Analysis of SiN Optical Waveguide for 2D Beam Steering

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1. Introduction

SQUID (superconducting quantum interference device) is a sensitive magnetometer used to measure human's brain magnetic fields as the medical instrument. It needs to work at low temperatures due to high sensitivity. Magnetic fields can be measured at room temperature by using NV (Nitrogen Vacancy) center. NV center can be excited by green light, and color center emits a red fluorescence signal as a miniature magnet detector. The incident light needs to change direction to illuminate the NV center. The grating coupler has the beam steering capability with phase changing.

The refractive index of SiN is around 2. SiN can also transmit green light [1]. In this research, we design SiN grating coupler to achieve 2D beam steering by using FDTD technique [2]. The relationship between coupler performance and design parameters of this grating coupler will be discussed in detail.

2. Device structure and computational method

Figure 1 shows the model of the SiN phased array grating coupler. When the reflected angle θ =0°, the pitch(Λ) of the grating at 0.34 μm is calculated based on following equation (1) [3].

$$\sin\theta = \frac{n_{eff} - m\lambda/\Lambda}{n_{clad}} \quad (1), \qquad \sin\alpha = \frac{2\pi d}{\lambda\Delta\varphi} \quad (2)$$

The equation (2) means the phase shift angle α, the model can achieve the α and θ steering called 2D beam steering.

3. Simulation Results

To achieve beam steering: One is changing ambient temperature, the refractive index of material will be changed by less than 0.02 for each 100K [4]. If temperature changed from 300K-400K, the reflected angle will be deflected from -0.95° to -0.92°. The other is that the changing wavelength from 500-550 nm. Figure 2 shows the image of the intensity at 300K changed by wavelength. the angle is changed from 3.18° to -3.88°. Figure 3 shows the relationship between temperature and wavelength of the reflected angle. The wavelength changed at the 50 nm level will achieve almost 7° of beam steering. Figure 4 shows the dependence of phase changed from 0 to $\pi/8$ based on equation (2). The result of α is the shift from 0° to 1.91°.

4. Conclusion

In this research, the grating coupler is used to solve the problem of optical deflection angle on a small magnetic device. The 8 MMIs connect the 16 phase array grating couplers could achieve 2D beam steering.

References
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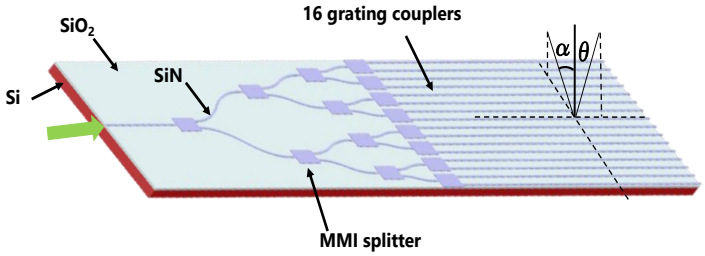

Fig. 1 The total model of phased array grating coupler.

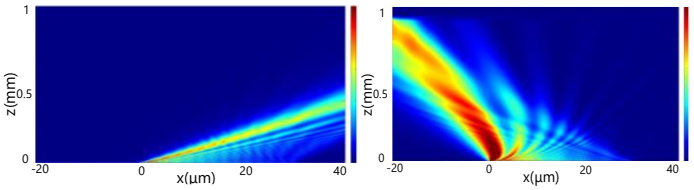

Fig. 2 The reflected angle of wavelength at 300K.
(a)λ=500nm, θ=3.18° (b)λ=550nm, θ= -3.88°.

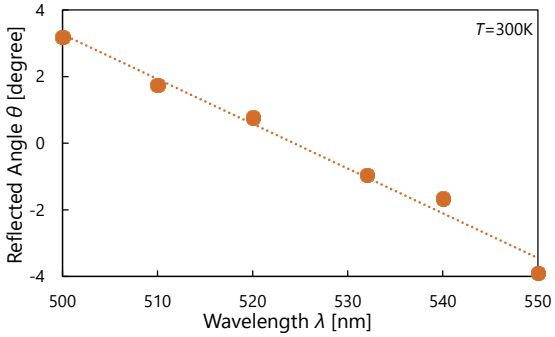

Fig. 3 Wavelength dependence of reflected angle.

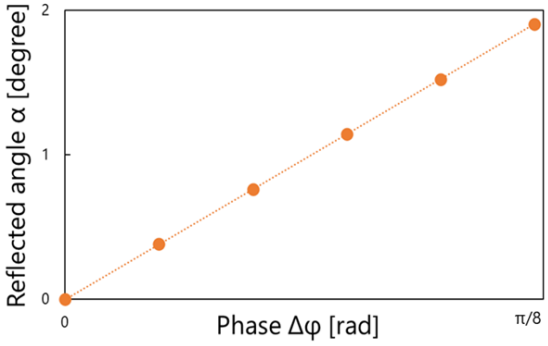

Fig.4 Phase changed dependence of reflected angle.