6cm) are cut out by a fiber optic cleaver. These three sections are fused by a fiber optic fusion splicer and the sensing structure is fused with lead-in SMF and lead-out SMF, respectively.

Experiment and results

The sensor is fixed horizontally at the bottom of the glass container, and the two sides of the sensor are connected to a broadband light source (BBS,1528nm-1603nm) and an optical spectrum analyzer (OSA), respectively. Glycerol solutions with different refractive indices from 1.35 to 1.43 are configured with an Abbe refractometer. Glycerol solutions with different refractive indices are dropped uniformly into the glass container to submerge the sensing structure and the experimental data are recorded by the OSA.

As can be seen from Fig.3, with increasing refractive index, the interference spectrum gradually shifts towards the long wave direction. Fig.4 shows the refractive index sensitivity of the proposed sensor in the range of 1.35-1.41 is 171.29 nm/RIU with a linear fit value R^2 of 0.984.Fig.5 shows the transmission spectra in the refractive index range of 1.41 to 1.43.It can be seen in Fig.6 that the refractive index sensitivity of the proposed sensor in the range of 1.41-1.43 is 892.56 nm/RIU with a linear fit value R^2 of 0.992.

In the temperature sensing experiments, the proposed sensor is fixed horizontally in a temperature controller and the temperature is raised from 30°C to 90°C, with data recorded every 10°C. Fig.9 illustrates that the temperature sensitivity of the proposed sensor is 0.06684 nm/°C from 30°C to 90°C with a linear fit value R^2 of 0.997.

