Electro-optic Long Period Ti:LiNbO$_3$ Waveguide Gratings in Parallel for Broadband Filtering

De-Long Zhang$^{1,2,*}$, Jia-Qi Xu$^1$, Wing-Han Wong$^{1,2}$, Edwin Yue-Bun Pun$^2$

1 School of Precision Instruments and Opto-electronics Engineering, Tianjin University, Tianjin 300072, China, and Key Laboratory of Optoelectronic Information Technology (Ministry of Education), Tianjin University, Tianjin, 300072, China.

2 Department of Electronic Engineering and State Key Laboratory of Millimeter Waves, City University of Hong Kong, Kowloon, Hong Kong SAR, China.

* dlzhang@tju.edu.cn

We report broadband optical filter based on two parallel electro-optic long period Ti:LiNbO$_3$ waveguide gratings with different pitches. By utilizing electro-optic and photorefractive effects of LiNbO$_3$ and by changing driving voltage, one can realize 360 nm broadband linear tunability and 0-30 dB linear adjustment of dip contrast.

Long-period waveguide grating (LPWG) and long-period fiber grating have similar working principle and application background [1, 2]. An LPWG based on electro-optic effect of LiNbO$_3$ (LN) is promising for high-speed application [3,4]. Here, we demonstrate a broadband filter based on a parallel structure of two electro-optic long period gratings in two same Ti:LN strip waveguides. The device was developed on the basis of the electro-optic and photorefractive effects of LN.

The device was fabricated in a following way. First, a special structure of an array of strip waveguides embedded in a planar waveguide was fabricated on an LN substrate surface by successive diffusion of 60 nm thick homogeneous Ti film at 1060 °C for 6 h and an array of 6-μm-wide, 105-nm-thick Ti-strips at 1060 °C for 11 h. Second, a 320 nm thick SiO$_2$ buffer layer was coated onto the waveguide surface. Third, two parallel interdigital Al electrodes with pitches 675 and 880 μm were patterned on the top surface. Upper left of Fig. 1 shows the structure of the device.

After the fabrication, the device performances were fully characterized. The lower left part of Fig. 1 shows the morphology of waveguide surface and the mode patterns of the strip waveguide at the 1.5μm wavelength. The upper right of Fig. 1 shows the normalized transmission spectra of the device driven under different voltages for the grating having a pitch of (a) 675 μm and (b) 880 μm. Two features could be identified from these spectra. First, the contrast of the dip increases with a rise in driving voltage. The panel (a) in the lower right of Fig. 1 shows the driving voltage dependence of the dip contrast for the two grating pitches. We note that as the voltage changes from zero to 300 V the contrast increases almost linearly from zero to 30 dB. This feature is associated with the electro-optic effect of LN. Second, the panel (b) in the lower right of Fig. 1 shows the driving voltage dependence of the resonant wavelength for the two grating pitches.
One can see that the resonant wavelength red-shifts almost linearly with the increase of the driving voltage. The shift is ~160 nm for the shorter period grating and ~200 nm for the longer pitch grating, and hence ~360 nm in total. An overall investigation shows that the shift is due to the photorefractive effect of LN.

In summary, we have demonstrated a broadband filter based on two parallel electro-optic Ti:LN LPWGs with different pitches. By using the electro-optic and photorefractive effects of LN and by changing the driving voltage, one can realize 360 nm broadband linear tunability and 0-30dB linear adjustment of dip contrast. Broader bandwidth is expected by using more parallel LPWGs. The device may find its use in fields of high-speed optical filter, gain flattening and sensing.

References