***Abstract*—A high-sensitivity curvature sensing configuration is implemented by using a fiber Mach-Zehnder interferometer (MZI) with D-shaped fiber Bragg grating (FBG). A segment of D-shaped fiber is fusion spliced into a single mode fiber at both sides, and then a short FBG is inscribed in the D-shaped fiber. The fiber device yields a significant spectrum sensitivity as high as 87.7 nm/m^{-1} to the ultra-low curvature range from 0 to 0.3 m^{-1}, and can distinguish the orientation of curvature experienced by the fiber as the attenuation dip producing either a blue or red wavelength shift, by virtue of the asymmetry of D-shaped fiber cladding. In addition, by tracking both resonant wavelengths of the MZI and embedded FBG, the temperature and curvature can be measured simultaneously.**

***Index Terms*—Mach-Zehnder interferometer (MZI), D-shaped fiber, fiber Bragg grating (FBG), curvature measurement.**

θ

Φ

$$\Phi = \frac{\Delta n \quad \lambda\ L}{\lambda} + \phi \quad \lambda$$

Δn L ϕ

x-z y-z

μ μ

L ϕ

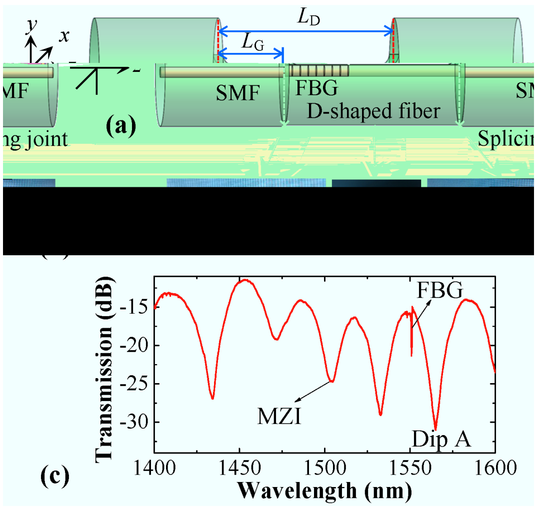
μ

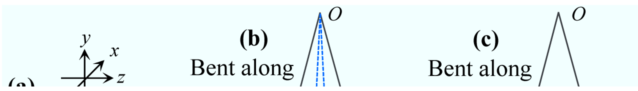
λ λ

Φ m $\pi\,(m$

λ λ λ

$$\lambda_m = \frac{\Delta n \quad L}{m+}$$





x-z x-y y-z

Δx

Δs

r

$\Delta s'$

This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/JLT.2017.2776297, Journal of Lightwave Technology

Δs

$$\varepsilon = {}_{\Delta s \to} \frac{\Delta s' - \Delta s}{\Delta s}$$

r

R

Δs Δx

Δx R O

$\Delta\theta$

Δs Δx $R\Delta\theta$

Δs $\Delta s'$ R r $\Delta\theta$

$$\varepsilon = {}_{\Delta\theta \to} \frac{R - r\ \Delta\theta - R\Delta\theta}{R\Delta\theta} = -\frac{r}{R} = r \cdot C\,,$$

C

r ε r R ε

r

$\Delta\varepsilon$

$\Delta n \quad = k\ \Delta\varepsilon = k\ d\ R$

d

k

$$\Delta\lambda_m \cong \frac{kL\ d}{m+} \cdot \Delta C$$

λ n Λ

$\Delta\lambda \quad = (\ + P\ )\lambda\ \ r \cdot \Delta C$

P

r

r

λ n Λ

$$\Delta\lambda_m^T = \frac{}{m+}\left(\Delta n \quad \frac{\partial L}{\partial T}\Delta T + \ \ L\ \frac{\partial\ \Delta n}{\partial T}\right)\Delta T$$
$$= \lambda_m\left(\alpha + \xi'\right) \cdot \Delta T$$

$$\Delta\lambda^T \ = \ n \quad \frac{\partial\Lambda}{\partial T}\Delta T + \ \Lambda\frac{\partial n}{\partial T}\Delta T = \lambda\ \left(\alpha + \xi\right) \cdot \Delta T$$

ΔT α ξ

ξ'

