VARIATION OF RESIDUAL POLARISATION VOLTAGE WITH TEMPERATURE IN SOME MANGANITE ELECTRETS

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Received on October 18, 1973 and in revised form on March 8, 1974

1. INTRODUCTION

Recently electrets have attracted a lot of attention because of their potential industrial applications [1, 2]. Most of the earlier work has been on electrets prepared from organic dielectrics. Studies on inorganic and ceramic electrets [3] and photoelectrets [4] are more recent. Recently the phenomenon has been observed even in semiconductors [5]. We have prepared three manganite spinels which are oxidic semiconductors, and have studied their electret-like behaviour as a function of temperature.

2. EXPERIMENTAL DETAILS

Three manganites, *viz*., $CdMn_2O_4$, $ZnMn_2O_4$ and $MgMn_2O_4$ were prepared by wet grinding appropriate proportions of L.R. grade $CdCO_3$, $MgCO_3$, ZnO and $MnCO_3$ and firing these mixtures in platinum crucibles at 1100° C for five hours. The fired compositions were then crushed with the help of a pestle and mortar and pellets of 12·5 mm diameter were pressed with the help of a binder. The pellets were then sintered at 1150° C for 5 hours. After cooling contacts were made with a silver paste which was fired at 700° C. The leads were then soldered on to these silver contacts. The pellets were then charged in an electric field of 2 kV/cm for 5 mins. After charging the pellets were short circuited and left overnight to allow for complete discharge of the capacitive charge. The voltage still retained across the samples was then measured as a function of temperature using a constant temperature oil bath thermostat and a Philips dc microvoltmeter with 100 M ohm input impedance.

3. RESULTS AND DISCUSSION

All the samples showed homocharge. A typical representative graph of residual polarisation voltage *versus* temperature is described in Fig. 1.

It can be seen from this graph that the polarisation voltage of our samples decreases with increasing temperature and becomes zero above a certain transition temperature. The voltage, however, reappears on cooling even