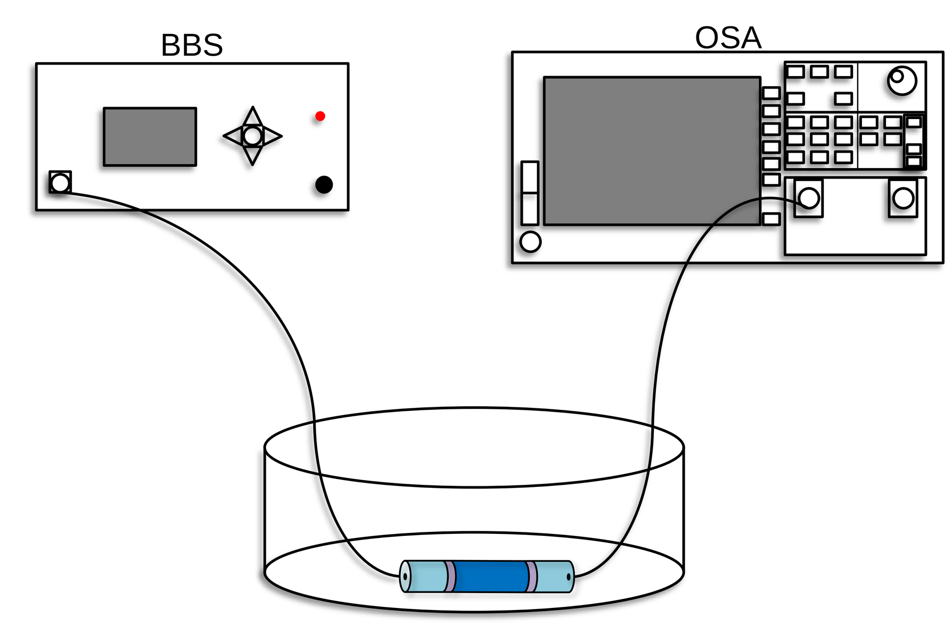

Fig.2 Refractive index experimental devices

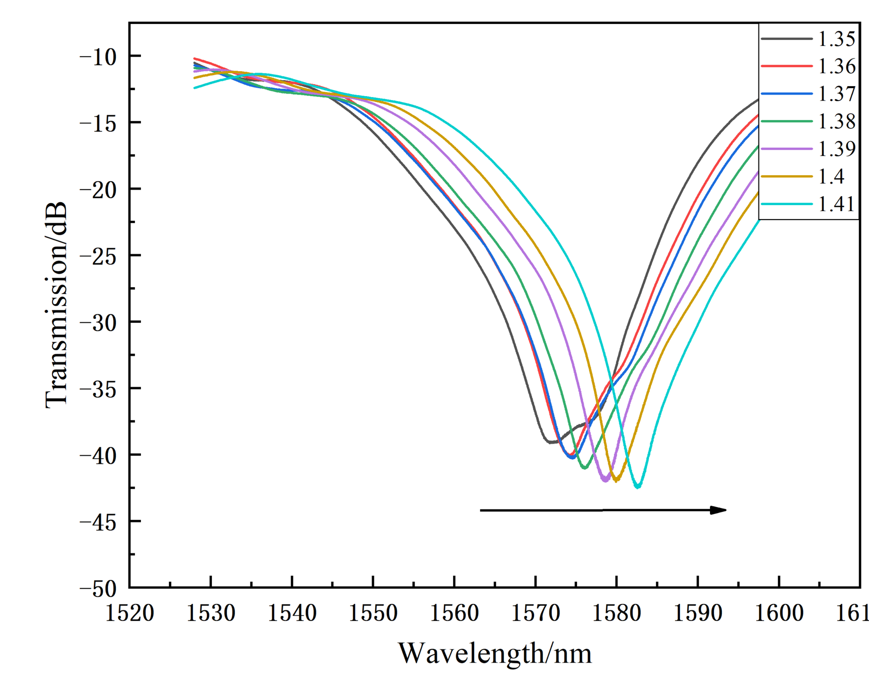

Fig.3 Transmission spectra in the refractive index range from 1.35 to 1.41.

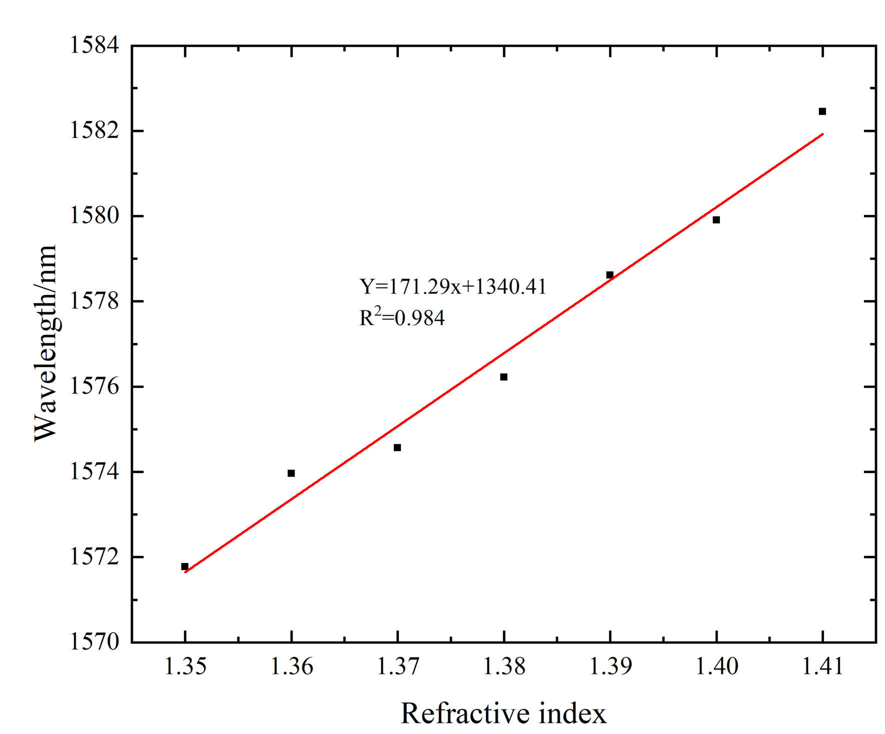

Fig.4 Linear fitting in the range of refractive indices of 1.35 to 1.41.