ΔC ΔT

$$\begin{bmatrix}\Delta C \\ \Delta T\end{bmatrix} = \frac{}{D}\begin{bmatrix}K_T & -K_T \\ -K_C & K_C\end{bmatrix}\begin{bmatrix}\Delta\lambda & \\ \Delta\lambda & \end{bmatrix}$$

D K_C K_T K_T K_C K_C

K_T K_C K_T

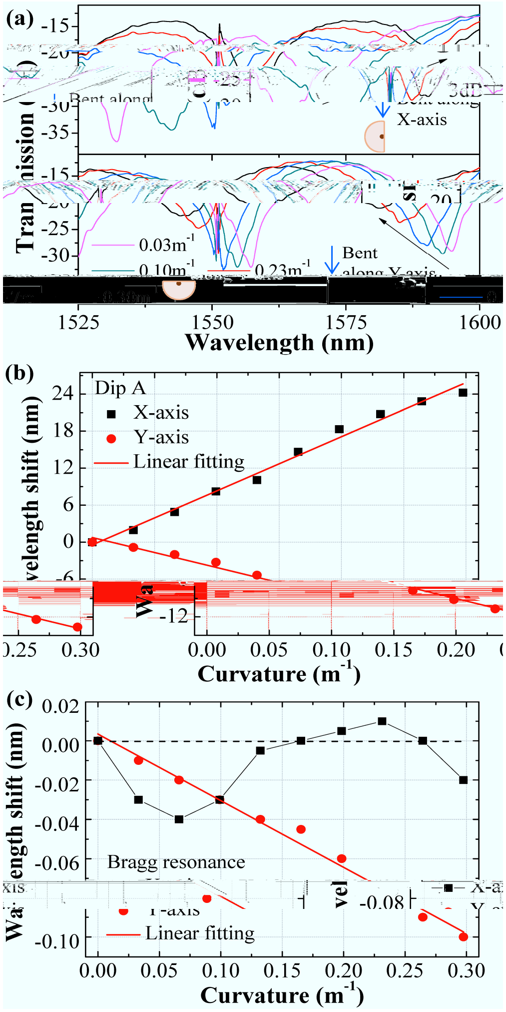
K_C K_C

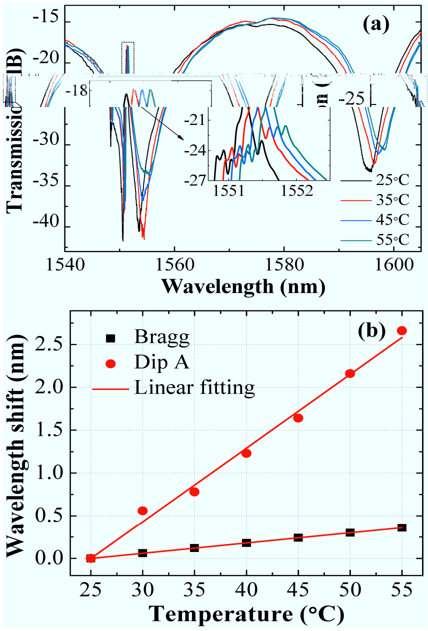
L

C R y y L

y

This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/JLT.2017.2776297, Journal of Lightwave Technology





$$\begin{bmatrix} \Delta C \\ \Delta T \end{bmatrix} = \frac{}{(- \quad)} \begin{bmatrix} (\quad) & - \quad (\quad) \end{bmatrix} \begin{bmatrix} \Delta\lambda \\ \Delta\lambda \end{bmatrix}$$

	87.7	Sensitive	86.0	

Meas. Sci. Technol.,

Opt. Lett.,

J. Lightwave Technol.,

Opt. Lett.,

Opt. Lett.,

Opt. Express,

IEEE Photon. Technol. Lett.,

J. Lightwave Technol.,

Sci. Rep.

IEEE Photon. J.,

Opt. Eng.,

IEEE Photon. Technol. Lett.,

Opt. Express,

IEEE Photon. J.,

IEEE Photon. Technol. Lett.,

Opt. Lett.,

Opt. Express,

IEEE Photon. Technol. Lett.,

Opt. Express,

Opt. Lett.,

Appl. Phys. Lett.,

Appl. Opt.,