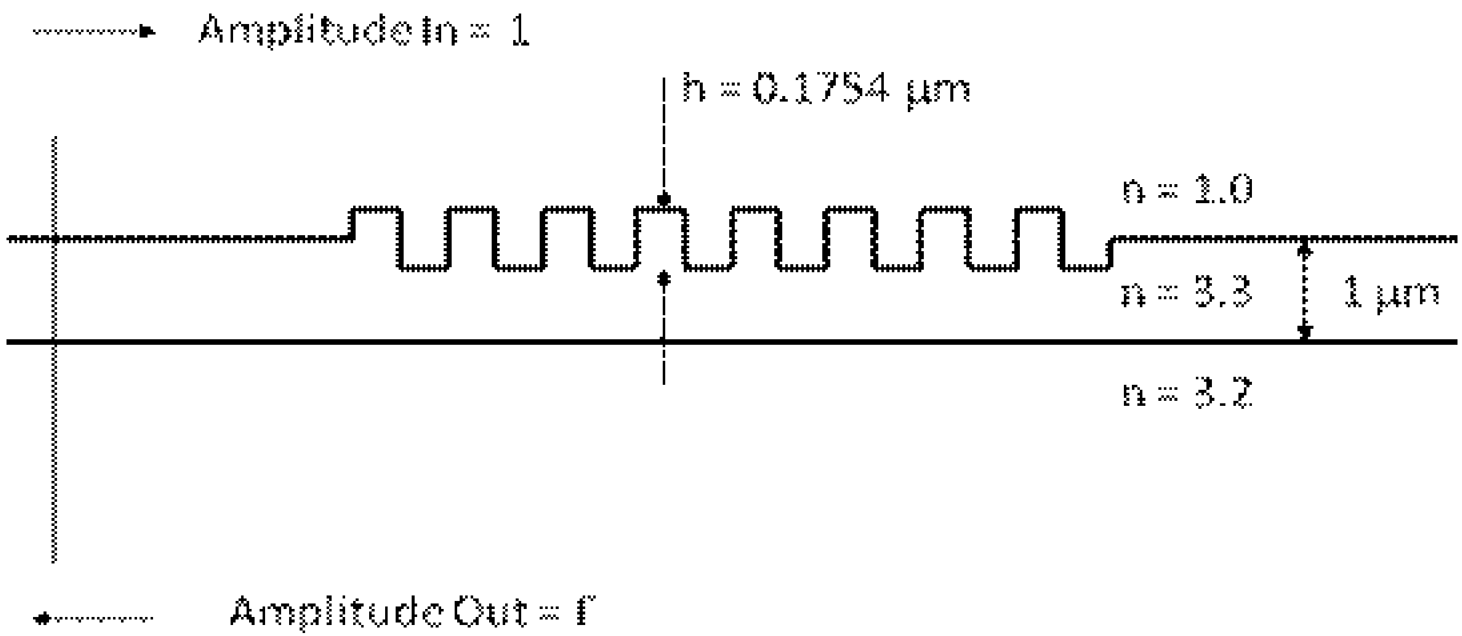
Flat-topped Transmission Gratings

This application example shows one way of making a flat-topped pass-band from gratings, operating in transmission mode. The desired transmission spectrum can be made from phase-shifted Bragg grating filters. All simulations and display of results is done with OptiGrating.

In the paper of Ref. 1, the authors note that standard Bragg reflectors have a flat-topped stop-band, and that this is convenient for isolating an optical communication channel. However, the Bragg reflector works in reflection. The authors wanted a structure that would work in transmission mode instead. The usual way to get a transmission at a single wavelength is by using a pair of Bragg gratings – the Fabry-Perot etalon. However, the etalon often makes a transmission peak that is too narrow for broad-band optical communications. In this application example, we follow the solution proposed in Ref. 1, and reproduce the results.