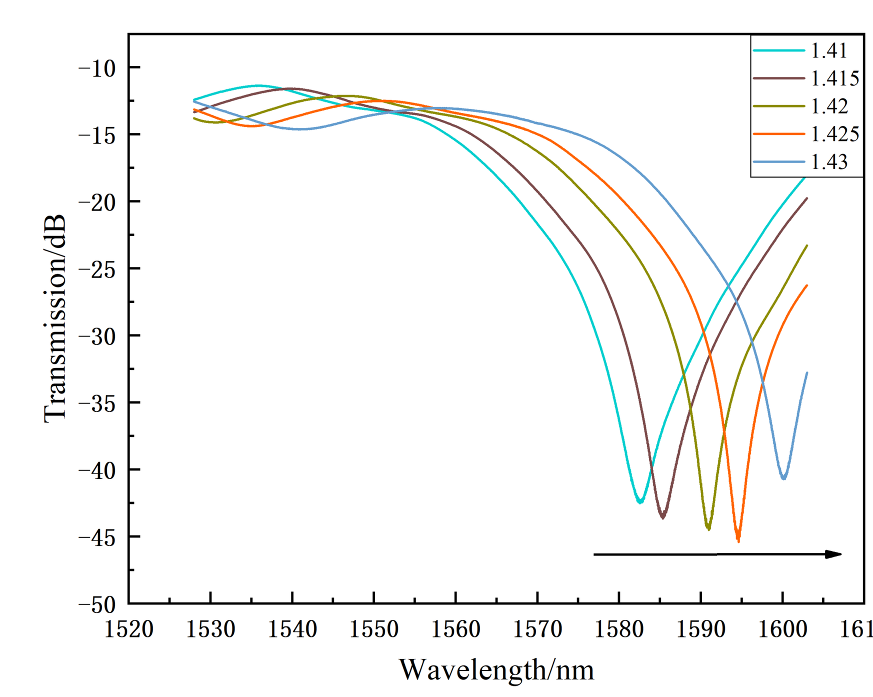

Fig.5 Transmission spectra in the refractive index range from 1.41 to 1.43.

