Bi_2Te_3–Bi_2Se_3. Thus,
inter-band transition
luctors, whether caused
oying perturbation, do
oles in the transport
s, of course, will be
smaller band gap.

(B. S. KRISHNAMURTHY)
f Scientific and Industrial
or the grant of a fellowship
stigation.

NCES

nd SINHA K. P., *J. Phys.*
(1965).
s L. S., *Rep. Progr. Phys.*
heory of Metals, p. 267.
Press (1954).
ik **9**, 607 (1931).
A. R. and HERMAN F.,
958).
Rev. **104**, 22 (1956).
hys. Chem. Solids **8**, 423
LI and SPENCER C. W.,
3 (1963).
RD A., *J. Electron. Control*

J. Phys. Chem. Solids Pergamon Press 1966. Vol. 27, pp. 637–642. Printed in Great Britain.

TEMPERATURE DEPENDENCE OF THE ELASTIC CONSTANTS OF SODIUM

MARY E. DIEDERICH* and J. TRIVISONNO

John Carroll University, Cleveland, Ohio

(*Received* 10 *July* 1965; *in revised form* 7 *October* 1965)

Abstract—The adiabatic elastic constants of single crystal sodium were measured as a function of temperature from 195°K to 78°K by the ultrasonic pulse-echo technique. In order to eliminate transit time errors a buffer technique was employed. The measured elastic constants at 78°K (in units of 10^{10} dyn-cm^{-2}) are as follows:

$$C = 5{\cdot}78,\quad C' = 0{\cdot}688,\quad C_n = 13{\cdot}30,\quad \text{and}\quad B_s = 7{\cdot}30$$

The notation $C = C_{44}$, $C' = (C_{11}-C_{12})/2$, $C_n = (C_{11}+C_{12}+2C_{44})/2$, and $B_s = C_n - C - C'/3$ is used. The shear constants C and C' are interpreted in terms of Fuchs' electrostatic contribution to the shear stiffness of the alkali metals. The results of this work are in agreement with those of Daniels at 300°K and the shear constants are within 3% of the values computed by Quimby and Siegel. The results are also compared with Bender's value of the elastic constants at 90°K and with Swenson's isothermal compressional data.

INTRODUCTION

THE single crystal elastic shear constants of sodium were first determined by QUIMBY and SIEGEL.(1) They employed a composite oscillator technique over the temperature range 80°–210°K. O. BENDER(2) made static measurements on single crystals of sodium at 90°K. In both investigations the elastic compliances were the directly measured quantities and from this data the elastic constants were computed. Since a 15% discrepancy exists in these data and since the elastic constants were not directly determined, it was decided to measure the elastic constants directly by the conventional and more reliable ultrasonic pulse-echo techniques over the temperature range 78°–195°K.

FUCHS(3) has calculated the theoretical values of the elastic shear stiffnesses for the alkali metals at absolute zero. He predicts that the main contribution of the shear stiffnesses in these metals arises from the long range electrostatic interaction between ion cores and the valence electrons, which accounts for the large elastic anisotropy observed in the alkali metals.(4–7) He also includes a second, but minor, constituent arising from short range ion core interactions. Since the ultrasonic pulse-echo technique yields directly measured values for the shear constants, $C = C_{44}$ and $C' = (C_{11}-C_{12})/2$, a direct comparison with Fuchs' theoretical values of these constants can be made.

EXPERIMENTAL PROCEDURE

The procedure for crystal growth, orientation, and preparation of the acoustic specimens was the same as described in a paper by DANIELS(8) and similar to the techniques employed on potassium presented in a recent publication from this laboratory.(7)

For a cubic material all three independent elastic constants can be obtained by the ultrasonic pulse-echo technique if the appropriate wave is propagated along the [110] direction. Generation of longitudinal, fast shear, and slow shear waves was straightforward once the proper handling techniques were perfected. Because of the high anisotropy of sodium, generation of slow shear waves caused the most difficulty and proved quite sensitive to crystal orientation and to proper positioning of the polarization direction of the Y-cut transducer. Two crystals oriented in the [110] direction

---

* NSF Undergraduate Research Participant. Presently NSF Graduate Fellow at University of Chicago.