97,693

SECONDARY HIGH PRESSURE STANDARD FOR THE FAR-INFRARED
SPECTRAL REGION

B. T. Smith and A. J. Sievers

Laboratory of Atomic and Solid State Physics
Cornell University
Ithaca, New York 14850

February 1974

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Issued by
The Materials Science Center

#2170

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

flg

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Secondary High Pressure Standard for the Far-Infrared Spectral Region*

B. T. Smith and A. J. Sievers

Laboratory of Atomic and Solid State Physics
Cornell University
Ithaca, New York 14850

Abstract

The defect lattice mode in $\text{NaCl}:\text{Cu}^+$ provides a convenient secondary pressure standard for far infrared measurements of solids at low temperatures.

We have found a defect lattice mode in an alkali halide crystal, $\text{NaCl}:\text{Cu}^+$, which provides a convenient secondary pressure standard for far-infrared measurements of solids at low temperatures.

Hydrostatic pressure studies to 10 kbars of the far-infrared properties of solids at 4.2°K^1 have been obtained with a con-

ventional optical pressure cell² containing solid helium as the pressurizing medium. The cell is initially pressurized at room temperature then cooled slowly while monitoring the pressure with a room temperature manganin gauge. At the freezing point of helium, about 55°K at 8.5 kbar, a solid block forms in the pressure tubing near the cell. An appropriate correction to the pressure must be made for cooling from the freezing point to 4.2°K at constant volume.

It has long been recognized that a simple way around the experimental uncertainties of the pressure determination is to use a spectroscopic pressure standard which can be placed inside the optical cell next to the sample. Such a secondary standard for the near infrared was developed by Drickamer, et al.³ They monitored the stretch vibration frequency of the CNO^- molecule embedded in NaCl. Similarly, the absorption line associated with Cu^+ in NaCl at 23.4 cm^{-1} , which has a full width at one half maximum absorption of 0.4 cm^{-1} , is particularly useful for the far-infrared region.

We found that a three mm thick crystal of NaCl doped with 0.012% by weight CuO gives an absorption peak of about 50%. The pressure dependence of the center frequency of this mode is shown in Fig. 1. The relatively large error bars occur because of the experimental uncertainty in the absolute pressure determination of solid helium. However, the accuracy can be improved

somewhat by using our knowledge of the property of this mode.

Because hydrostatic pressure causes a large frequency shift in the mode frequency, it is not particularly helpful to make a Taylor's expansion of the frequency in terms of the pressure. A simpler expression results if one makes an expansion in the frequency squared since this is proportional to the force constant of the lattice mode and it is the force constant which directly responds to the lattice change. From the linear plot in Figure 1 the pressure in kbars is

$$P = 7.7 \left[\left(\frac{\omega}{\omega_0} \right)^2 - 1 \right] \equiv 7.7 F(\omega).$$

A more precise absolute calibration of this secondary standard could be obtained if the temperature of the optical cell were maintained above the helium freezing point so that the room temperature manganin gauge would always be in hydrostatic contact with the liquid helium around the sample. The rapid temperature dependence of the transmittance of the high pressure sapphire windows did not permit such measurements.

References

* This work has been supported by the U. S. Atomic Energy Commission under Contract No. AT(11-1)-3151, Technical Report No. C00-3151-37. Additional support was received from the National Science Foundation under Grant #GH-33637 through the Cornell Materials Science Center, Report #2170.

1. A. M. Kahan and A. J. Sievers, Physics Letters 37A, 203 (1971).
2. D. B. Fitchen, Rev. Sci. Inst. 34, 673 (1963).
3. H. G. Drickamer, R. A. Fitch and T. E. Shykhov, J. Opt. Soc. Am. 47, 1015 (1957).

Figure Caption

Figure 1: $\left(\frac{w}{w_0}\right)^2 - 1$ versus pressure for defect impurity mode of NaCl:Cu⁺. The slope of the straight line is 0.13.