## Title
A VARIABLE BAND PASS FILTER WITH HIGH REJECTION RATIO FOR RAMAN SCATTERING



## Authors
Huang, Y.
Yu, P.Y.

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# Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

## Materials & Chemical Sciences Division



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Y. Huang and P.Y. Yu

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# A Variable Band Pass Filter with High Rejection Ratio for Raman Scattering

Yihe Huang and Peter Y. Yu

Department of Physics, University of California

and

Materials and Chemical Sciences Division,

Lawrence Berkeley Laboratory, Berkeley, California 94720

Recent advances in the technology of optical multi-channel analyzer ( OMA ) has greaty increased the sensitivity of Raman Scattering.[1,2] However to take advantage of the OMA one has to open fully the intermediate and exit slits of a double monochromator. The resultant stray light rejection ratio may not be sufficient for Raman spectroscopy. One possible solution is to use triple monochromators such as the Triplemate available from Spex Industries. However for most laboratories which have already a double monochromator, a much cheaper solution is to use a filter to remove the elastically scattered laser light. Many different designs for such filter have been suggested such as the interference filter [3], the iodine cell, [4] and various interferometers.[5] These designs are either restricted to only one laser line or too delicate. In this note we describe a relatively inexpensive alternate solution to this problem.

It consists of a double monochromator with subtractive dispersion. The design of this filter is shown in Fig.1. The gratings are off-the-shelf 1200 grooves/mm concave holographic gratings made by J-Y Diffraction Grating Inc. for the Instruments SA Inc Model H-20 monochromators. The second grating is oriented and adjusted to exactly cancel the dispersion of the first grating and hence recombine the spectrum. Both gratings are mounted on translational and rotational stages for ease of alignment. Some of its parameter are listed in the Table 1. The maximum throughput of the filter is about 20% with numerical aperture f/4.

As a test of this filter, we measured the Raman spectrum of an unpolished Si sample. The solid curve in Fig.2 was taken with a cooled RCA C31034 tube and a Spex 1403 double spectrometer. The broken curve was taken with the filter placed before same spectrometer with fully opened intermediate slits and an OMA. The counting time was four time shorter in obtaining the broken curve. The stray light background was completely removed and the two phonon Raman peaks became quite prominent.

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Table 1

| slit B (mm) | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 |
|---|---|---|---|---|---|---|
| bandpass ($cm^{-1}$) | 350 | 300 | 250 | 200 | 150 | 100 |
| rejection ratio | $5x10^{-5}$ | $3x10^{-6}$ | $3x10^{-7}$ | $1x10^{-7}$ | $5x10^{-8}$ | $3x10^{-8}$ |

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2. McWhirter, et al; J. Phys. E: Sci. Instr. 15, 145 (1982).

3. M.C. Tobin, J.Opt.Soc.Amer. 49, 850 (1959).

4. L.L. Chase, J.L. Davis, G.E. Devlin, S.Geschwind. The SPEX SPEAKER XV, No. 3 (1970).

5. K.H.Langley and N.C. Ford, Jr., J.Opt.Soc.Am. 59, 281 (1969).

## FIGURE CAPTIONS

Figure 1: Construction of a variable bandpass filter.

Figure 2: Raman spectrum of an unpolished Si wafer.

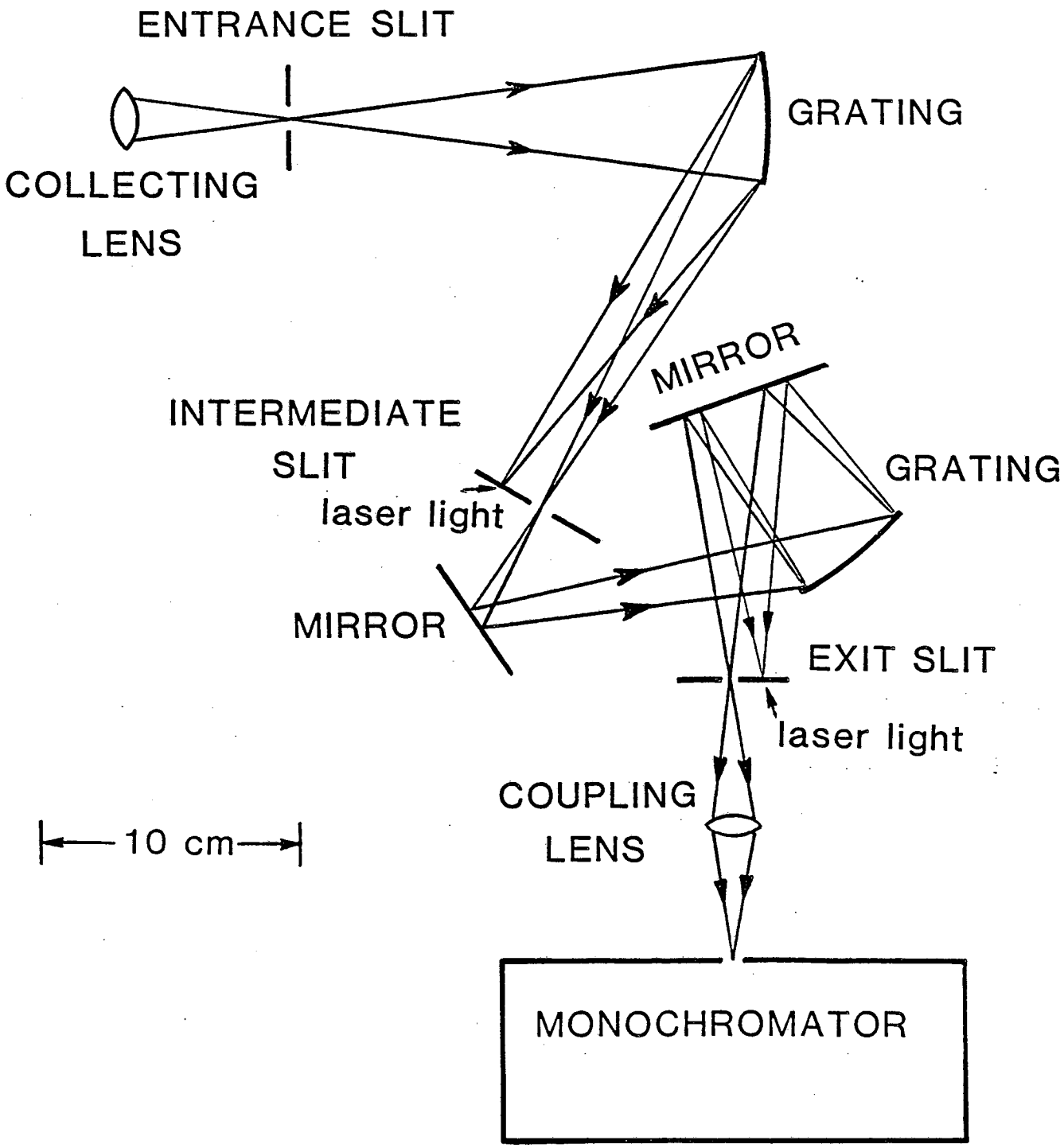
ENTRANCE SLIT
COLLECTING LENS
GRATING
MIRROR
INTERMEDIATE SLIT
laser light
GRATING
MIRROR
EXIT SLIT
laser light
COUPLING LENS
10 cm
MONOCHROMATOR

