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Surface conductivity of freshly cleaved mica

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The surface conductivity of freshly cleaved muscovite and phlogopite micas has been determined at room temperature. It has been observed that freshly cleaved mica has higher conductivity than unsplit mica.

Itroduction

From their crystallographic study Metsik & Zhidikhanov (1958) have shown the presence of partly bound water molecules in the interblock layer of muscovite crystal through which contact between individual blocks is established at a number of points. On splitting the mica crystals along their cleavage planes, separation of heterogeneous particles occur, and the surfaces become electrified (Metsik 1959-60). The freshly split mica specimen may thus be regarded as a composite dielectric consisting of the mica specimen and a charged layer of partly bound water molecules. In an earlier communication (Dhar 1966) it has been reported that the presence of partly bound layer of water molecules on the surface of freshly split muscovite mica was responsible for the increase of its dissipation factor over that of unsplit muscovite mica.

When a solid insulating material is stressed by a steady electrical potential, there is flow of leakage conduction current not only throughout its volume but also along its surfaces. Semenov & Chirkov (1946) and Chirkov (1947) have observed that the surface conduction in mica is due to flow of current through a film of moisture adsorbed or other conducting material present on the surface of mica. Presence of layer of partly bound water molecules on the surface of freshly split mica may be expected to have some effect on the surface conduction in mica. This communication reports the finding of some observations on the surface conductivity of freshly cleaved muscovite and phlogopite micas.

Experimental

Megohmmeter (Model RM 160) of British Physical Laboratories was used for measurement of surface conductivity of mica. Accuracy of measurement was within 6%. Electrode system employed was similar to that described by Lacoste (1965). Highly polished brass electrodes were used to ensure intimate contact with test specimen. The surface conductance was measured between two parallel blocks of brass electrodes placed on the surface of the test specimen at a gap of 25 mm. The low potential electrode was the guarded electrode. In order to concentrate the field near the surface, we placed an electrode on the other side of the sample and it was connected with the guard electrode The electric stress applied was 500 volts d.c. All measurements were made at room temperature, 30 ± 1°C, and relative humidity 25 to 30%.

After the electrical measurement was over, the thickness of the sample was determined with a micrometer correct to ± 0.001 mm.

The surface conductivitv was calculated from the following formula

$$\sigma_S = G_S \cdot \frac{g}{b}$$

where

σ_S is the surface conductivity in mho, G_S conductance in mho, g the distance between electrodes is in cm and b the breadth of the electrode is aiso in cm.

Results And Discussion

The surface conductivities of a few unsplit mica samples have been presented in table 1. (These samples were dried in a desiccator for 48 hours before any measurement taken on them). This shows that in the experimental technique adopted the thickness of the test specimen had but little effect on the surface conductivity. In table 2 are given the results of the surface conductivity of muscovite and phlogopite mica immediately after splitting to different thicknesses. It is observed that the surface conductivity of the split mica is much greater than unsplit mica. The systematic variation in surface conductivity with thickness indicates that the contribution of volume effect could not be totally eliminated. From table 1 it is seen, however, that the effect of thickness is not

Table 1. Surface conductivity of unsplit mica

Sample	Thickness mm	Surface conductivity mho
Muscovite	0.958	8.00×10^{-14}
Mica	0.432	8.00×10^{-14}
	0.216	8.70×10^{-14}
	0.178	9.00×10^{-14}
Phlogopite	0.889	4.00×10^{-13}
Mica	0.140	5.97×10^{-13}

TABLE 2. SURFACE CONDUCTIVITY OF FRESHLY SPLIT MICA

Sample	Thickness mm	Surface conductivity mho
Ruby Muscovite		
Before splitting	0.254	8.00×10^{-14}
After splitting	0.165	1.00×10^{-11}
	0.102	4.76×10^{-11}
	0.076	6.70×10^{-11}
	0.051	8.33×10^{-11}
Phlogopite Mica		
Before splitting	0.148	5.97×10^{-13}
After splitting	0.089	1.40×10^{-12}
	0.076	1.30×10^{-12}
	0.061	4.24×10^{-11}

so much as to decrease surface conductivity by decades as observed for freshly split mica specimens.

The increase in surface conductivity of mica on splitting indicates the presence of some conducting layer on their surface. From Metšik's (1959-60) observation we know that partly bound water molecules are present on the surface of freshly split mica. These water molecules might be responsible for the increase in surface conductivity. They have also been found earlier (Dhar 1966) to increase the dissipation factor of freshly split muscovite mica.