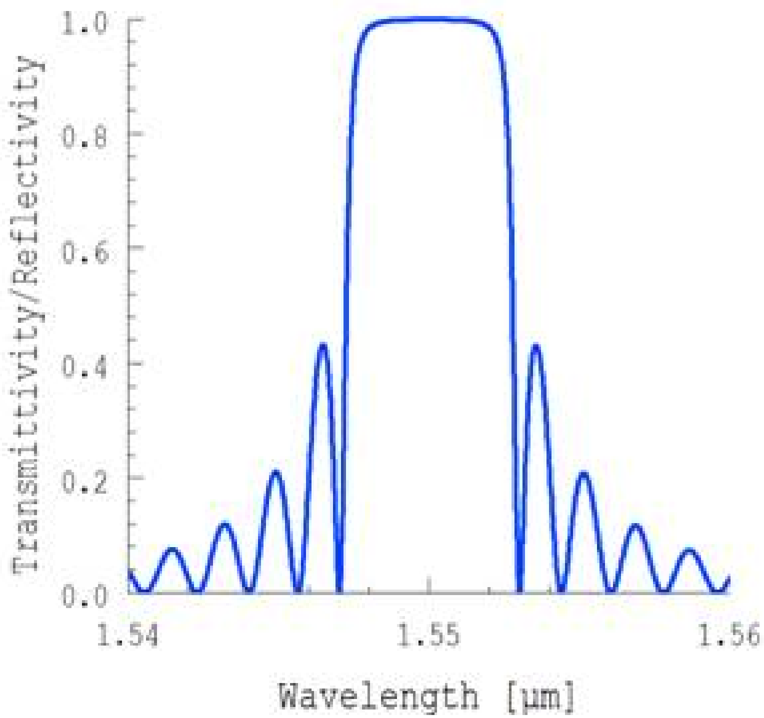


Fig. 1 Left: Surface Grating in InP waveguide. Right: Reflectivity spectrum, note the flat-topped stop-band

First the waveguide data is entered in the waveguide profile dialog box of OptiGrating to specify layer width and refractive index of each layer. The location of the grating can also be selected. Next the modes of the waveguide are found, and the parameters of the grating specified by grating length, height of surface relief, period, and shape of the modulation within each period (this grating has a rectangular shape).

