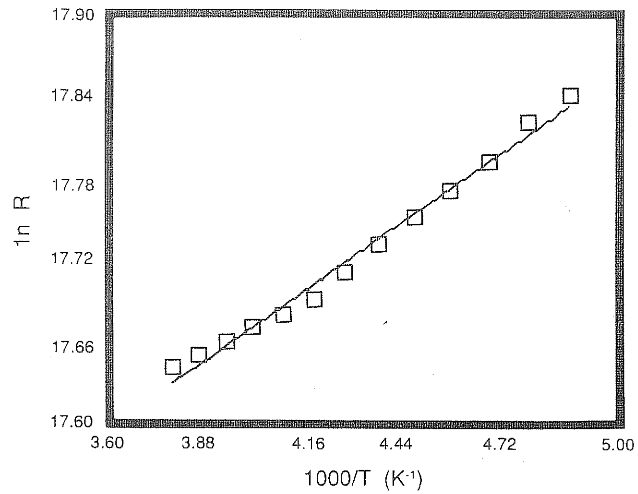


Figure 5. The variation of ln R with inverse of temperature calculated from the parallel path model.

MLC CAPACITORS WITH 6 MICRONS ACTIVE DIELECTRIC AND X7R ELECTRICAL CHARACTERISTICS

Galeb H. Maher
Research and Development Laboratory
Sprague Electric Company
North Adams, MA 01247

ABSTRACT

A multilayer ceramic capacitor in a 0805 size chip with a 6 micron active dielectric thickness was successfully made. The materials were based on a fine powder barium titanate designed to sinter at or below 1100°C and utilized a 70/30 Ag/Pd electrode system.

Superior electrical properties, such as dielectric breakdown voltage (95V/micron) and stable insulation resistance (IR), at accelerated life test conditions (50V, 150°C, and 25V, 200°C), were observed.

INTRODUCTION

The growing demand for a high volumetric efficiency MLC capacitor has accelerated research activities in raw material and in manufacturing technology of the capacitor.

An obvious route to achieve high capacitance values would be to reduce the active dielectric thickness, while maintaining a high dielectric constant.

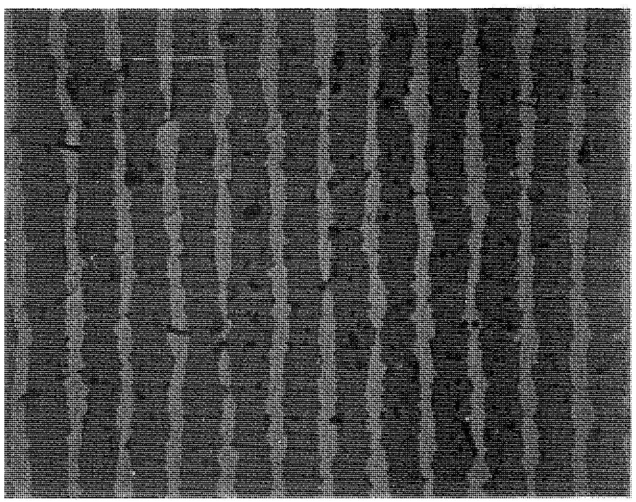
Although reducing the dielectric thickness below 10 microns is an industry challenge at the present time, the long-term reliability of the MLC chips would also pose a greater challenge. Of particular concern is the effect of the internal electrode on the sintering characteristics and overall electrical properties.

The objective of this paper is to describe some of the physical and electrical properties generated on a 0.1µF chip in a 0805 size with X7R characteristics.

RESULTS AND DISCUSSION

The dielectric materials used in this study were based on a modified fine powder barium titanate system. The MLC chips were manufactured by the wet process (1), and consisted of 40 active dielectric layers with a fired layer thickness of about 6 microns, and 70/30 Ag/Pd for the internal electrode. A microphotograph of a polished cross-section is shown in Figure 1. The chips were sintered at 1100°C, and soaked for about 2.5 hours at the peak temperature.

