A Multi-Channel Tunable Periodic Narrowband Filter Chip Composed of Cascaded Silicon Nitride Microring Resonators

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INTRODUCTION

A multi-channel tunable periodic narrow band filter chip composed of cascaded silicon nitride micro-ring resonators (MRR) is proposed and implemented in this paper. We have assembled eight MRRs with the same structure on a silicon based chip with a size of 9mm*1.8mm. The waveguide material is silicon nitride with low transmission loss, and its transmission loss is about 0.2dB/cm. The central wavelength of the MRR can be tuned by thermal-optical effect. The experimental results show that the FSR is about 260GHz, the channel's 3dB bandwidth range is 0.78-1.33GHz, the thermal modulation coefficient is about 0.33GHz/mW, and the central frequency tuning range is about 60GHz. The chip has the following features, including multi-channel, narrow bandwidth and wide tuning range, which can be used in microwave photonic system instead of traditional optical filters.

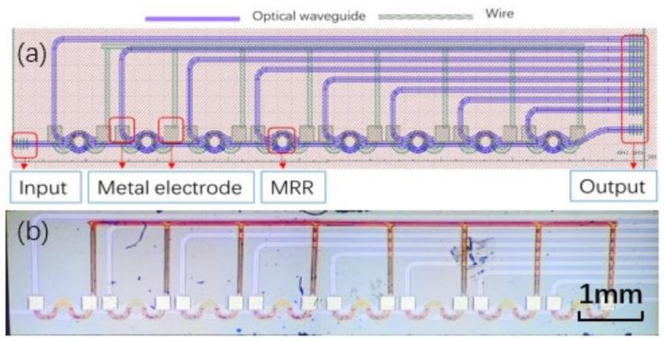

Fig. 1 (a) Design layout (b) Micrograph

PRINCIPLE

MRR is an interference device with four ports called input, through, add and drop. The principle of the MRR is based on the interference principle. The light which conforms to interference condition in the MRR is output from the drop port, so as to realize the function of wavelength selection. Light which is not selected is output directly from the through port.

SIMULATION

The spectral response of through port and drop port is as follows.

$$T=\frac{t-at\exp(j\theta)}{1-at^2\exp(j\theta)} \quad (1)$$

$$D=\frac{-k^2a^{1/2}\exp(j\theta/2)}{1-at^2\exp(j\theta)} \quad (2)$$

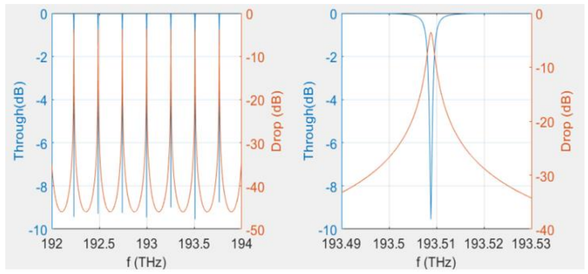

Fig. 2 The simulated spectral response.

RESULTS

In Fig. 3, the spectral response is periodic with many resonance peaks. The FSR is about 260GHz. In Fig. 4(a), it can be seen that the spectral response is of Lorentz type.

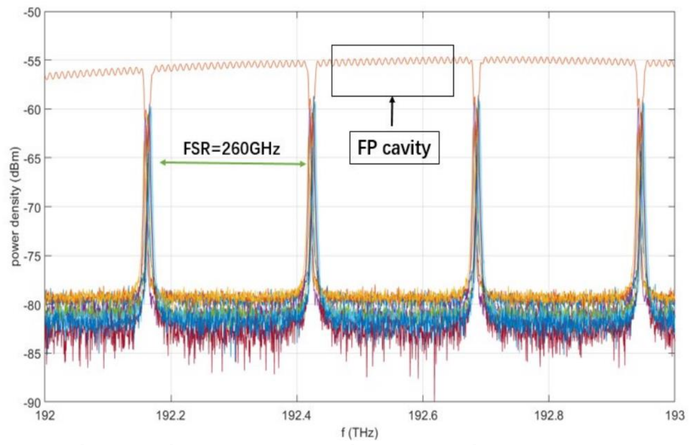

Fig. 3 The measured spectral response.

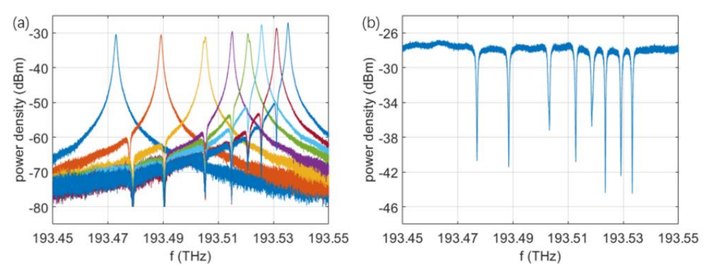

Fig. 4 Detail of measured responses (a) Through (b) Drop.

Table. 1 3dB bandwidth and center frequency.

Channel	*3dB bandwidth /GHz*	*Center frequency /THz*
1	0.857	193.47291
2	0.864	193.48922
3	1.329	193.50535
4	0.842	193.51503
5	1.267	193.52071
6	0.832	193.52571
7	0.964	193.53105
8	0.758	193.53526

The thermo-optic tuning ability of the micro-rings is tested. the shift of the resonant frequency of the micro-ring is about 60GHz.

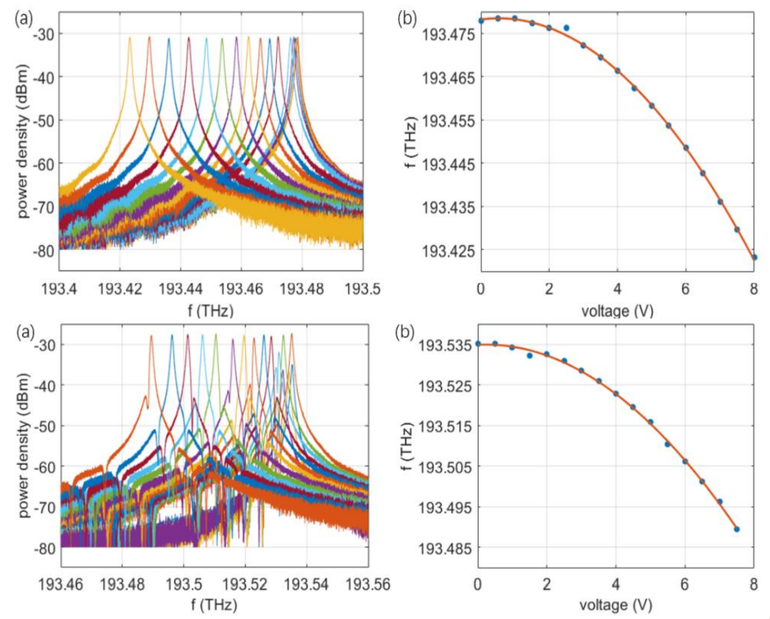

Fig. 5 (a) The spectrum (b) The relationship between spectral drift and voltage

CONCLUSIONS

- **FSR**:**260GHz**
- **3dB bandwidth**:**0.78-1.33GHz**
- **Thermal coefficient**:**0.33GHz/mW**
- **Tuning range**:**60GHz**

A multi-channel tunable periodic narrowband filter chip composed of cascaded silicon nitride micro-ring resonators is proposed and implemented in this paper. The chip has the following features, including multi-channel, narrow bandwidth and wide tuning range, which can be used in microwave photonic links instead of traditional optical filters.