Add drop optical filter based on tandem and multi ring resonators

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A new filter suitable for integrated optics is proposed. Pass band loss is very low. Pass band can be designed for narrow-width or wide-width according to requirement. Stop bandwidth can be also designed. A new method to make sharp cutoff characteristics is proposed.

1. Introduction

In DWDM systems several type optical filters are used. In near future DWDM system technologies may be used not only for trunk line but also for LAN and access line systems. At that time optical filters must be small such as laser diode and expect to be produced using optical integrated technology. From the viewpoint of characteristics, narrow and wide pass band- width, low pass band loss, sharp cutoff and wide cutoff bandwidth are expected

Coupled resonance filter can produce flat pass-band has been reported [1]. Wide-FSR of coupled ring resonator has also reported [2]. . Some investigation about wave guide-coupled micro ring resonators has been reported also [3].

Recently semiconductor process technologies are progressing very rapidly. Micro ring optical resonators may be possible in near future. This filter consists of two parts. One is a main filter and another one is a sub filter as shown in Fig.1. The main filter is constructed with three rings connected by directional coupler. Sub filter is constructed with two rings cogs.

2. Main filter characteristics

Main filter characteristics from drop port 1 are shown in Fig.2. There can be seen two kind of FSR. FSR1 corresponds to large ring resonance and FSR2 corresponds to small ring resonance. FSR2 decides frequency range of this filter. If wide frequency range is necessary, smaller

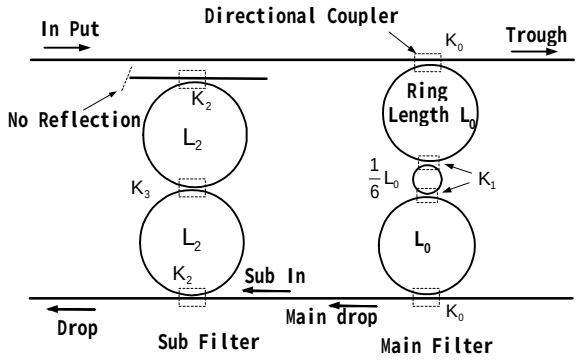

Fig.1 Proposed filter structure

ring is required. Pass-band of through port is very wide, which nearly corresponds to FSR2. One round ring optical length nL0 is 300um, so the FSR1 is 1THz and FSR2 is 6THz as shown in Fig.2.

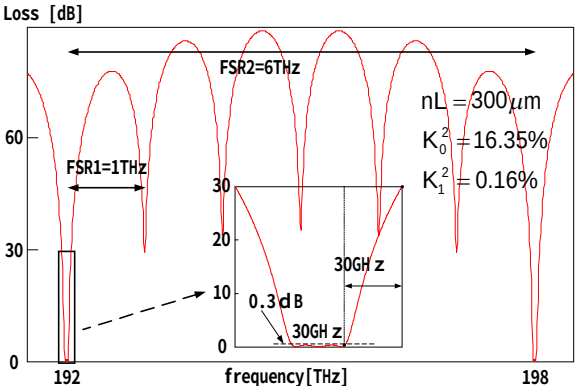

Fig.2 Main filter characteristics at the main drop port

Main filter characteristics are discussed next. Power transfer ratio of directional coupler mast is selected proper value. Pass band loss, pass bandwidth and cutoff characteristics all are related to FSR and power transfer ratio of directional couplers. These relations are shown in Fig.3. In this figure, 3 areas such as A, B and C are shown. Pass band- width and 30dB cutoff characteristics are normalized to FSR1. Area A corresponds to narrow pass band filter. Area B corresponds to wide pass band filter. In each area, pass-band loss becomes lower according to K_0 value. But on the other hand, cutoff characteristics become bad according to K_0 value. Filter characteristics shown in Fig.2 correspond to area C. Calculated pass band loss is less than 0.3dB and pass bandwidth is 30GHz. Cutoff characteristic is obtained as 30GHz /30dB.

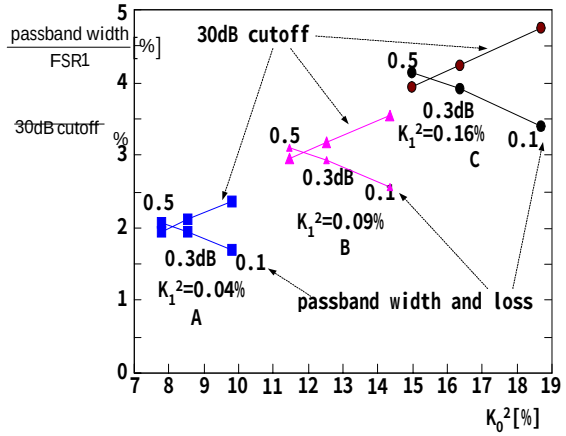

Fig.3 Passband width and 30dB cutoff characteristics

3. Sub filter characteristics

Sub filter plays on important part to make sharp cutoff characteristics of this filter. There are two methods to design a sub filter. One is to select a ring size of the sub filter the same as that of the main filter large ring. And power transfer ratio is selected as larger value. According to K_3, coupled-ring resonance frequency changes from f_0 to f_1 and f_2. If these resonant frequencies f_1 and f_2 are set outside of main filter pass-band, very high loss appears at the sub filter from sub-in port to drop port. Two areas required for main and sub filter are almost the same. This point may be an advantage of this method. But frequency ranges of higher loss near frequencies f_1 and f_2 become narrow. This point may be a disadvantage of this method.