The following figures show some of the electrical properties generated on these chips:



MARKER = 10 MICRONS

Figure 1

Two samples, 25 chips each, were subjected to an accelerated life test at 50V DC, 150°C, and 25V, 200°C, for 2000 hours. The electrical properties before and after life test are summarized in Table 1.

Table 1. Accelerated Life Test

Test Conditions	50V, 150°C	25V, 200°C
Initial:		
Capacitance (nF)	92	92
D.F. %	2.3	2.3
Insulation Resistance (ohms)	$> 3 \times 10^{10}$	$> 3 \times 10^{10}$
IR at Test Conditions (ohms)	5.3×10^{9}	6×10^{8}
After 2000 Hour Test:		
Capacitance (nF)	89.8	90.7
D.F. %	2.3	2.3
IR (ohms)	2.4×10^{10}	9×10^{9}
Sample size: 25 units		

The electrical properties described above are self-explanatory. Of particular interest, however, is the significant voltage capability of this fine powder dielectric. Even with a relatively non-uniform electrode, an ultimate dielectric breakdown of about 95V/micron was quite impressive. This is about twice as much as that observed on X7R dielectric with conventionally prepared powder, with 12 microns active dielectric thickness. The second important feature of these results is the life test stability at accelerated test conditions. At 50V, which is equivalent to 200V/mil and 150°C, there was no evidence of any degradation in the insulation resistance. This is a very encouraging observation, because of the concern that the Ag/Pd electrode system may result in silver diffusion under a high field at high temperature, might become a reliability problem in these thin layer chips.

Although these results are very preliminary, they do indicate that this type of fine powder dielectric system has the inherent capability to be used in a MLC with 6 micron dielectrics.

SUMMARY

A thin chip of 0805 size with 0.1μF X7R characteristic was successfully made, using a fine powder, modified barium titanate dielectric. A summary of the electrical properties is shown in Table 2.

Table 2. Summary

Capacitance at 1Vrms, 1KHz	95 nF
Dissipation Factor	2.4%
Fired AD Thickness	6 ± 1 micron
Dielectric Constant	2800
TCC (-55 to 125°C)	±5%
Ultimate Dielectric Breakdown	550 volts (95V/micron)
Insulation Resistance (50V, 150°C)	10^{10} ohms
Life Test (50V, 150°C, 2000 hours)	No degradation

ACKNOWLEDGEMENT

I wish to thank Sprague Electric for allowing me to publish this paper, and to Mrs. Gudrun Hutchins, Mr. Thomas Morin, Mr. Ralph Stewart, and Mr. Reginald Hofmaier for their assistance in preparation of the sample and generating the electrical properties.

REFERENCE

(1) T. P. Hurley and A. C. McAdams, Jr., "Ceramic Slip Composition", U.S. Patent # 3,717,487, issued February 20, 1973.

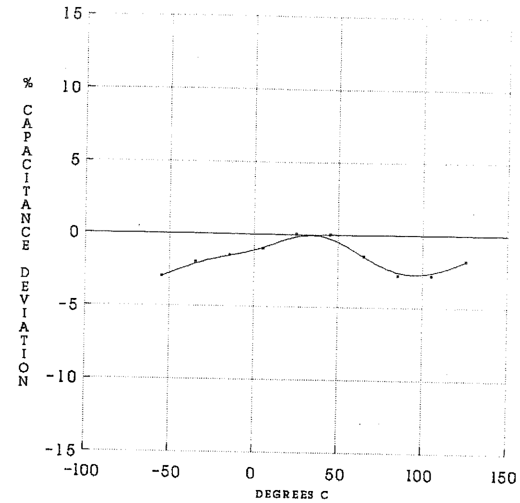


Fig. 2. Capacitance change with temperature measured at 1 kHz, 1 Vrms.

