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Fabry-perot cavity array based on-chip waveguide spectrometer

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Motivation & Introduction

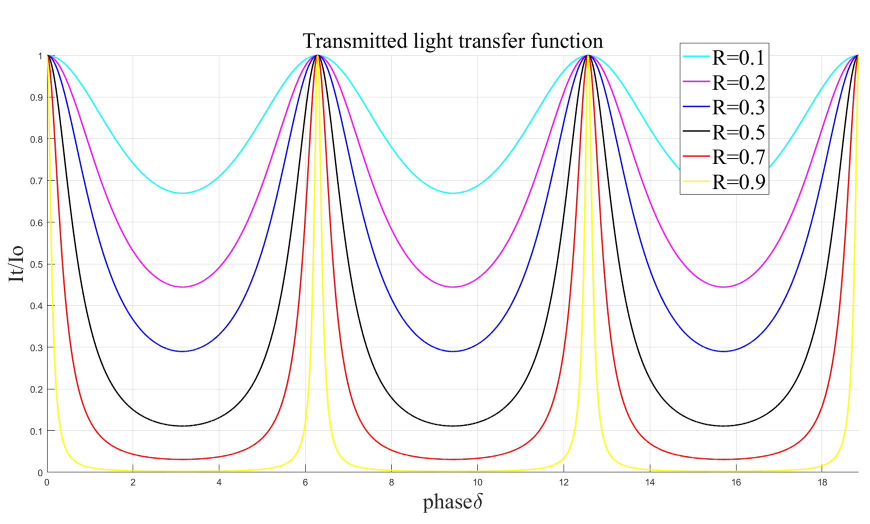
Spectrometer is widely used in daily production and life. Compared with other types of spectrometers, Fourier transform spectrometer (FTS) has the advantages of multi-channel, high radiation flux and accurate wave number. It has good potential in spectral analysis. In addition to detecting solid, liquid and gas samples, FTS can also analyze organic and inorganic substances, polymers and coordination compounds, not only qualitatively but also quantitatively

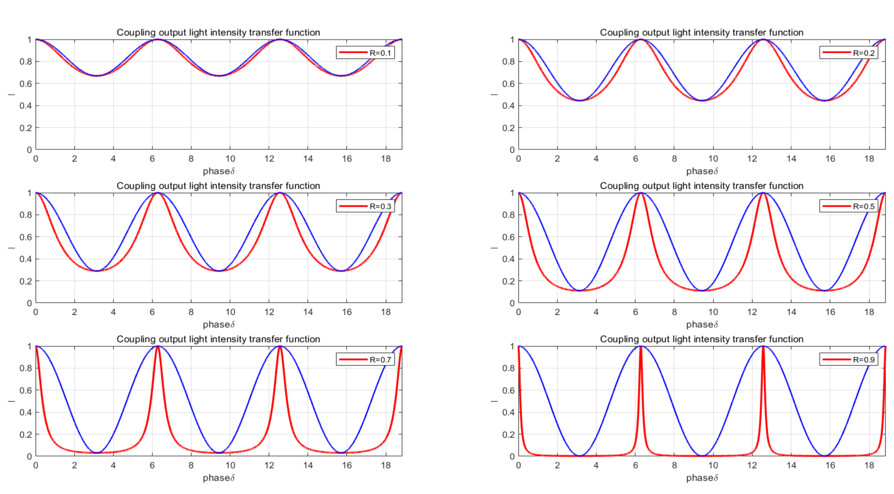
Raman spectroscopy can realize the accurate identification of substances and molecules, so it is widely used in the field of sensing and detection. At present, commercial Raman spectrometers are based on spatial optics, which has large volume and high cost, which limits their further popularization and application. Raman spectrometer chip can be made by using integrated optical technology, which can not only realize small-size and low-cost Raman spectrum analysis scheme, but also embed it into various mobile intelligent terminals (such as mobile phones, smart watches, etc.), and make full use of the data retrieval, analysis and interaction capabilities of mobile intelligent terminals to meet the needs of real-time and field Raman spectrum analysis.