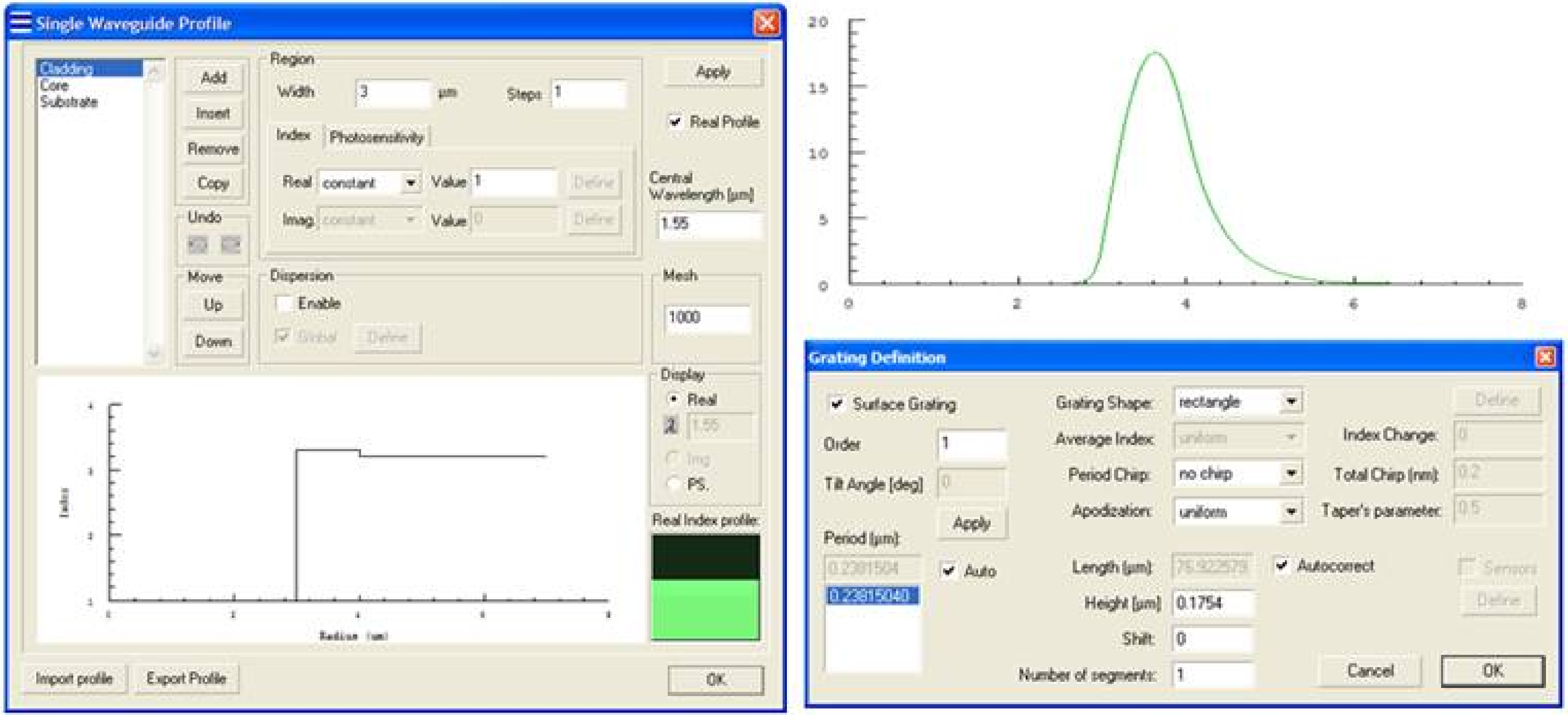


Fig. 2, Specification of waveguide and grating.

A grating with pass-band transmission can be made by putting two gratings in series, with a p/2 phase shift between them. The resonance found at the centre wavelength creates high optical intensity between the gratings. The high intensity permits transmission across a structure that would otherwise be highly reflective.

