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ELASTIC CONSTANTS OF α-ZnS*

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Abstract—The elastic constants of hexagonal zinc sulfide were measured at room temperature. Velocity measurements used for computing the elastic constants were made at 10 mc/sec using a coherent pulse/cw technique. The derived values of the elastic constants, in units of 10^{12} dyn/cm^2 are: $c_{11} = 1{\cdot}312$, $c_{12} = 0{\cdot}663$, $c_{13} = 0{\cdot}509$, $c_{33} = 1{\cdot}408$ and $c_{44} = 0{\cdot}286$. Curves of intersection of the velocity surfaces with the XZ plane are given and compared with similar curves for hexagonal cadmium sulfide.

1. INTRODUCTION

THE WORK reported here was undertaken primarily to measure the velocities of propagation of pure compressional and pure shear elastic waves along the c axis of zinc sulfide, required for determining the thickness of half-wavelength vapor deposited ZnS piezoelectric transducers.(1) As the ZnS sample obtained was large enough to propagate elastic waves along three suitable separate crystallographic directions, all five independent elastic constant (c_{11}, c_{12}, c_{13}, c_{33} and c_{44}) were determined from the eight independent velocity measurements made. In addition, three internal checks on the accuracy of the results were obtained. The velocities were measured by a coherent pulse/cw technique(2) which permitted a simultaneous comparison with the conventional pulse/echo technique.

2. RELATIONS BETWEEN ACOUSTIC VELOCITIES AND ELASTIC CONSTANTS

For propagation of plane elastic waves in hexagonal crystals, MUSGRAVE(3) has derived the following wave equation

$$\begin{vmatrix} l^2a+m^2(c/2)-H, & lm(a-(c/2)), & n\,l\,d \\ lm(a-(c/2)), & l^2(c/2)+m^2a-H, & m\,n\,d \\ n\,l\,d & m\,n\,d, & n^2h-H \end{vmatrix} = 0 \quad (1)$$

where l, m, n are the direction cosines of the wave normal, c_{ij} are elastic constants, v is acoustic velocity, ρ is density and

$$a = c_{11}-c_{44} \quad (2)$$

$$c = c_{11}-c_{12}-2c_{44} \quad (3)$$

$$d = c_{13}+c_{44} \quad (4)$$

$$h = c_{33}-c_{44} \quad (5)$$

$$H = \rho v^2-c_{44} \quad (6)$$

It can be shown from equation (1) that circular symmetry about the X_3 or Z axis exists for both the velocity and wave surfaces. Thus the circles of intersection of the free velocity surfaces with the basal plane are the roots of the equation

$$H^3-(a+\tfrac{1}{2}c)H^2+\tfrac{1}{2}acH = 0 \quad (7)$$

which is obtained from equation (1) by allowing n to become zero.

The elastic constants c_{11}, c_{12}, c_{44} can be obtained by measuring the velocities of propagation of the three acoustic modes in the basal plane. The appropriate equations are

$$\rho v_L^2 = c_{11} \quad (8)$$

$$\rho v_{T_1}^2 = \tfrac{1}{2}(c_{11}-c_{12}) \quad (9)$$

$$\rho v_{T_2}^2 = c_{44} \quad (10)$$

In these equations L refers to the compressional mode, T_1 to the shear mode with displacement

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