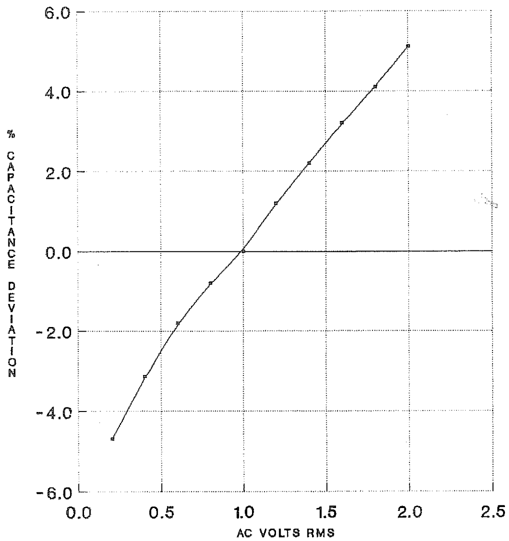


Fig. 3a. Capacitance change with ac signal measured at 1 kHz and 25^{o} C.

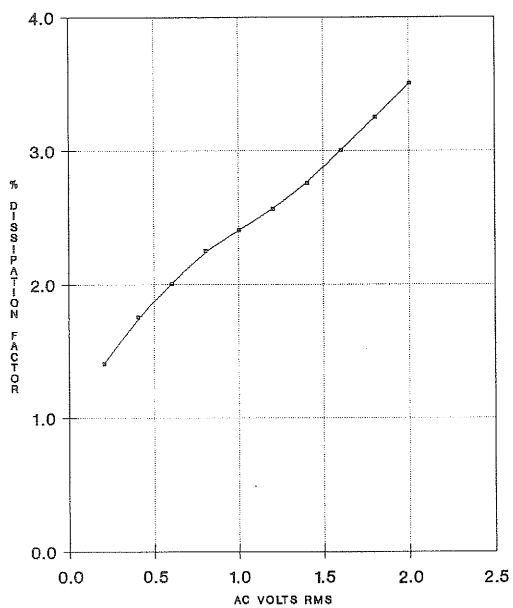


Fig. 3b. Percent dissipation factor change with signal measured at 1 kHz and 25^{o} C.

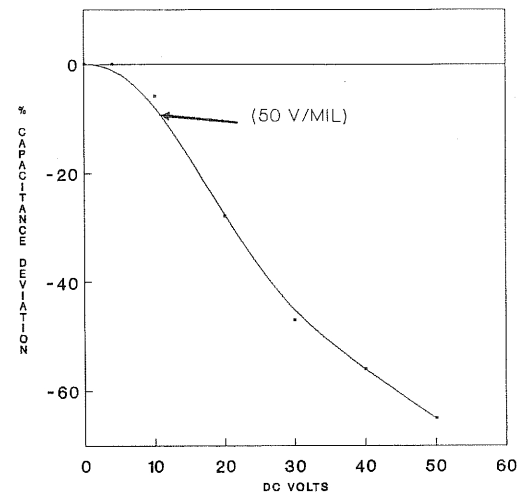


Fig. 4. Capacitance change with dc bias measured at 1 kHz, 1 Vrms, 25^{o} C.

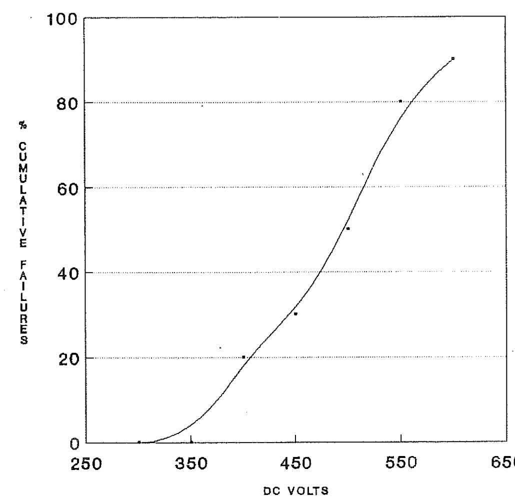


Fig. 5. Ultimate dielectric breakdown voltage, tested at 25^{o} C: sample size = 25.