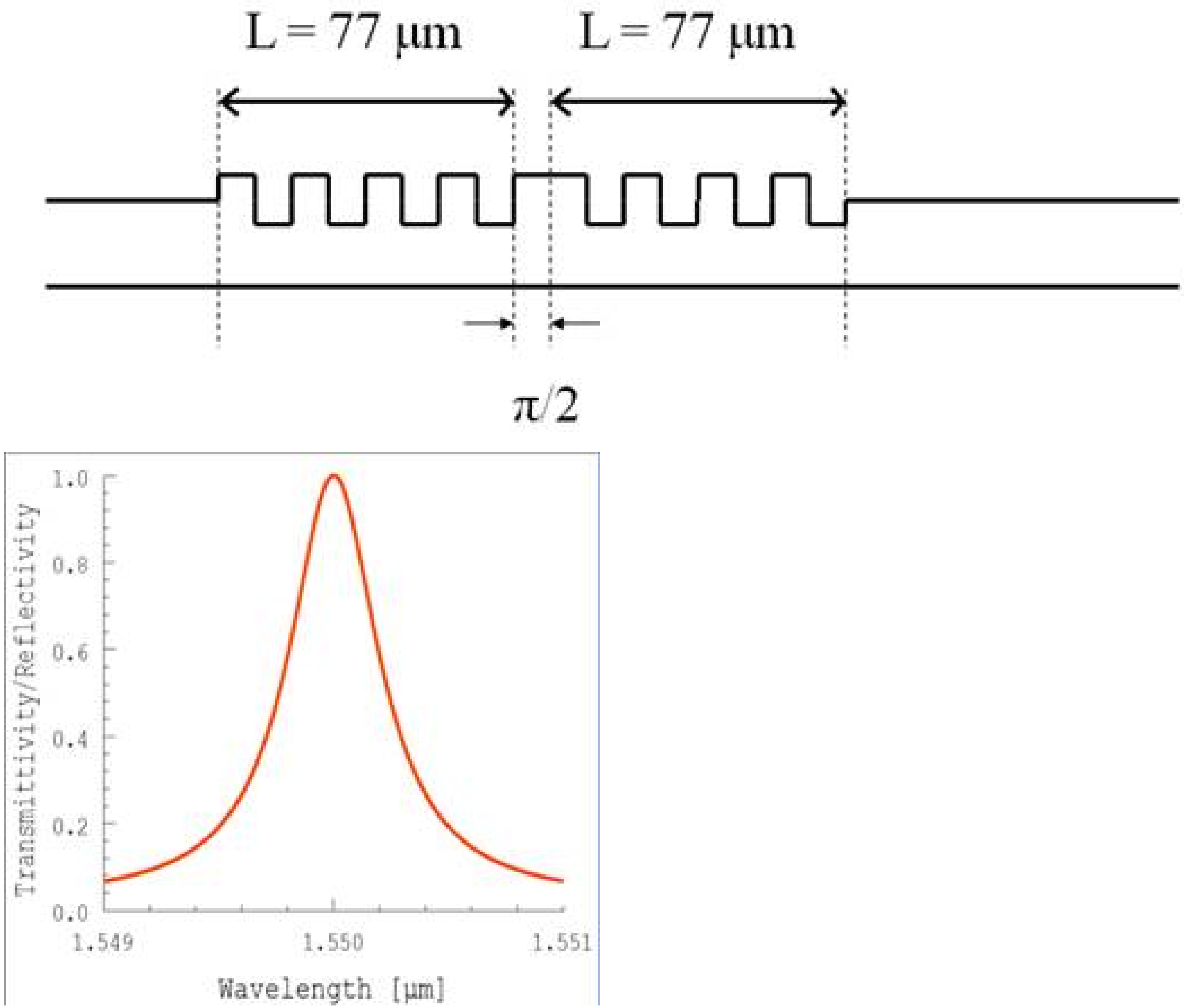
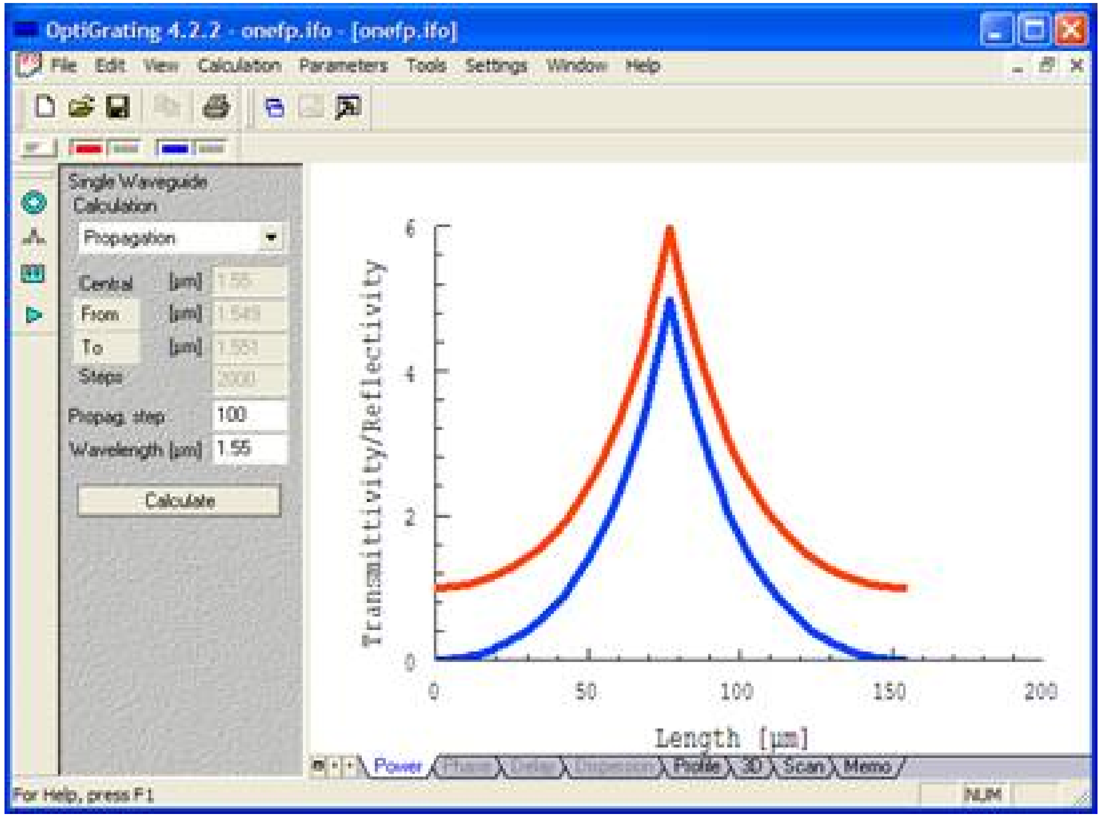


Fig. 3, The Fabry-Perot configuration consists of two gratings in series, with a p / 2 phase shift between them. Shown on the right is the transmission spectrum.