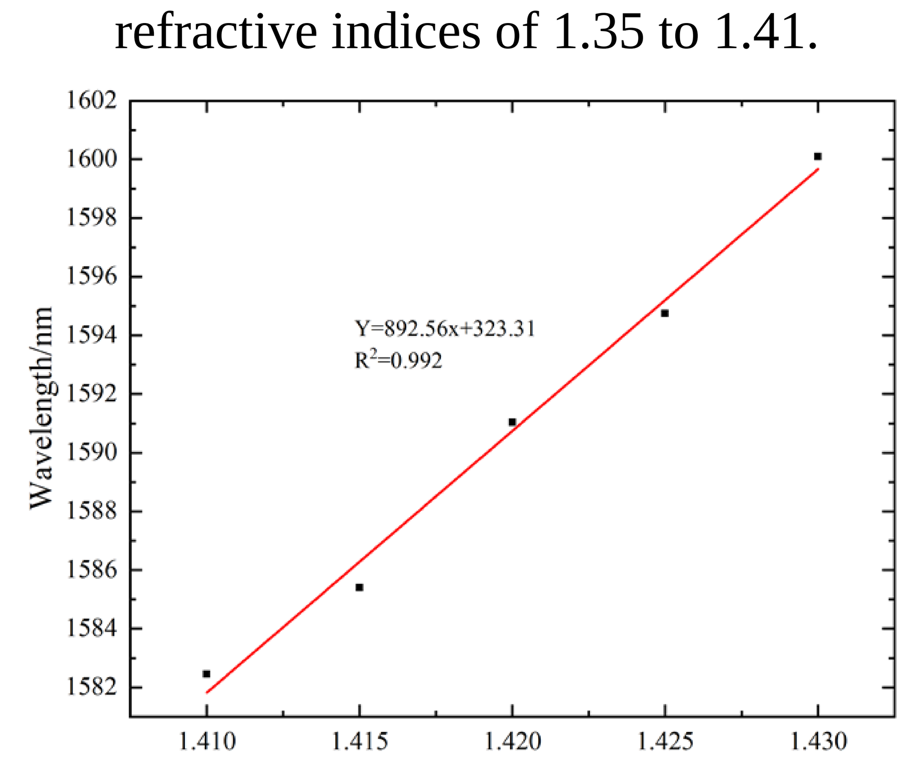

Fig.6 Linear fitting in the range of refractive indices of 1.41 to 1.43.

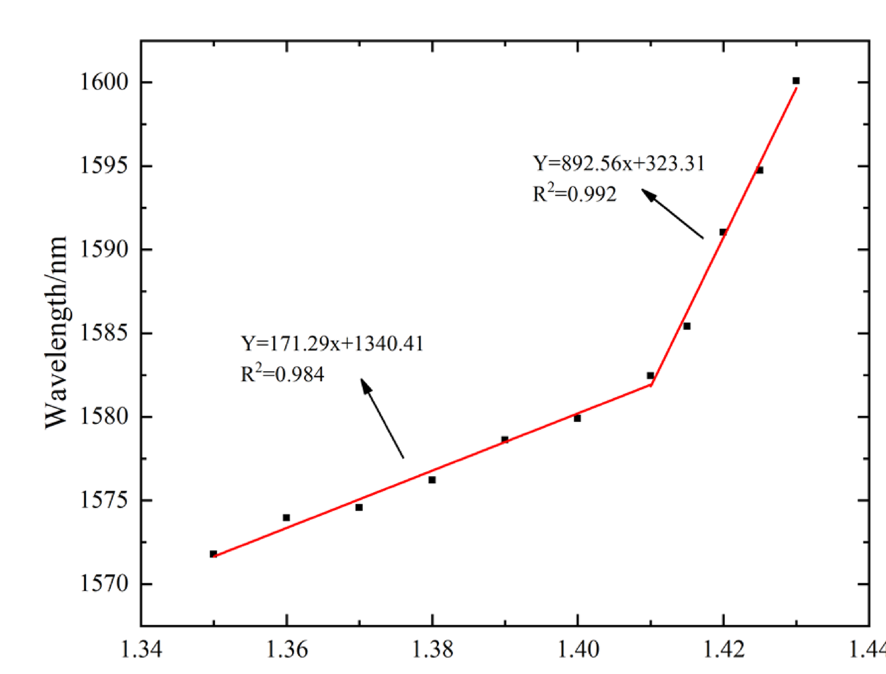

Fig.7 Linear fitting in the range of refractive indices of 1.35 to 1.43.

Conclusions

In conclusion, an optical fiber sensing structure based on NCF and FMF coupling is proposed to excite the higher order modes in NCF for refractive index and temperature measurements. The structure has the advantages of small size, simple structure and large measuring range, which can be widely used for refractive index and temperature measurements.

