STUDY OF A NOVEL NANOCARBON BASED THIN FILM TRANSISTORS

B.S.Satyanarayana, Shounak De & R.Bhattacharya+
Innovation center & Dept. of Electronics and Communication,
Manipal Institute of Technology, Manipal, Karnataka, India 576 104
+ National Physical Laboratory, New Delhi, India 110012.

Abstract

The roadmap for semiconductor technology ITRS, envisages that, advancement based on purely silicon based technologies would reach a plateau or a near dead end around 2013-14. One of the key element that may find the first incorporation in to the silicon technology seems to be carbon. Nanocarbons in its various manifestations varying from nanotubes to fullerenes, nanodiamond and amorphous carbon, have already been shown to process exceptional properties, either in terms of their use as conducting, semiconducting or insulating layers. However one of the biggest stumbling blocks to implementation of the carbon process technologies is their incompatibility to existing silicon technology. Further if we were to look at the scene of macroelectroncis, the road map envisages development of diverse materials including nanocrystalline silicon, microcrystalline silicon nanostructured silicon, laser crystallized silicon and better ordered organic semiconductors for enhanced performance and implementation of complete systems on glass and plastic. The application may vary from displays with drive electronics also incorporated on the substrate or other system on chip (SoC) or system in package (SiP) type applications for areas including displays, optoelectronics, sensors and instrumentations. With the motivation to look at this issue, we have tried to work on low temperature process grown nanocarbons and amorphous carbon to develop novel thin film transistors.

Presented in this paper is some of our initial results of the simulated thin film transistors based on our as grown material properties of nanocarbons and amorphous carbon. The carbon films with properties varying from insulating to semiconducting (conductivities varying from 10^{-13} to 10^{-3} Ω^{-1} cm $^{-1}$) were grown using a pulsed cathodic arc process. The morphology of the films could be varied from atomic smooth films to clusters, pillar like structures and fibers, by varying the deposition parameters. These depositions were carried out with the initial substrate temperatures vary from room temperature to 100^{o} C. Earlier amorphous carbon based TFTs and carbon nanotube based field effect transistors have been reported in literature. However the amorphous silicon TFTs have not gone beyond the initial study after nearly a decade of the first publication and the recent nanotube based field effect devices and complete circuits like oscillators demonstrated by IBM, would take 2 to 3 decades to come to the market. Hence we believe the nanocarbon based TFTs grown at low temperature would be a faster means to implement. The initial simulations show the device to be promising. Also discussed in the paper is a brief model for defect density distribution in carbon, for simulation considerations.