As well as spectrum, OptiGrating can show the optical fields along the length of the grating. In Fig. 4, the fields are shown, decomposed into right and left travelling waves. The field pattern is shown for light at the resonance (1.550 mm) and off resonance (1.549 mm). This demonstrates the physical mechanism behind the sharp transmission peak.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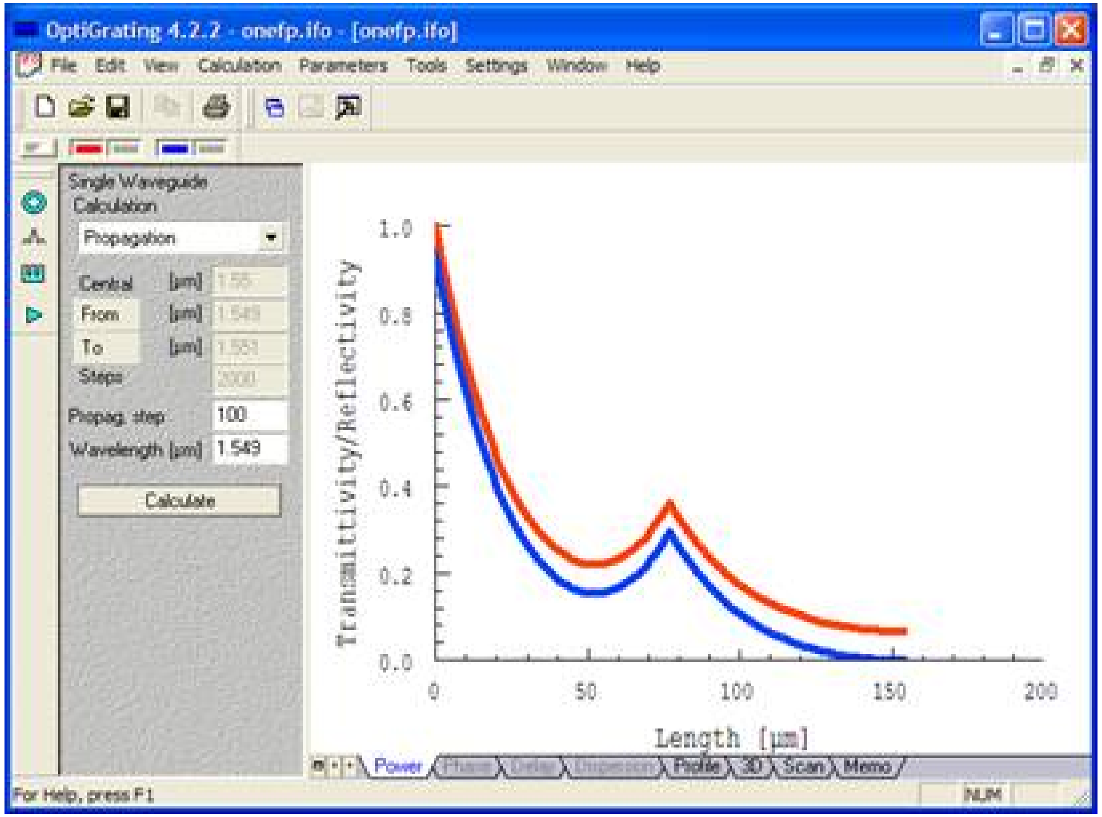


Fig. 4, Propagation picture for the series grating of Fig. 3. Right travelling amplitudes in red, left travelling in blue. The Wavelength field indicates the wavelength of the light in each simulation, 1.550 mm on the left (resonance), 1.549 mm on the right (off-resonance).

A suitable figure of merit for the flat-top is the ratio of bandwidth at a transmission of -1 dB to the bandwidth at -10 dB. In the ideal filter this ratio would be 1. For the two-grating system of Fig. 3, this ratio is only 0.16

$$s = \frac{B_{-1\,dB}}{B_{-10\,dB}} = 0.16$$

There is a way to broaden the peak. It is a well known property of resonant systems, that if two identical systems are brought together such that their fields start to interact, the single resonance will split into two. The two new resonances occur at wavelengths slightly below and slightly above the original, having a broadening effect. Two Fabry-Perot gratings of the kind in Fig. 3 are put in series, as shown in Fig. 5

