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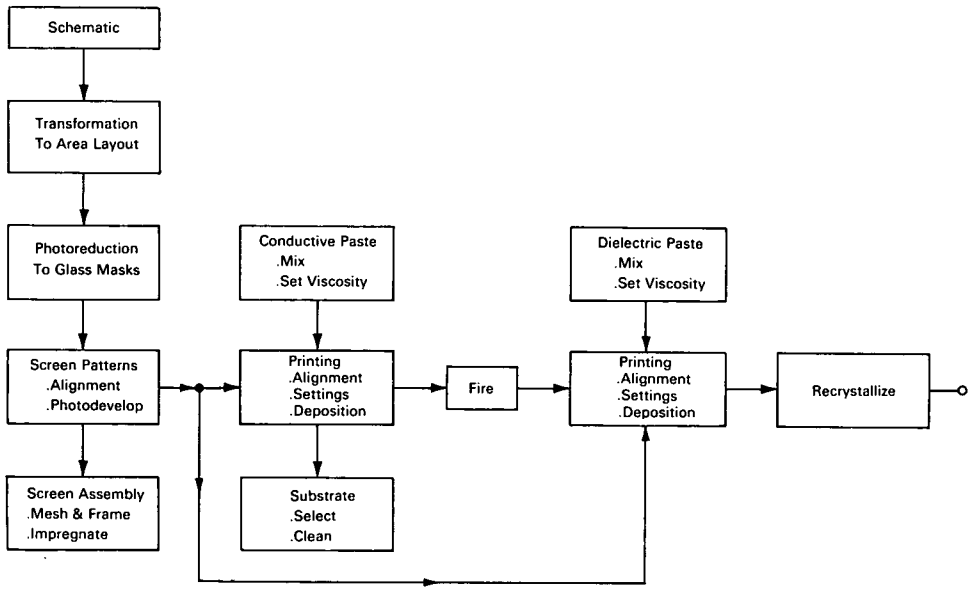
High Dielectric Thick Films for Screened Circuit Capacitors



In the past, screened hybrid microcircuits have used low dielectric thick films for capacitors. These consist of ceramic dielectric particles mechanically suspended in a lead monosilicate glass matrix. Because of the small volume of high dielectric particles (35% by weight) which can be packed into the low dielectric glass, the dielectric constants of such thick films are less than 100. The mechanical suspension results in low-density structures featuring high-dissipation factors.

Techniques and materials have recently been developed to obtain high dielectric films (K of 300 to 800). For these new materials, high dielectric barium titanate particles are mixed in a barium titanate glass. The final dielectric material thus consists of barium titanate particles bound by smaller grained barium titanate which has recrystallized out of the glass, giving a total barium titanate content of 90 to 95 percent. The films are deposited and recrystallized in place on alumina substrates for integration into a complete circuit.

Each thick film composition consists of barium titanate glass and barium titanate microcrystals. Compositional ratios for the two mixtures, A and B, are shown in Table 1, overleaf. Table 2 lists the constituents of the barium titanate glass.

Reagent grade chemicals are dry blended for 1 hour and ball milled in distilled water. The water is removed by filtering and the material is dried under an infrared lamp. After calcining in air at 1000°C for 1 hour and comminuting, the composition is melted at 1450° to 1600°C and quenched to a glass frit in distilled water. The frit is milled and sifted through a 325-mesh screen.

(continued overleaf)

Table I
Composition of Dielectric Thick Films

Component	Mixture A (wt.%)	Mixture B (wt.%)
Barium Titanate Glass	20	80
Barium Titanate Microcrystals	80	20

Table II
Composition of Barium Titanate Glass

Constituent	Amount (wt. %)
BaO	54.7
BaF_2	3.2
TiO_2	24.0
Al_2O_3	7.9
GeO_2	2.0
SiO_2	8.2

Barium titanate is then blended with the frit and the total composition suspended in a binder and lubricant for screening. The binder-lubricant formulation is 200 ml of butyl cellosolve acetate to 21.5 grams of Ethoxyl T-10.

The block diagram shows the integration of the dielectric paste into a thick film capacitor. Bottom platinum electrodes are screened on alumina substrates and fired at 1260°C. Dielectric films with a surface area of 0.06 cm^2 are deposited on the electrodes. A 165- or 200-mesh screen gives satisfactory depositions. The films are outgassed by drying in a vacuum and then heating at 100°C.

The films are recrystallized according to the following schedule: soaked at 425°C for 10 minutes to complete burnout of the binder; heated to 1225° to 1275°C in 5 to 10 minutes for recrystallization; soaked at temperature for 5 to 15 minutes, and cooled with furnace shutdown. To evaluate the capacitors, air-dried silver is deposited as the top electrode.

Notes:

1. At room temperature and 10 kHz, the dielectric constants of materials A and B, when screened as thick films, are, respectively, 615 ± 25 and 325 ± 10. These represent capacitance densities of 12,000 pf/cm^2 (77,400 pf/in^2) and 3850 pf/cm^2 (24,800 pf/in^2). Their temperature coefficients are positive to 140°C, the dielectric Curie temperature.
2. Documentation for the invention is available from:
   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: B68-10542

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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