Letters to the Editor

Dielectric properties and effective ionic charge of calcium sulphide

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The dielectric constant of calcium sulphide was measured by Sharma & Gupta (1963) who obtained a value 6·69 at 7·2 MHz   More recently a value of 8·10 was reported by Drofenik & Azman (1972)   It can be seen that there is considerable difference in the two values   From their value of dielectric constant Drofenik & Azman (1972) obtained a value of 0 52 for the effective ionic charge. The value differs from the value 0·43 obtained by Drofenik *et al* (1971) from theoretical calculations   In view of these differences, it was considered worthwhile to measure the dielectric constant and to calculate the effective ionic charge of CaS

A pure sample of CaS, supplied by Reidel de Hahn was powdered and sieved to get particle size of $\approx 45\mu$ Die-pressed cylindrical pellets of 2·5 cm in diameter and ≈ 5 mm thick were prepared   The samples were dried for several hours at 100°C before taking measurements   The dielectric measurements were done at room temperature on a Marconi Circuit Magnification meter TF 1245 in conjunction with a special Marconi Test Jig 155 C/1 in the frequency range 50 KHz to 50 **MHz**

Several procedures are available for obtaining dielectric constant ϵ of the solid from the measured dielectric constant e_p for the powder samples   We have used the following relation suggested by Dube *et al* (1971)

$$\frac{1}{\delta^2}\ [(e_p - A)^{\frac{1}{2}} - (1 - \delta)(1 - A)^{\frac{1}{2}}]^2 + A \tag{1}$$

where A is a constant with a value 0·5 and δ is the packing fraction.

In order to test the accuracy of the procedure adopted, the dielectric constant of the die-pressed powdered samples of NaCl and KCl (particle size $\approx 45\mu$) of various packing fractions were investigated at 1 MHz.   The variation of ϵ with δ are given in Table 1.   The average value of ϵ for NaCl and KCl are also shown along with the literature values.   The values obtained are in fair agreement within $\pm 3\%$

This agreement indicates that the equation used for determining ϵ from ϵ_p is valid over the range of packing fraction 0·7 to 0·9. In the present investigation measurements were done for samples with packing fractions $\approx$0·7. A typical frequency vs dielectric constant (ϵ) curve for the sample with packing fraction 0·7 is shown in figure 1. The frequency dependence of tan δ is also shown in figure 1. Over the range of frequencies covered in this investigation, the dielectric constant should be frequency independent (Lowndes & Martin
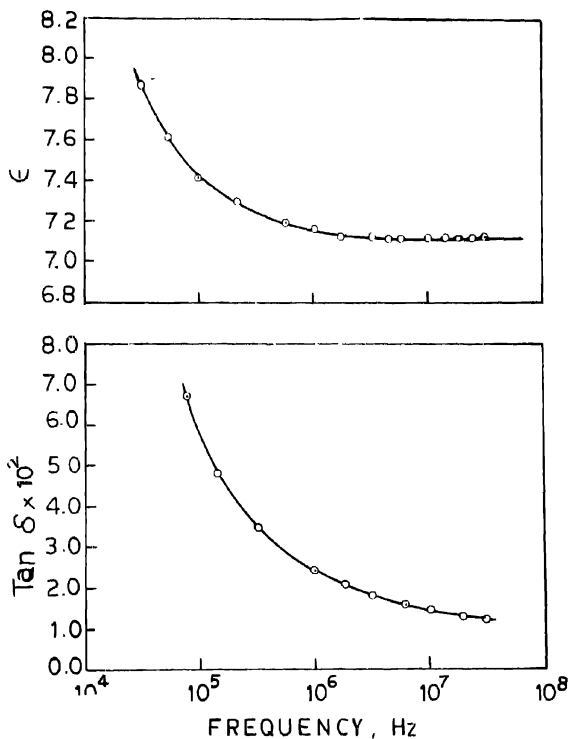

Fig 1. Variation of dielectric constant ϵ and loss (tan δ) of CaS with frequency.

1969). The variation observed at low frequencies is due to factors like unknown impurities and other imperfections. The variation ceases at about 2 5 MHz. The frequency independent value is taken as the static dielectric constant. Such

anomalous frequency dependence of dielectric constant and tan δ have been observed by Chaudhury & Rao (1969) in the case of some oxides

Table 1. Dielectric constant of bulk computed from powder sample (particle size $\approx 45\mu$) measured at 1 MHz.

Crystal	δ	Authors	Average	Literature value
NaCl	0 66	5·76		
	0 74	5 79	5 80	5·89
	0 80	5·82		(Andeen C. et al 1970)
	0 90	5 83		
KCl	0 72	4 72		
	0 86	4·70	4 73	4 81
	0 90	4·76		(Andeen C. et al 1970)
	0·96	4·73		

The frequency independent value of dielectric constant ϵ is used to estimate the effective ionic charge q^* from the Szigeti (1950) equation

$$q^* = (\omega_0/Ze)[3/(n^2+2)](mv)^{\frac{1}{2}}[(\epsilon-n^2)/4\pi]^{\frac{1}{2}} \tag{2}$$

where ω_0 is the restrahlen frequency, n the refractive index, m the reduced mass, Ze the formal charge and v the volume per ion pair The value of ω_0 is taken from Drofenik & Azman (1972), n is taken from 'Hand Book of Physics and Chemistry' (Chemical Rubber Co 1973-1974). v is estimated from r the nearest neighbour distance taken from Guntert & Faessler (1956). The values of ϵ and q^* are given in table 2 along with those given by earlier workers

Table 2. Dielectric constant and Szigeti charge of CaS.

Present work	Drofenik and Azman (1972)	Sharma and Gupta (1963)	Dorfenik Kotter and Azman (1971)
7 11	8 10	6·69	·
0·41	0·52		0·43

The data given in table 2 shows that the present value of ϵ is closer to the value obtained by Sharma & Gupta (1963) than that obtained by Drofenik & Azman (1972) Our value of q^* is different from the value obtained by Drofenik & Azman (1972). However it agrees well with theoretical value obtained by Drofenik et al (1971).

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Microwave measurement of complex permittivity and conductivity of silicon by a simple technique

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The properties of semiconductors at microwave frequencies studied earlier (Benedict & Shockley 1953, Benedict 1953, Goldley & Brown 1955) fall into two categories In the first, the semiconductor parameters were obtained from the propagation characteristics of the transmitted signal The other relates to the changes introduced by the sample inside a cavity in the resonant frequency and quality factor Montgomery (1947) From devices' point of view, the conductivity is one of the most important parameters which at microwave frequencies becomes complex. As the time period of the wave is comparable with the mean free time of carriers, the real and imaginary parts of conductivity are of the same order i.e , the relaxation effects are important The earlier workers employed dc methods to investigate the conductivity behaviour of semiconductors But these methods suffer from the limitations of using low currents to avoid heating of samples and having ohmic and surface contacts. However, microwave methods automatically overcome these difficulties

In the present paper measurements made on silicon wafers, of different resistivities, for the determination of the complex permittivity and the microwave conductivity variation with temperature are reported using a different technique.

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