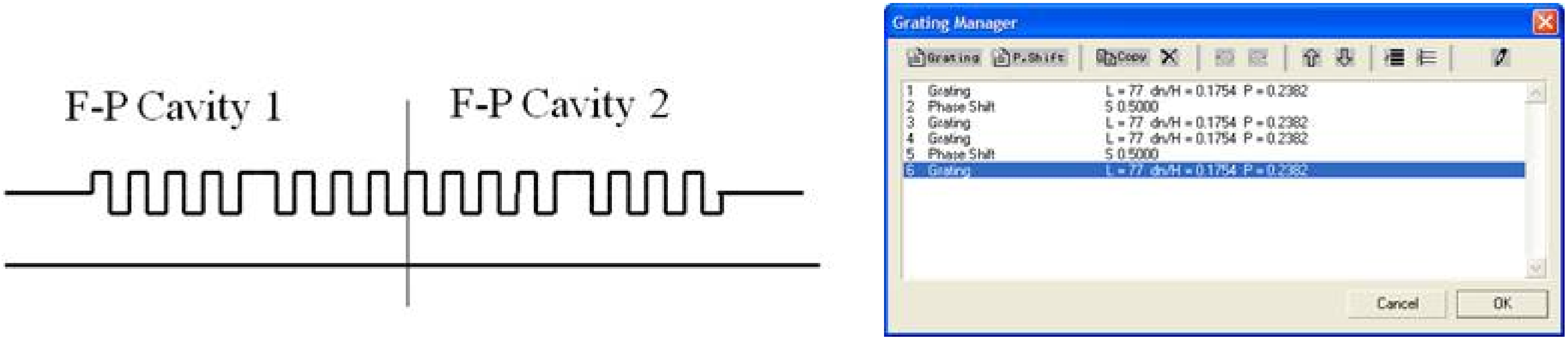
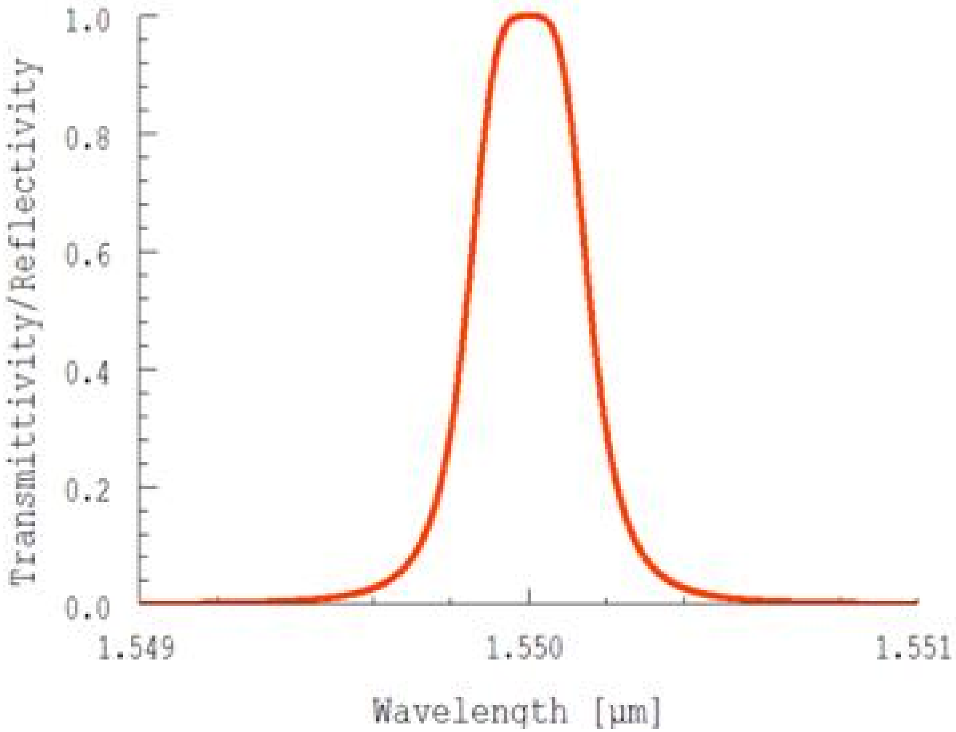