Figure 1

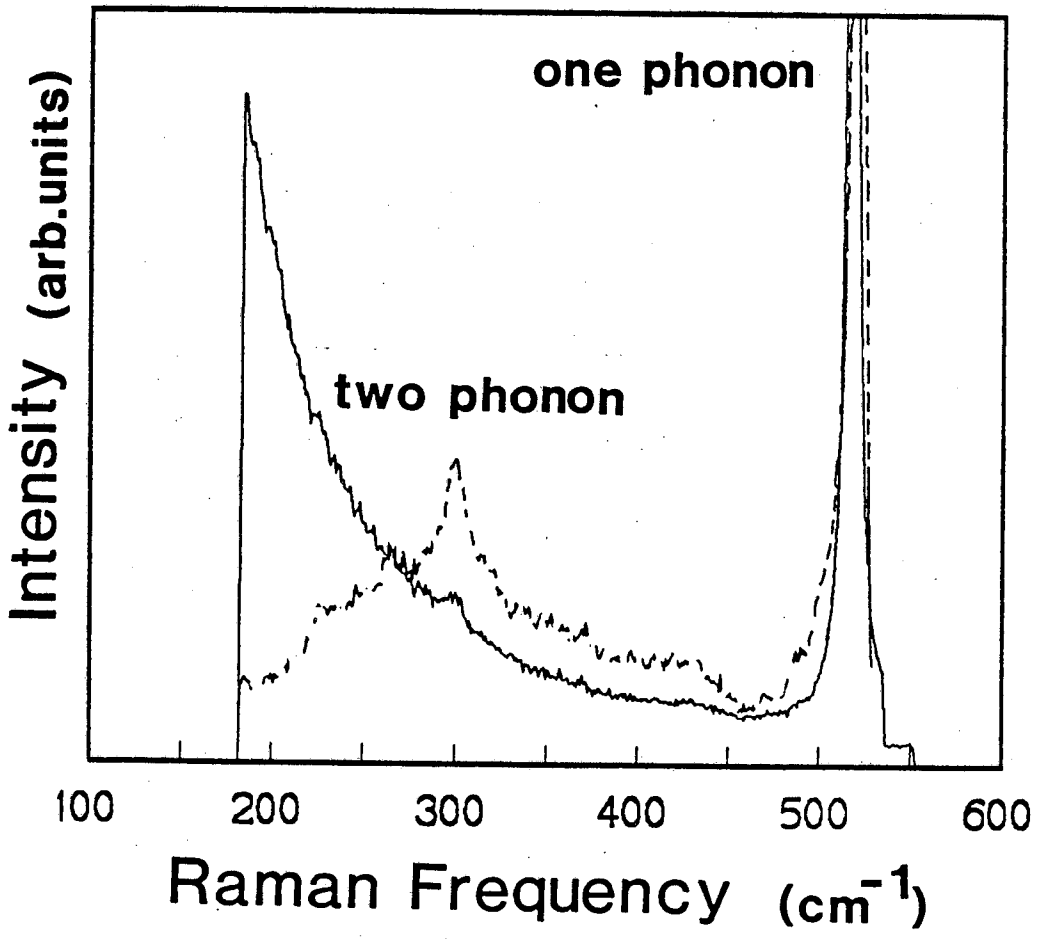
one phonon
two phonon
Intensity (arb.units)
100
200
300
400
500
600
Raman Frequency (cm-1)

Figure 2

*LAWRENCE BERKELEY LABORATORY*
*TECHNICAL INFORMATION DEPARTMENT*
*UNIVERSITY OF CALIFORNIA*
*BERKELEY, CALIFORNIA 94720*