illustrate the excellence of suppression of polarization noise of the device, we compared the output power of TE mode and TE + TM mode, as shown in Fig. 5(c). It is clearly demonstrated that the output TM mode power has little influence on TE mode even the input power for TE and TM modes are the same.

In most applications, the input linearly polarized light can be set to excite the TE mode. The polarization related coupling and instability, which are mainly from the fluctuation of fiber geometry and environment, can be suppressed well in the resonator, which is especially attractive for certain specialized applications such as gyros and current sensors. These functions cannot be realized in a one-dimensional fiber system. The Q factor can be increased by optimizing these parameters to tune the coupling coefficient and decrease the loss of the TE mode. Obviously, more polarization-related functions can be integrated with a compact size for future lab-on-a-rod devices.

4. Conclusion

We propose a new approach, the lab-on-a-rod, for polarization-related multifunction integration on a single rod by one ONM. The device has a unique 3D geometry obtained by wrapping the ONM around the nanostructured rod. The nanostructuring procedure is performed only on the thick rod, rather than on the thin fiber [10], which simplifies fabrication.

Compared with conventional fiber polarization devices, this device offers more freedom and greater potential for compactness and functionality. Moreover, we present numerical simulations that investigate the polarization loss mechanism. By functionalizing the rod surface with a nanoscale silver film and tuning the pitches of the coils, a broadband polarizer and single-polarization resonator, respectively, are demonstrated. The polarizer has an extinction ratio of more than 20 dB over a wavelength range of 450 nm. A higher extinction ratio can be easily obtained by adding more turns. The resonator has a Q factor of >78,000 with excellent suppression of the polarization noise. A higher Q factor can be achieved by optimizing those parameters. This type of compact single-polarization resonator is impossible to realize with previously reported methods and has a number of applications in communications, nonlinear optics, and sensing. More polarization-related functions can be integrated with an ultracompact size for future lab-on-a-rod devices. The platform is also quite compatible with the emerging 2-D materials, such as graphene and MoS_2. These new material can introduce more functionalities to the fiber system, such as the nonlinear effect, mode locking, light-wave modulating etc. For instance, if we use graphene to modify the rod, the device may work over a larger bandwidth since the linear dispersion of the Dirac fermions enables graphene broad band applications [15]. Overall, our results demonstrate how the definition of viable lab-on-a-rod technologies would enable the realization of technological platforms completely integrated on a single rod with one ONM, for exploitation in many application fields.

Acknowledgments

This work is supported by National 973 program under contract No. 2012CB921803 and 2011CBA00205, National Science Fund for Excellent Young Scientists Fund (61322503) and National Science Fund for Distinguished Young Scholars (61225026).The authors also acknowledge the support from PAPD and the Fundamental Research Funds for the Central Universities, and the help on FEM simulation by Prof. Xiaoshun Jiang and Xuejing Zhang.