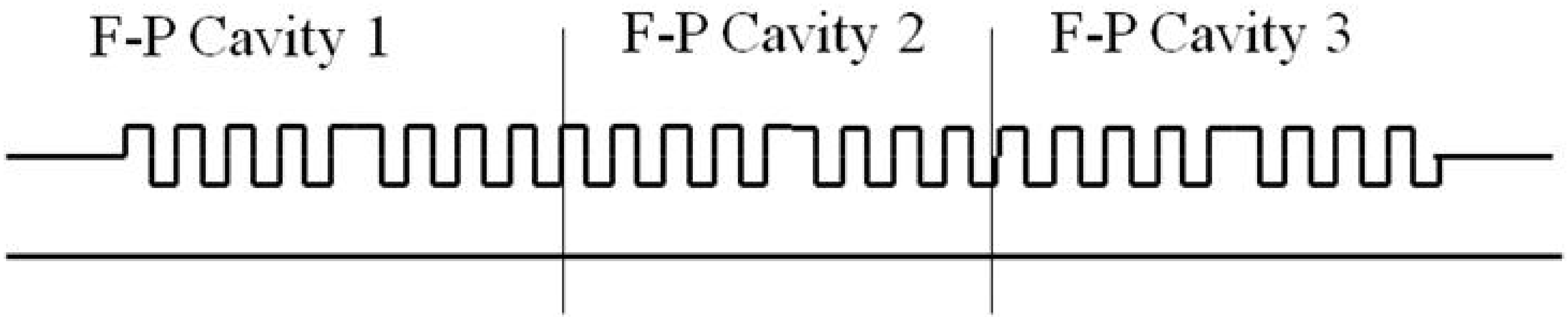
Fig. 5, Two Fabry-Perot gratings in series. The gratings and phase shifts are specified as a list in the Grating Manager of OptiGrating.

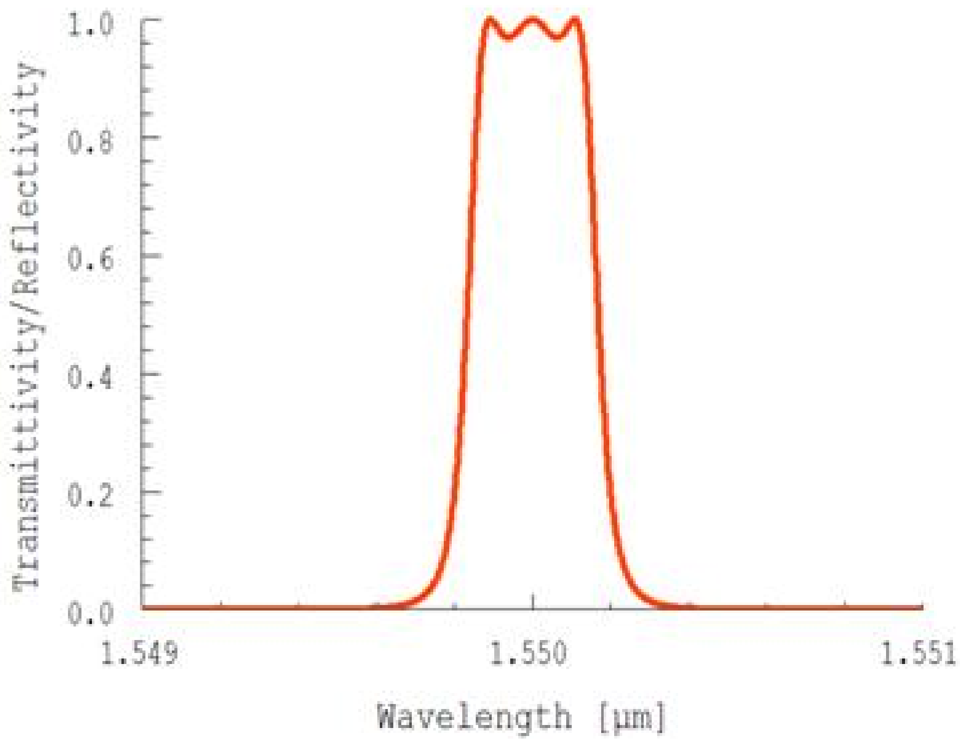


$$s = \frac{B_{-1dB}}{B_{-10dB}} = 0.4$$

Fig. 6, Transmission Spectrum of Grating of Fig. 5. Note the flat peak of the spectrum, and improvement in the figure of merit.

By adding a third identical resonator, there are now three resonances that participate, flattening the filter response more.





$$s = \frac{B_{-1dB}}{B_{-10dB}} = 0.65$$

Fig 7, Three Fabry-Perot resonators in series, spectrum, and passband figure of merit

Another feature of OptiGrating is an integrated tool for analysis of bandwidth, calculation of numerical values of peak position and sidelobes, and gainslopes.