Table 3 shows the results of the surface conductivity of a few mica immediately after splitting and drying for 24 hours in a desiccator.

TABLE 3. EFFECT OF STORING ON SURFACE CONDUCTIVITY OF FRESHLY SPLIT MICA

Sample	Surface conductivity mho		
	Before splitting	Immediately after splitting	24 hours after splitting
Ruby Muscovite	8.70×10^{-14} (0.216)	1.56×10^{-11} (0.076)	1.56×10^{-13} (0.076)
Green Muscovite	8.00×10^{-14} (0.432)	2.86×10^{-11} (0.089)	1.12×10^{-13} (0.089)
Phlogopite	6.00×10^{-13} (0.140)	1.37×10^{-10} (0.064)	2.30×10^{-13} (0.064)

Figures within brackets in tables 3 and 5 indicate thickness of the sample in mm.

It is observed that drying in a desiccator decreases the surface conductivity. Similar decrease in dissipation factor on storing as well as drying freshly split muscovite mica has been observed earlier (Dhar 1966). As explained earlier evaporation of the surface moisture during storage as well as leakage of charge over the surfaces might be responsible for the change.

The presence of a fluid medium on the surface of a freshly split mica is corroborated from the results reported in table 4, which describes the average voltage flashover at 50 cps of freshly split mica for a surface spacing gap of 25 mm. The flashover voltage is affected by the nature of the solid surface ; particularly the presence of moisture on the surface decreases the flashover voltage.

TABLE 4. FLASHOVER VOLTAGE OF FRESHLY SPLIT MICA

Sample	Thickness mm	Flashover voltage kv
Ruby Muscovite		
Before splitting	0.700	9.5
After splitting	0.140	6.1
Green Ruscovite		
Before splitting	0.597	8.0
After.splitting	0.127	6.0

A few mica samples were heated at 130°C for 24 hours, dried in a desiccator for the same period and then the surface conductivity was determined. The mica sample was then split and the surface conductivity redetermined. The results reported in table 5 show that the

TABLE 5. EFFECT OF INITIAL HEATING ON SURFACE CONDUCTIVITY OF FRESHLY SPLIT MICA

Sample	Surface conductivity mho	
	Before splitting	After splitting
Ruby Muscovite	9.04×10^{-14} (0.292)	3.89×10^{-11} (0.102)
Green Muscovite	1.72×10^{-13} (0.798)	1.34×10^{-11} (0.190)
Phlogopite	1.80×10^{-13} (0.535)	1.15×10^{-12} (0.064)

initial heating of mica before splitting did not affect the surface conductivity on splitting. In other words, interlaminar moisture could not be expelled on heating the mica sample at 130°C.

The surface conductivity, σ_S, is related to the volume conductiviy, σ_V, of the surface layer by the relation

$$\sigma_S = \sigma_V . t \text{ (McIlhagger \& Salthouse 1965).}$$

Where t is the thickness of the layer. The volume conductivity of water is about 10^{-6} mho cm^{-1} and the surface conductivity of freshly split mica is of the order of 10^{-11} mho. This gives a layer thickness of the order of 1000 Å or about 350 molecular layer of water on the surface of freshly split mica. But a film of this thickness is unreasonable (Yager & Morgan 1931). To bring the film thickness to a reasonable level, the volume conductivity of film should be much higher than 10^{-6} mho cm^{-1}. This is possible if the film is charged and it is then compatible with the observation of Metsik that there are electrically charged areas on the surface of a freshly cleaved mica.

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References

Chirkov N. M. 1947 *Zh. Fiz. Khim.* **21**, 1303.

Dhar R. N. 1966 *Nature* **210** (5041), 1144,

Lacoste R. 1959 *C. R. Acad. Sci.* **248**, 655.

McIlhagger D. S. & Salthouse E. C. 1965 *Proc. I.E.E.* **112**, 1468.

Metsik M. S. & Zhidikhanov R. A. 1958 *Kristallografia* **3**,9995.

Metsik M. S. 1959-60 *Sov. Phys. Sol. State* **1**, 9910

Semenov N. N. & Chirkov N. M. 1946 *CR Acad. Sci. IRSS* **51**, 39.

Yager W. A. & Morgan S. O. 1931 *J. Phys. Chem.* **35**, 2026.