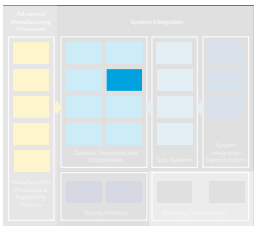


PATHFINDER 2015

SYSTEM INTEGRATION

Offset lithographic printing of nanocomposite barium titanate capacitors (OPCAP)

NERANGA ABEYWICKRAMA
BOB STEVENS

PARTNERS
NANO PRODUCTS
NOVACENTRIX
PROMETHEAN PARTICLES
BOWATER INDUSTRIES

Advances in conductive printing inks and stable multi-layer printing processes enable various passive electronic circuit components to be formed on low cost flexible substrates, for example connectors, resistors, inductors and low value capacitors. Printed hybrid flexible electronics combines these printed passive components with conventional silicon, and III-V semiconductor devices, to create functional electronic sub-systems. One area of particular interest is printed intelligent labels. However, these require additional circuit elements to create working systems, such as high value capacitors (> 10nF).

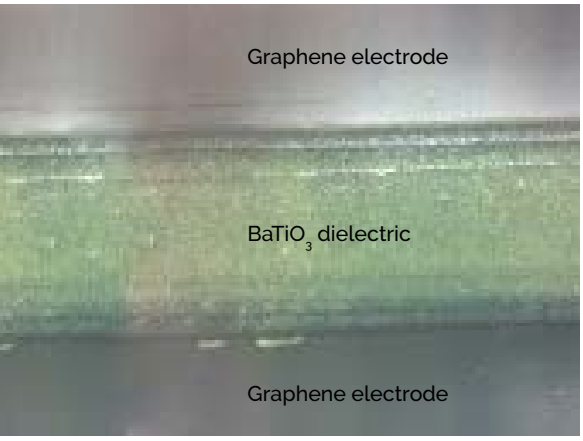
The aim of this project is to use offset lithography to print high-K dielectric parallel plate capacitors to remove the need of the discrete capacitors. The project objectives are to;

1. Investigate a new nanoparticle loaded UV curable ink made from barium titanate nanoparticles.
2. Offset printing $BaTiO_3$ ink onto different substrates and photonically sinter the dielectric layers to remove the polymers in the ink, and maximize the capacitance per unit area.

The UV curable $BaTiO_3$ ink was formulated by mixing 10nm, 50 nm or 100 nm $BaTiO_3$ nanoparticles (Pharm2Farm) with UV polymer and UV reduce fluids/ gels. Different loadings of $BaTiO_3$ nanoparticle inks were formulated and printed onto graphene electrode layers. Test devices were fabricated by sequential offset printing and UV curing of the graphene electrode, dielectric layer and top graphene electrode. The bottom electrode graphene layer was modified to improve the conductivity and minimise features which may lead to low leakage current. It was evident that due to large agglomerations of the nanoparticles (>20 µm), usable inks could not be produced due to poor ink pick up and transfer between rollers during printing. Therefore further work was carried out to mill the powder before formulating the ink. However, it has not been feasible with this technique and equipment available to reduce the particle size to sub-micron levels. It may prove to be necessary to coat appropriate capping agents on the $BaTiO_3$ particles during synthesis to prevent particle agglomeration and to aid dispersion in the UV carrier polymers.

This research has demonstrated that it is feasible to formulate and offset lithographically print flexible capacitors on flexible polymer substrates and the printed capacitor test devices exhibited low leakage current. However, the aim of a significant step change in dielectric constant has not been achieved, but lessons for future work have been learned.

(a) Picture of dielectric ink transferring process.



(b) Offset printed BaTiO3 layers on printed graphene electrode.