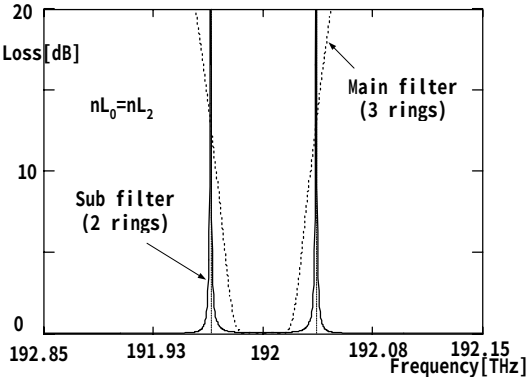

Fig.4 Main filter and sub filter (Method 1)

Second method is to select large size ring compared to main filter ring L_0. Resonant frequencies appear very frequently. FSR becomes small value. Resonant frequencies of sub filter mast be set up just outside of main filter pass-band. It is shown in Fig.5. In this case sub filter loss from sub-in port to drop port becomes very high.

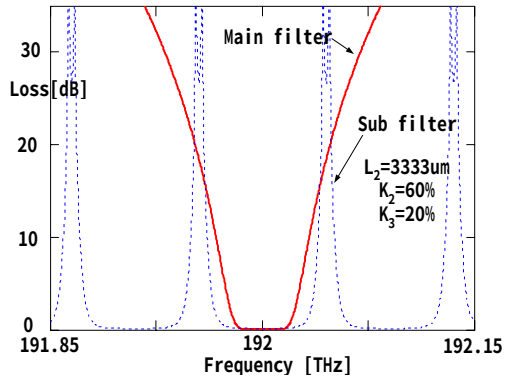

Fig.5 Main filter and sub filter(Method 2)

4. Filter characteristics of the proposed filter

Output from the main filter goes through the sub filter. In the area of main filter pass-band, sub filter loss is very low. Pass band loss of sub filter is very small. Total loss does not increase in the area of pass band. Very high loss areas exist just outside from the pass band. As a result very sharp cutoff characteristics are obtained.

In Fig.6, output characteristics from drop port are shown around the pass band. In this case sub filter is designed using the method 1. Solid line shows out put from the drop port and dotted line shows the output from the main filter. Improvement of cutoff characteristics can be seen, but it is not so remarkable.

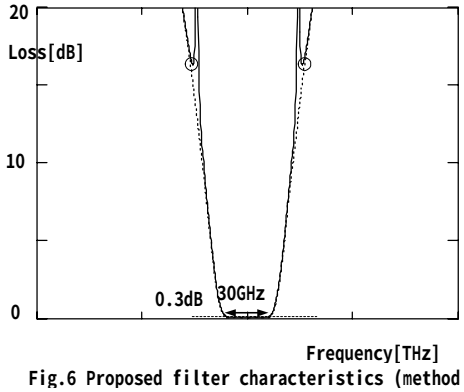

Fig.6 Proposed filter characteristics (method 1)

Next a result where sub filter is designed using method 2 is shown in Fig.7. Solid line shows output from the drop port and dotted line shows the output from the main filter also. Remarkable improvement of cutoff characteristics can be seen. At 26dB loss point, cutoff characteristics become sharp almost twice.

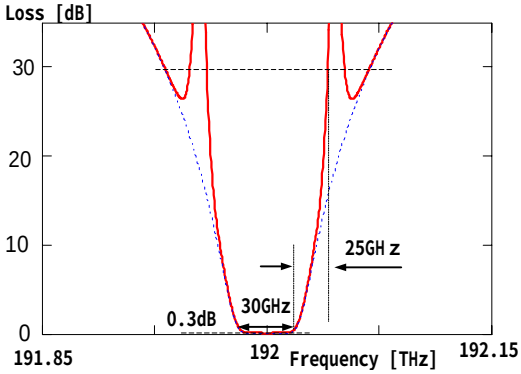

Fig.7 Proposed filter characteristics(method 2)

5. Conclusion

A sharp cutoff optical filter is proposed. Pass bandwidth can be designed according to requests. Components of this filter are ring resonators, so this filter can be made using optical wave-guide technology. But ring radius becomes very small. So semiconductor such as InP material is necessary. And very fine process technology is also necessary. Recently some experiments about micro-ring optical resonators are reported. Very compact optical filter like this may be possible.

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