Abstract

Rapid progress in the field of display technology, has intensified the search for flexible screens which can bend, fold and conform themselves to the shape surface. Organic semiconductors, have emerged as the promising technology for flexible displays. Organic thin film transistors (OTFTs) and Active Matrix Organic Light Emitting Diodes (AMOLEDs) have a potential to realize flexible displays. The choice of materials used and modeling the electronic transport behaviour in OTFTs plays a significant role in improving the performance of OTFTs. This work, aims at a study of the material issues especially the gate dielectric and the substrate in an OTFT and modeling of the OTFT characteristics both from the device physics perspective and SPICE model.

To improve the performance parameters of an OTFT by choosing a proper gate dielectric material is carried. Initially the relation between the performances of an OTFT: threshold voltage, mobility, subthreshold swing, stability and current modulation ratio with the material parameters of gate dielectric is analyzed. Based on the analysis, surface energy, dielectric constant, glass transition temperature and break down field are identified as the key parameters. Furthermore, to choose a gate dielectric material, well established, Multi-Criteria Decision Making (MCDM) approach has been applied. Three MCDM techniques: Multi Objective Optimization using Simple Ratio Analysis (MOOSRA), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Vlsekriterijumska Optimizacija I KOmpromisno Resenje (VIKOR) are used for solving the material selection problem. Various low-*k* polymers were analyzed and it was observed that CYTOP is a promising material for gate dielectric in OTFTs. This result is in good agreement by MOOSRA, VIKOR and TOPSIS.

The need for flexibility, adds a new dimension: mechanical stability; to the field of OTFTs. It is observed that the role of a substrate is significant in determining the stability of the OTFT. Therefore, several material parameters: thermal conductivity,

coefficient of thermal expansion, glass transition temperature and Young's modulus are taken into consideration while choosing a substrate for OTFT to enhance their reliability and stability. Since the available data for these parameters is available in the form of an interval, a variant of TOPSIS technique: interval TOPSIS is used to analyse polymer substrate materials reported in the literature. The outcome of the analysis suggests that, polyimide is the most suitable substrate for fabricating OTFTs with improved flexibility and good reliability.

Surface potential based models are one among the best known compact models for thin film transistors. However, their use in computer aided design (CAD) tools is restricted due to the fact that they need computationally intensive and iterative approach to obtain the device characteristics. Existing techniques for computing surface potential use region wise approximations, smoothing functions and empirical methods to solve for surface potential. These techniques, often result in in-consistent results, large errors especially in transition regions. Moreover, solutions obtained using such approximations quiet often fail to establish a relation with intrinsic device parameters. This work, proposes a computationally efficient, compact, accurate and a physically based closed form solution for surface potential in case of organic thin film transistors(OTFTs). The analytical expression obtained for surface potential is a non-iterative (single step) and extremely accurate with an absolute error less than 1% compared with numerical solution. Further, the surface potential expression derived is incorporated in the all-region I-V characteristics expression of an OTFT. The I-V characteristic curves obtained using the analytical solution for surface potential are able to accurately model both linear and saturation behaviour of an OTFT.

To facilitate the design and optimization of electronic circuits using OTFTs, a compact SPICE model for OTFTs is presented. This model, which is capable of replicating the behavioral characteristics of an OTFT across all the regions of operations is an adaptation of the existing semi-empirical SPICE Level 3 model. Due to its semi-empirical nature, it could be used to replicate the terminal IV characteristics of an OTFT. Parameters like the threshold voltage, effective mobility, and the subthreshold swing have been extracted from experimental data to fit the model.

Further, the utility of this model is demonstrated by implementing a few frequently used circuits in both analog as well as digital applications. This illustrates its utility of this compact model for design and analysis of circuits using OTFT in the early stages of development.