A simple cryostat for optical measurement

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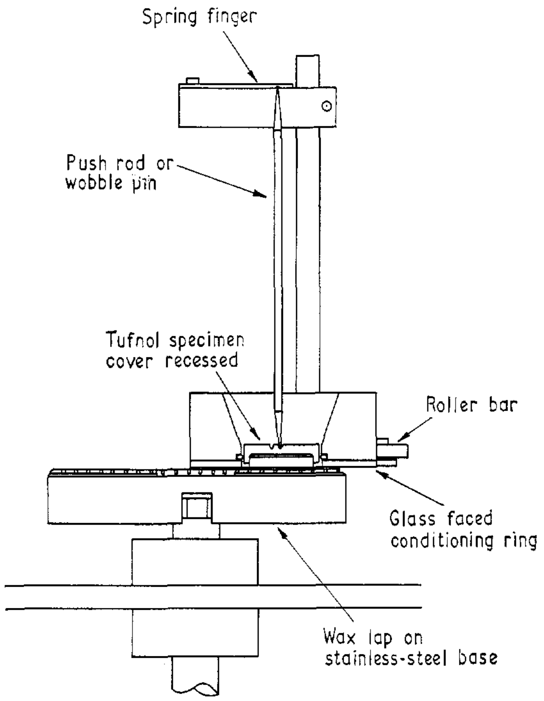

Figure 2

could be stopped at the critical time for the desired flatness. Proustite, for example, has been polished to $\lambda/20$ (He); but the technique for LiF has not been optimized. Polishing on proprietary cloths gives surfaces which result in comparable transmission figures ($\sim 57\%$) but the flatness is inferior.

Although the process described herein has been specifically related to cleaved LiF surfaces, it is applicable to low-damage sawn or lapped (gray) specimens. In these instances, the need for pitch polishing for an extended time is even more important since the surface layer must be removed without propagation of the fissures. Polishing loads and times are, up to a point, interdependent. Excellent specimens have been prepared with pressures lower than $40\ \mathrm{g\ cm^{-2}}$ with an attendant decrease in material removal-rate, but the process has not been optimized. Pressures in excess of $140\ \mathrm{g\ cm^{-2}}$ may well give results faster, but this has not been determined. The measured transmittance of LiF (Lα 121·6 nm) specimens, 1 mm thick, is 57% which is about 5% lower than that measured on similar samples of cleaved material. Measurements made by surface profile (Talystep) and interferometric techniques gave figures of the order of 2 nm for peak-to-valley scratches with agreement of 20% for the methods used. It is concluded that this method of deep polishing is an improvement over conventional techniques which give figures, typically, of the order of 40%.

Acknowledgments
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A simple cryostat for optical measurement

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Abstract A cryostat is described which is suitable for the measurement of optical and electrical properties of solids at any temperature between 82 and 400 K. It is very simple and portable and does not need any vacuum system.

1 Introduction

For studying the optical properties of semiconductors by means of modulation spectroscopy (Cardona 1969, Seraphin 1970) we designed a very simple cryostat which is suitable for electrical and magnetical measurements. The temperature of the sample can be maintained anywhere between 82 and 400 K. The spectral region for optical measurement is limited in the infrared and ultraviolet by the transparency of quartz.

2 Description of the cryostat

The cryostat is shown in detail in figure 1. The sample S is mounted on a copper rod CR (diameter about 15 mm) which is inside a transparent glass Dewar D1. Both parts are placed in a normal glass metal coated Dewar D2. The space around

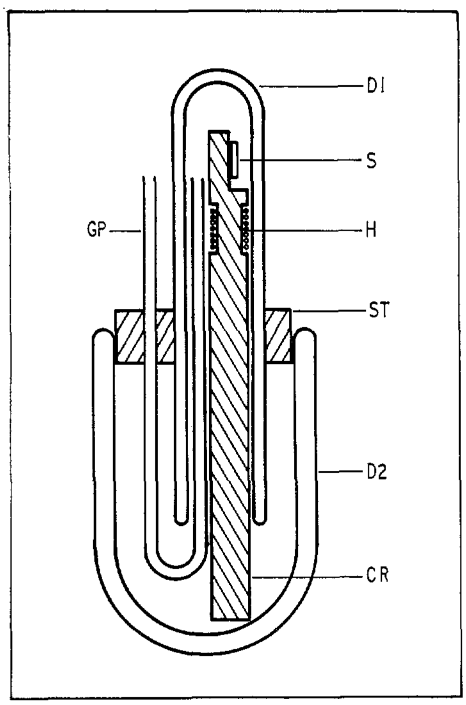

Figure 1 The cryostat

the sample is connected with the outside atmosphere by a thin glass pipe GP (diameter about 3 mm). The Dewar D1 and glass pipe are fixed in a stopper ST in which there are two holes for supplying the liquid nitrogen and cables respectively. There may be almost an arbitrary number of cables connecting the sample with the outside equipment without any special bushing. The temperature can be raised from minimum by means of the heater H (about 80 W). The thermocouple (copper–constantan) is mounted on the sample and enables the temperature to be measured and controlled.

