NASA TECH BRIEF

Dopant for Sodium Niobate Capacitor Dielectric

A dopant, barium titanate ($BaTiO_3$), for sodium niobate ($NaNbO_3$) dielectric has been determined to have potential application in integrated circuit components. Such a dielectric could bring about the development of components that have a higher voltage capacity, especially capacitors.

In order to fabricate a suitable sodium niobate dielectric that will evaporate on an integrated circuit substrate, a number of materials including sodium carbonate powder were investigated. Although initial tests in which only sodium carbonate was used proved unsuccessful, those in which a "moltensphere" evaporating technique were employed provided a good capacitor dielectric, but its dielectric constant and voltage breakdown potential characteristics were not high enough.

The next step in the investigation was to examine a series of selected impurities, including lead oxide (PbO) and $BaTiO_3$. Numerous attempts to optimize powder feed control were made with $BaTiO_3$ as a dopant. These included pre-outgassing in a vacuum environment at 200°C for 24 hours, sieving, and finally, actually running the powder through the hopper in the vacuum system, recovering it, and then reusing it. This procedure proved to be so effective that it became difficult to maintain the speed slow enough to prevent excessive amounts of powder from arriving at the niobium drop. This problem was resolved on a trial-and-error basis by utilizing six layers of 40-mesh stainless steel screen in the bottom of the hopper. As was previously determined, barium titanate was found to produce not only the best dielectric, but also acted as an anticoagulant in the powder-feed controller of the molten-sphere technique. Both PbO and $BaTiO_3$ were added to the sodium carbonate powder in an attempt to improve the voltage breakdown characteristics. Further investigation, using different ratios of sodium carbonate (Na_2CO_3) to barium titanate, led to the conclusion that a 4:1 ratio, by weight, gave the best results. The average voltage breakdown potential was raised from approximately 2 to 3 volts for pure sodium carbonate powder to about 5 to 8 volts for the doped mixture (sodium carbonate powder and barium titanate). In addition, a majority of the dielectric constants for some mixtures were increased to a range of 100 to 200 and several to over 500. Also, the dissipation factor of the capacitors was significantly improved over those previously noted for the PbO-doped film, although this is not a consistent phenomenon.

Notes:

1. Preliminary experimentation indicates that sodium niobate dielectric doped with barium titanate has a potential application in integrated circuits with high packing densities and voltage levels below 5 to 8 volts. For previous work on thin-film $NaNbO_3$ capacitors, refer to NASA Tech Brief 68-10163.
2. Requests for further information may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center, Code BM7
   Houston, Texas 77058
   Reference: TSP 70-10190

Patent status:

No patent action is contemplated by NASA.

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Category 01