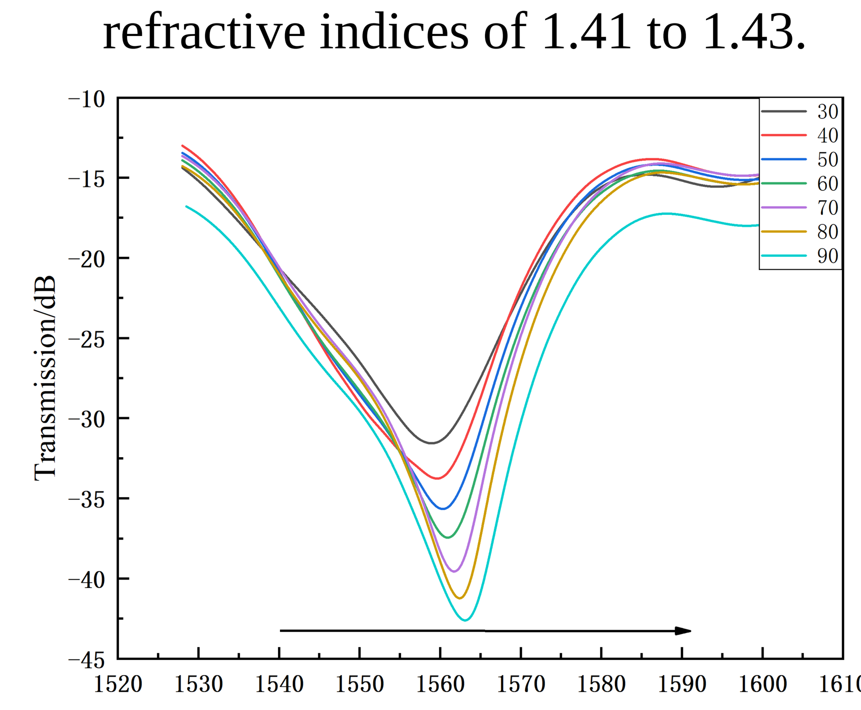

Fig.8 Transmission spectra of the proposed sensor within the temperature of 30°C to 90°C.

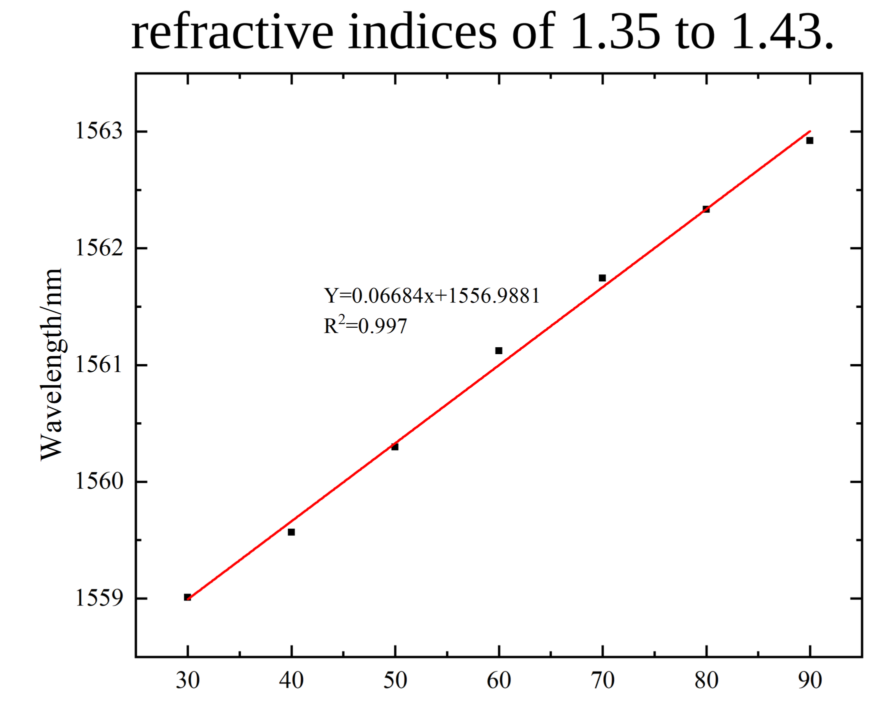

Fig.9 Linear fitting within the temperature of 30°C to 90°C.

*E-mail: tjzhaoyeming@163.com, tjtongzhengrong@163.com

Acknowledgment: This work has received support by the National Youth Natural Science Foundation of China (No.11704283), Natural Science Foundation of Tianjin City (No.18JCYBJC86300) and Tianjin Research Innovation Project for Postgraduate Students (No. 2020YJSS016).