3 Operation

When filling the Dewar D2 with liquid nitrogen the temperature of the sample decreases owing to the high temperature conductivity of copper rod. At the same time the liquid nitrogen vaporizes and the air inside the Dewar D1 is replaced by the cool dry gaseous nitrogen. The pressure in the Dewar D1 is equalized with atmospheric pressure through the glass pipe GP. At the normal laboratory conditions there is no condensation of water on the outside glass wall of the Dewar D1; however, during the rather humid weather it is reasonable to protect it by a thin film of glycerol or water solution of some detergent. The heater with the thermocouple and a suitable electronic device control the temperature at any value between the minimum and 400 K. The minimum temperature was usually 82–85 K. The cryostat was originally designed for the measurement of electroreflectance in the near infrared and visible part of spectrum (the glass Dewar D1) but for a more precise optical measurement it is possible to change the upper part of the Dewar D1 and use quartz instead of glass.

4 Results

To demonstrate the function of the cryostat we present one of the measurements of the electroreflectance spectra of Ge. The optical and electronic part of the experimental arrangement is very similar to that described by Cardona (1969). The sample was 15 Ω cm Ge with the aluminium oxide layer and semitransparent metal electrode. Figure 2 shows the plot of the electroreflectance $\Delta R/R$ against the energy of incident light at three different temperatures. For the modulation of reflectance we used square wave electrical signal ($\pm 0{\cdot}5$ V, frequency 40 Hz). The results agree well with the similar measurement by Nishino and Hamakawa (1969) obtained at slightly different conditions.

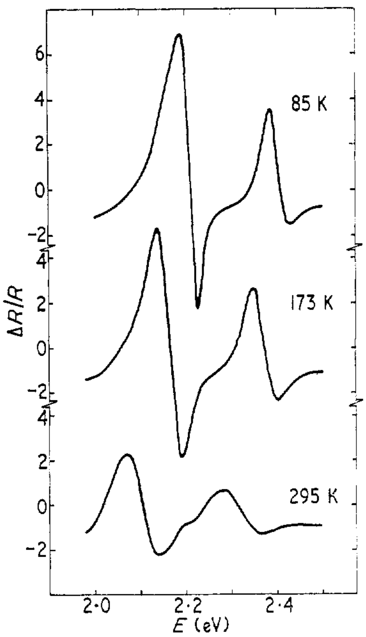

Figure 2 Electroreflectance spectra of germanium ($\Delta R/R$ in 10^{-4} unit) in the region 2·0–2·5 eV

5 Conclusion

The cryostat described is suitable for optical and electrical measurement on solids. It does not need any vacuum system and outside source of gas and so is very portable. The temperature of the sample may be varied from 82 to 400 K; the sample is surrounded by the gaseous nitrogen, the change of the sample is simple, the number of wires for the electrical measurement is not limited. The construction of the cryostat is very simple and the cost, especially of the glass version, is almost negligible.

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A simple linear demodulation system

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Abstract A demodulation system is described which has been developed for use in the receiver section of a pulsed nuclear magnetic resonance spectrometer. Because of the technique used the design could be used in any equipment where a demodulator of good linearity is required as the system is inherently broad-band.

1 Introduction

In many systems it is necessary to demodulate a radio frequency signal and then further process the resulting detected voltage. If this voltage is to be measured the demodulator should have a linear input–output characteristic, otherwise corrections must be applied to the data obtained to correct for the nonlinearity. Various systems were considered as described below but were rejected because they would not meet one or more of the following requirements: (i) the linearity should be as good as required by the proposed application; (ii) the system should operate successfully at 15 MHz (this condition arises because 15 MHz is the intermediate frequency used by the pulsed nmr spectrometer system mentioned above); (iii) it should have a fast response time, i.e. 10 μs from zero to full output; (iv) it should be capable of operation below the noise level: this is necessary in order that the data may be further processed by correlation techniques to improve the signal-to-noise ratio; (v) the circuit should be as simple as possible and therefore of low cost.

2 Unsatisfactory demodulators

The simplest type of demodulator is shown in figure 1(*a*) and consists of a diode and low pass filter. Because of the nonlinear forward resistance of the diode, particularly at low voltages, considerable nonlinearity results.