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Conclusions and Future Scope

Although quite a few aspects of organic molecular memories with polymer-small molecule blend were discussed in detail in this thesis, a lot of research and development is still needed to be carried out to fill the current gaps before the organic molecular memories make their presence felt in the market among other commercial electronics. This chapter covers a concise summary of the work carried out in this thesis and the possible scope for the future work in the field of organic molecular memories pertaining to the present research.

5.1 CONCLUSIONS

Primary goal of this research work was to explore a novel organic molecular memory with a hybrid of small molecule and polymer which shows all the characteristics of a non-volatile memory like high ON-OFF ratio, long retention time and good endurance, and has all the virtues of organic electronic devices such as flexibility, solution processability, low cost, low power consumption, and most important of all high package density. Various characterizations of such memories were carried out and the switching mechanisms were modeled for such memories. Furthermore, switching mechanisms were manipulated by changing the concentration of materials and fabrication parameters (rotational speed). A brief account of the thesis work is as listed below.

- Non-volatile memory devices with a blend of a small molecule semiconductor DDQ and insulating polymer PVP were fabricated using spin coating technique and various physical and electrical properties of the same were investigated with respect to the change in the concentration of DDQ.

- The ON-OFF ratio and the switching mechanism can be controlled by varying the concentration of DDQ with respect to PVP in the mixture. The ON-OFF ratio is high when either the concentration of the DDQ is very less compared to the PVP, or when it is exactly half (weight wise) of the PVP. In both cases, the ON-OFF ratio was observed to be in the order of 10^6

- At lower concentration, the direction of switching was in the negative bias region, whereas in the higher concentration, it shifted towards the positive bias indicating that the mechanism responsible for switching in the lower concentration devices was formation of metallic filament, whereas, in the higher concentration devices, it was predominately because of conformational change in the small molecule DDQ.

- All the aforementioned devices were observed to have a very stable logical state for a long time after the application of erase or write voltages. Also, the endurance cycle of Write-read-erase-read pulses was scanned repeatedly, and it was found that the repeatability and reliability of these devices was reasonably high. This means that the devices can be used for either RAM or ROM applications.

- Molecular switching devices based on DDQ and PVP blend were fabricated at different rotational speeds using the spin-coating method and the change in the switching characteristics were studied with respect to the change in the rotational speed of the spin coating process.

- By measuring the electrical and physical properties of these devices, it was found that the ON-OFF ratio of the devices increased exponentially with the increasing rotational speed of the spin coating process. The reason behind this exponential increase turned out to be a distinct variation in the surface morphology of the devices.

- The increase in rotational speed makes the film dry faster and hence the phase segregation is not allowed to occur in the film. Hence the pinholes are found in the samples fabricated at the higher rotational speed. Similarly, at lower speeds, the film thickness is more which makes the rate of evaporation slow which allows phases to segregate and hence the larger holes and structures are formed. Larger holes lead to a direct path and a lower ON-OFF ratio and pinholes lead to a thin filament formation and hence a higher ON-OFF ratio of the devices.

- Devices fabricated at the highest rotational speed observed to have a very stable high and low conduction states for a long duration. Also, the endurance cycle of Write-read-erase-read pulses was scanned repeatedly on this device and the repeatability and reliability of these devices were found to be reasonably high indicating towards the fact that the aforementioned device can be used for both RAM and ROM applications.

5.2 FUTURE SCOPE

Although a number of aspects of organic molecular memories were explored in the present work, there is still a lot to be explored before the organic molecular memories are finally ready for commercial applications. There are still many gaps in the research work being carried out in the area. A few possible extensions of the current research work are listed below for further exploration.

- In the present study, the effect of phase segregation was studied comprehensively. The phase segregation was controlled by varying rotational speed at the time of spin coating process. However, there is another method of controlling phase segregation of a mixture of a small molecule and a polymer which is by varying the solvent and/or using an additive in the solvent. The difference in solubility of small molecule and polymer in different solvents can be exploited here to tune the phase segregation.

- To increase the packing density, eventually, self-assembled monolayer (SAM) of the small molecule has to be explored.

- The flexibility of these devices remain unexplored. Fabrication of the small molecule-polymer blend based memories on flexible substrates like ITO coated PET can be carried out and their stability against various bend radii can be explored to find out the flexibility of the devices.

- Incorporation of inorganic nano-materials with either the polymer or the small molecule or the blend or both can be explored to find out the properties of such a hybrid organic molecular memory.