Design & Fabrication

Structural design

$$I = \left| \frac{tt'}{1 - r'^2 \exp(i\delta)} \right|^2 \times I^{(i)}$$





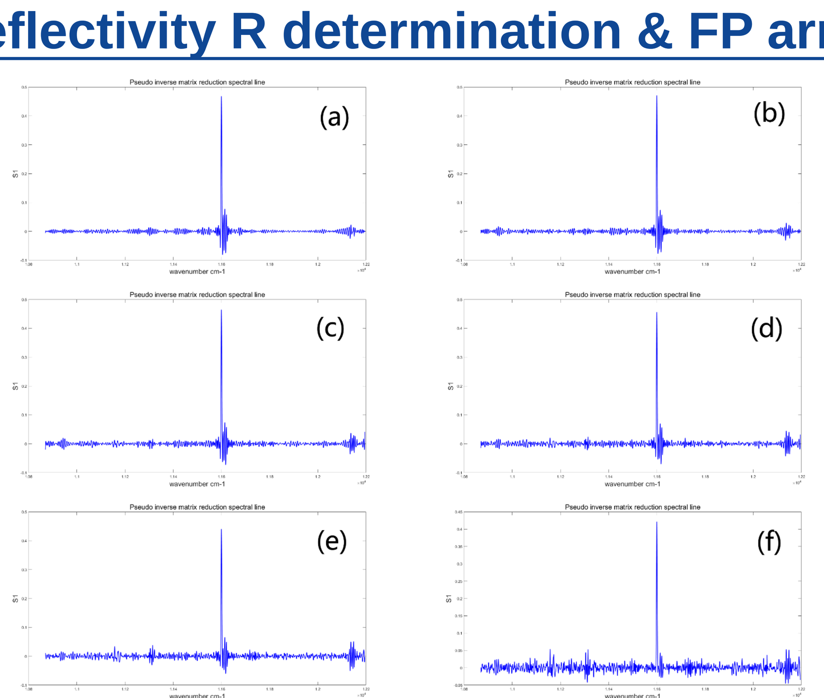
Let r = r', then there is also t = t', the reflectivity of each FP cavity wall is R = r2, and the variation of FP cavity output light intensity corresponding to different r with phase.

Compared with the original scheme, the light output with the same contrast has similar sinusoidal correlation, which also means that it has similar spectral reduction characteristics of the spectrometer.

we try to select the case where R is relatively small, that is, when the output spectral curve of FP cavity is close to the sinusoidal function curve, so that R is between 0.1 and 0.2.

Inverse designed OSUs & Discussions

Reflectivity R determination & FP array parameter determination



In order to improve the performance and reliability of filtering noise by digital filter, we try to select the case where R is relatively small, that is, when the output spectral curve of FP cavity is close to the sinusoidal function curve, so that R is between 0.1 and 0.2.