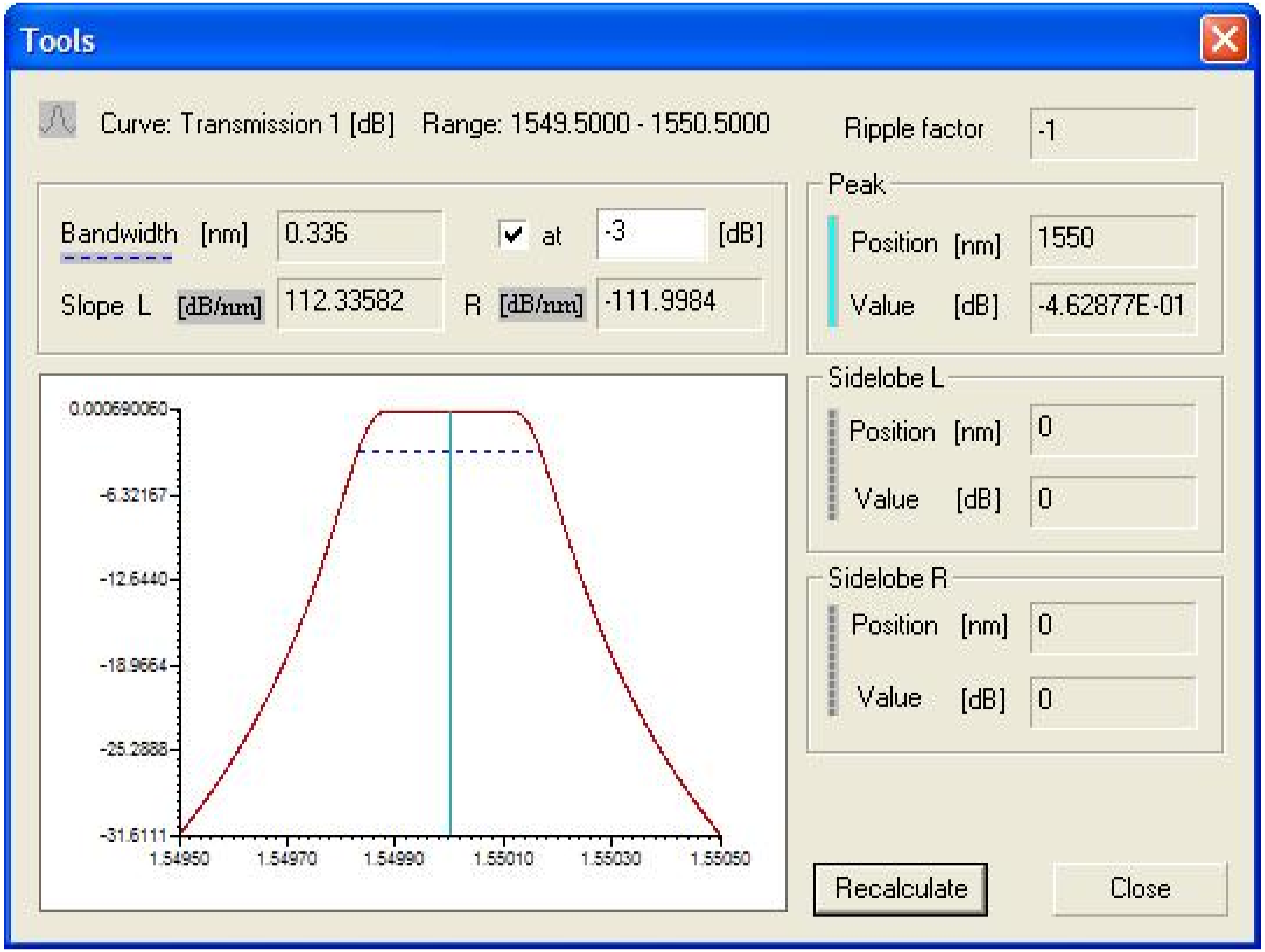


Fig. 8, OptiGrating Analysis of spectrum of Fig. 7. -3 dB bandwidth = 0.336 nm, with gainslopes of 112 dB/nm.

Reference

1. Remigius Zengerle and Ottokar Leminger, Journal of Lightwave Technology, Vol. 13, No. 12, p2354-2358 (1995)