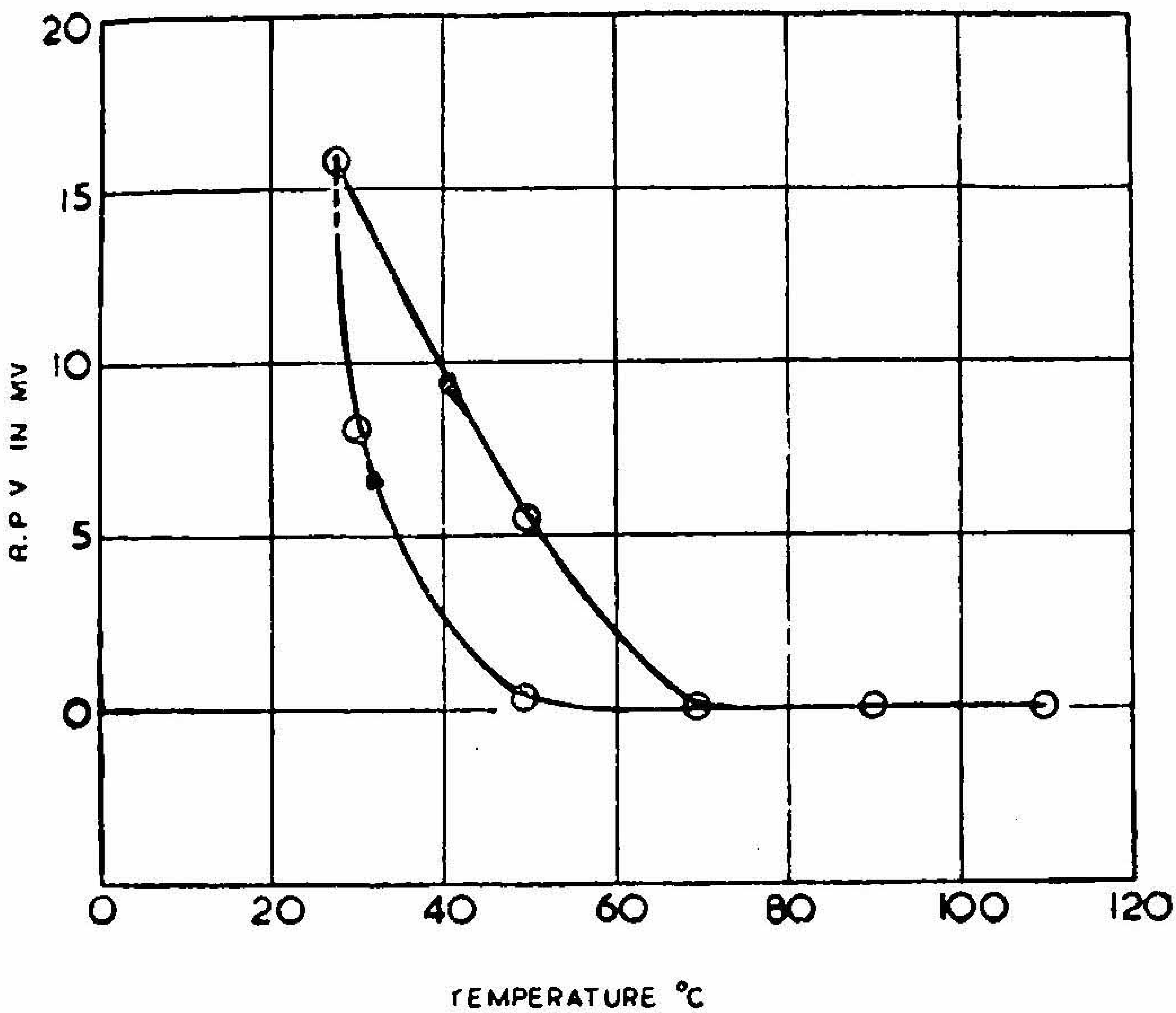

FIG. 1. Variation of Residual Polarisation Voltage (R.P.O.) as a function of temperature in $ZnMn_2O_4$. ($MgMn_2O_4$ and $CdMn_2O_4$ also exhibit similar behaviour.)

though the samples were heated well above their transition temperatures. During the heating cycles the samples showed stable voltage reading within about 30 minutes of maintenance of the corresponding measurement temperature. During cooling, however, the process of reappearance of the polarisation voltage was very slow and the samples took about 12 to 15 hours to restore its charge to its full value at room temperature. The restoring process was also observed to start at a slightly lower temperature as compared to the temperature at which it vanishes during heating. This gives rise to the hysterisis in the graphs described in Fig. 1. For the first few cycles the value of the polarisation voltage restored on cooling was appreciably lower than the initial value. After a few cycles the polarisation voltage appeared to stabilise to some extent and the restored voltage was almost equal to the initial value (Fig. 1). However, restoration of the polarisation voltage to exactly same value was not observed in any of the three samples, even after a large number of repetitions of heating and cooling cycles.

TABLE I

Experimental data

Material	Sample resistance at 25° C in *M* ohm	Resistivity in *M* ohm cm	Dielectric constant ϵ	Polarising field in kV/cm	Polarising temp.	Duration of field application	Type of residual polarisation
$ZnMn_2O_4$	40	88·4	5·0	2	25° C	5 mins	Homo
$MgMn_2O_4$	6	13·26	5·5	2	25° C	5 mins	Homo
$CdMn_2O_4$	3	6·61	10·5	2	25° C	5 mins	Homo

The existence of the permanent polarisation in electrets has been explained on the basis of ion migration, orientation of polar molecules, microscopical heterogeneity, pyro and piezoelectricity, interfacial conduction, charge spray during corona, etc. [1, 2]. In view of the ceramic and semiconducting nature of our materials and the polarisation taking place even at room temperature, the phenomenon reported in this paper (*viz.*, the disappearance and reappearance of polarisation during the heating and cooling cycles) cannot possibly be explained on the basis of these models. Further investigation of these interesting properties are being carried out.

4. ACKNOWLEDGEMENT

The author is thankful to Prof. H. V. Gopalakrishna and Prof. R. S. N. Rau for their encouragement and support.

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