σ=1/2ngΔLmax

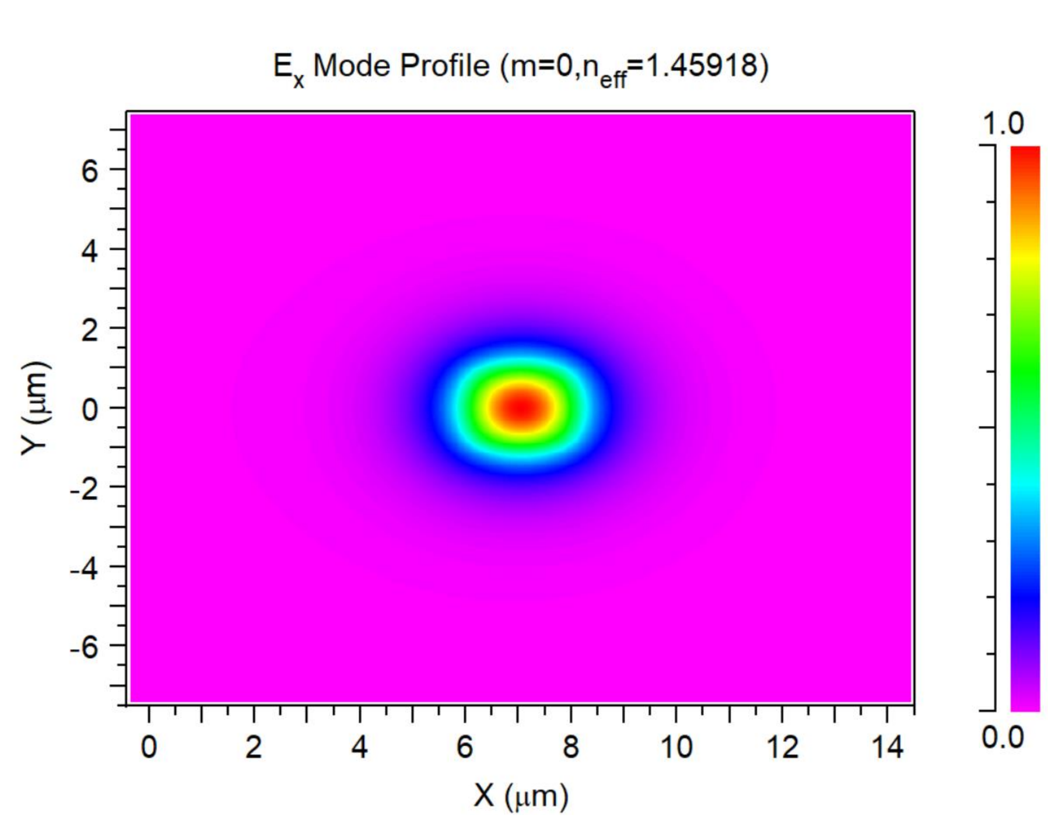
λ=λ02/2ngΔLmax

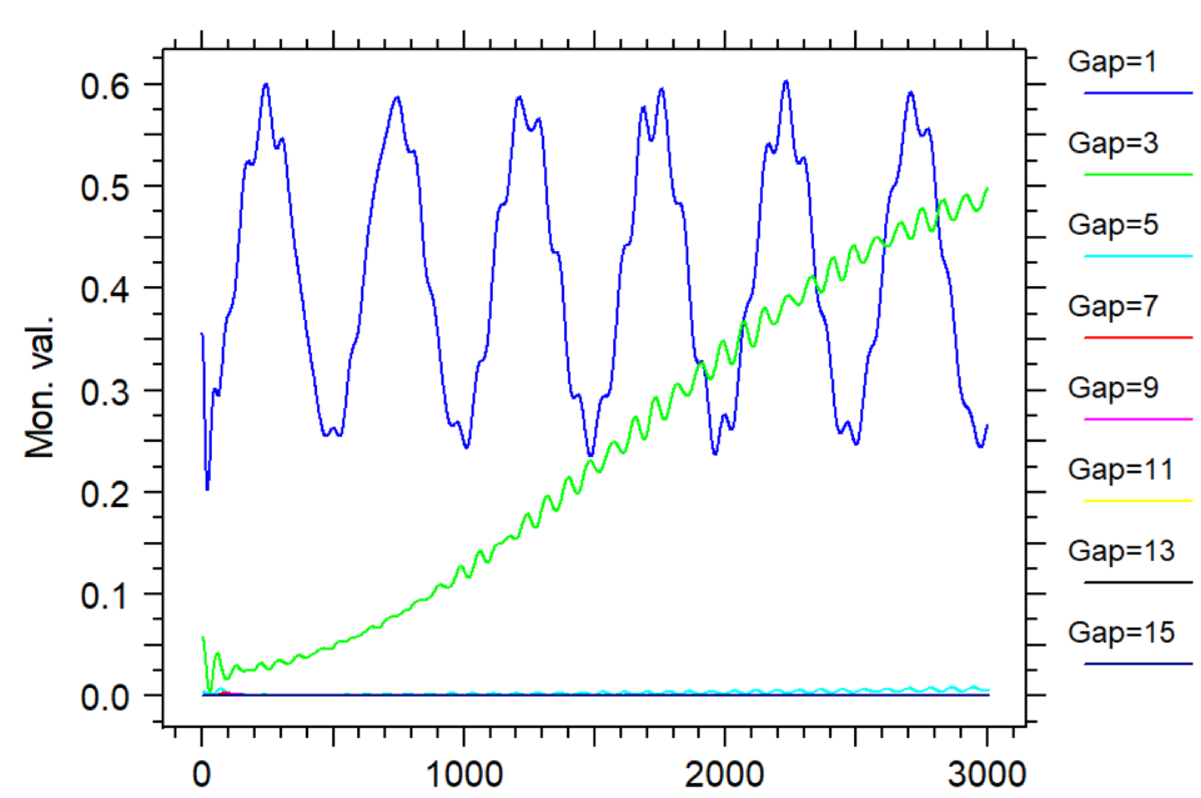
FSR=Nλ02/2ngΔLmax

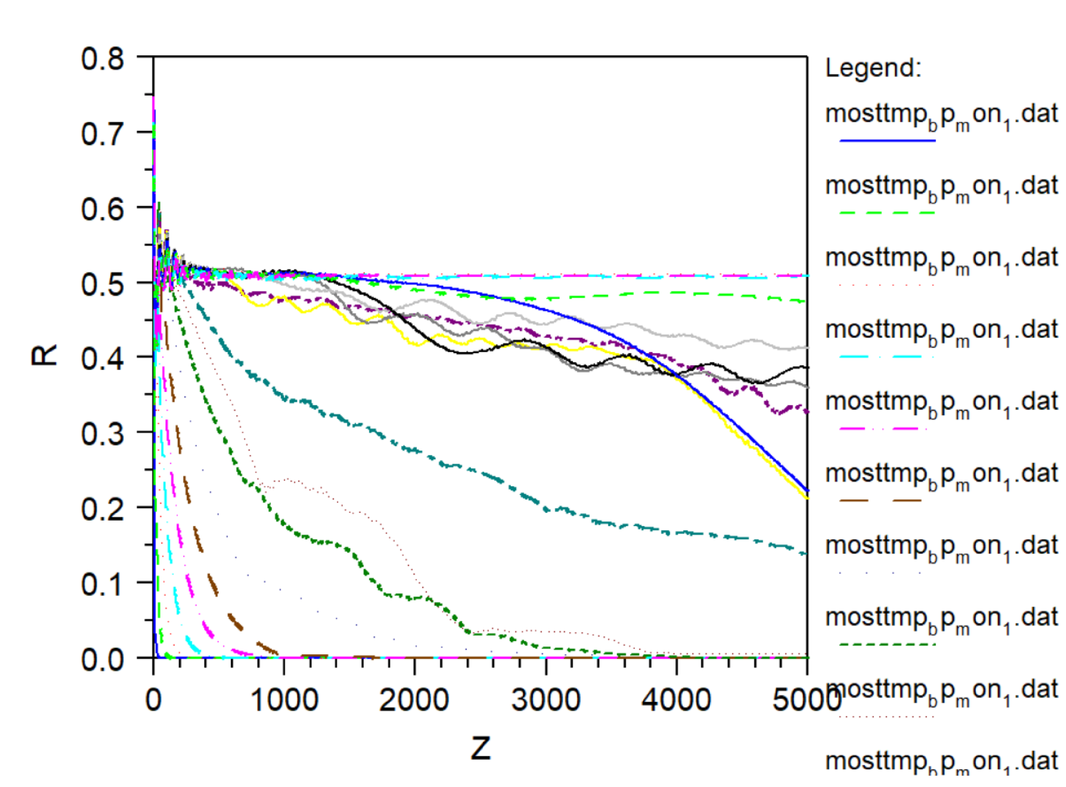
The target spectral resolution of the project is less than 5 cm-1, the spectral range is 600-1800 cm-1, and the excitation wavelengths are 785 nm and 830 nm.

Because the ratio between FSR and spectral resolution is equal to the number of FP arrays N. Then the number n of FP cavities is about 240. From this, we can obtain ΔL is about 2.7um.

Waveguide Design





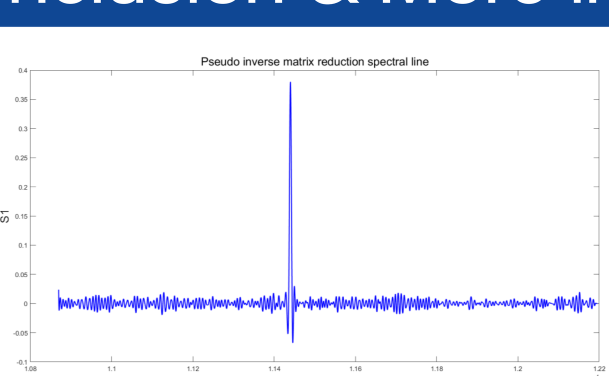


When the bending radius is greater than 900um, the bending loss is less than 0.001db/cm, so we make the minimum bending radius 900um.

When N is 341, ΔL is 0.7 um and the input wave number is 1.144 * 104 cm-1, we can obtain the reduction spectrum through the pseudo inverse matrix.

Conclusion & More information

- ✓ The information detection in the spectral range 600 ~ 1800cm-1
- ✓ Resolution 5cm-1
- ✓ The size of the device 0.4cm2



In the actual calculation, we also need to further filter the original reduction spectrum to eliminate the spectral noise as much as possible to meet our required signal-to-noise ratio requirements, but at the same time, it will also lead to the broadening of the reduction spectrum waveform, usually 1.5-2 times, so the number of corresponding FP cavities should also be doubled.