KNOWLEDGE INCUBATION FOR TEQIP
IIT KANPUR

TEQIP Long term training program at NcFlexE, IIT Kanpur

February 01- July 31, 2017

ABOUT

This was a 6 month training program under which KIT hosted two faculty from R.V College of Engineering, Bangalore for training at National Centre for Flexible Electronics, IIT Kanpur. With such programs KIT aims to encourage collaborative research and facilitate knowledge exchange between teachers from TEQIP colleges and IIT Kanpur.

	Faculty	Host
1	**Dr. Divakara S.G**	**Prof. Deepak Gupta**
2	**Mr. Ravishankar Holla**	**Prof. Siddhartha Panda**

Objectives of Training Program

- To enhance knowledge in state of the art research in the domain of smart flexible materials.
- To accelerate research work in the field of flexible electronics at IDRC, RV College.
- To write joint proposals, publications and development of materials for societal applications.
- To collaborate the work in future and networking with premier institution.
- To disseminate knowledge in this domain for benefit of UG and Research scholars.

HOSTS

1. **Dr. Deepak Gupta**
   Professor
   Materials Science and Engineering Department
   Indian Institute of Technology-Kanpur
   http://home.iitk.ac.in/~saboo/

2. **Dr. Siddhartha Panda**
   Professor
   Dept. of Chemical Engineering
   IIT Kanpur
   https://www.iitk.ac.in/che/spanda.htm/

VISITING RESEARCHERS

3. **Dr. Divakara S. G**
   Assistant Professor
   Department of Chemistry
   R V College of Engineering, Bengaluru
   http://rvce.edu.in/chem-dv

4. **Mr. Ravishankar Holla**
   Assistant Professor
   Department of Electronics & Communication Engineering
   R V College of Engineering, Bengaluru
   http://rvce.edu.in/ec-ravishankarholla

FEEDBACK

Technical:

- The learning was enlightening. More than the technical know how's, the way in which a problem is approached is the best thing learnt.
- Was also impressed by the professional approach with which information was disseminated.

Facilities:

- National Centre for Flexible Electronics, IIT Kanpur has state of the art equipment. With a very well thought access procedure which is in place, using the facility was a very smooth thing.
- Library facility was regularly used.

Hospitality:

- The accommodation provided was good. Thanks for the support provided in this regard. It took away a lot of financial burden and allowed the focus to be on the learning.
- Above all the humbleness shown during the interaction with Mentors, Faculty members, Staff, Research staff, Doctoral students was overwhelming and made it very pleasant experience. Would relish such opportunities in future.

Taken cumulatively, the outcomes of this long term training programme provided the benefit of a significant knowledge and research experience in the field of flexible electronics. In addition, the expansion of professional network made possible by this programme, which will enable a greater role for myself in the clean room activities at Inter Disciplinary Research Centre (IDRC), RVCE. Finally, and most significantly, the programme permitted me to better understand and assess the impact of Thin Film Transistors for potential applications.

OUTCOMES

- Such collaborations will open up consultancy opportunities.
- Joint proposals, publications and development of flexible sensors.
- Communication exposure with Professors/Researchers at International/National level.

Work reports

Program:	**Long Term Training in the field of *Thin Film Transistors***
	(Supported by : Knowledge Incubation for TEQIP – IIT Kanpur and CoE - Macroelectronics, RVCE)
Venue:	**National Centre for Flexible Electronics (NcFlexe), IIT-Kanpur**
Faculty Name:	**Dr. Divakara S. G, Assistant Professor** **Dept. of Chemistry, RVCE Bengaluru.**
Duration & Dates:	**6 months; 1st February to 31st July, 2017.**
Mentor Name:	**Dr. Deepak Gupta, Professor** **Dept. of Materials Science and Engineering, IIT Kanpur**
Type of Document:	**Report**

Introduction

Thin-film transistors (TFTs) with ZnO, In-Ga-Zn-O (IGZO), In-Zn-O (IZO), Zn-Sn-O (ZTO), channels have attracted a considerable attention because of their capacity of being used in flat panel displays, solar cells, wide area sensors, and various flexible electronics circuitry. Oxide semiconductors have numerous advantages over conventional amorphous silicon and organic semiconductor materials. Among the various TFTs, amorphous Indium-Gallium-Zinc- Oxide thin-film transistors (a-IGZO TFTs) have been most intensively studied, and are promising candidates for the next generation of flexible and large area electronics. IGZO TFTs show high electron mobility, simple, low-cost and room-temperature fabrication processes, optical transparency, good uniformity, satisfactory device lifetime, and large-area integration even on flexible substrates. The IGZO TFT devices typically have band mobility (μ_0) in the range of 20–50 cm^2/V-sec, depending on process conditions and film quality, a low off-current of ~100fA, and a steep sub-threshold slope (S) of 0.1–0.2 V/dec. Many studies have been attempted to further improve the TFT characteristics.

The contact interfaces between an amorphous oxide semiconductor channel and source/drain electrodes strongly affect the device performances.The contact resistance between metal electrodes and a-IGZO active layer tends to decrease with the work function of the metallic electrode. The ohmic contact between the S/D electrodes and the active layer has been used extensively to obtain linear electrical characteristics. Therefore it is indispensable to investigate the interface to improve the device performances.The effect of metal doping incorporated into IGZO thin film was essential to study. In order to improve the contact between the S/D-semiconductor interfaces for a-IGZO TFTs,we worked on addition of metal dopants to the region. The main objective of this work during this long term training programmeis the fabrication of the TFTs with IGZO channels,good n-type metal doped IGZO channels and their electrical characterizationin conjunction with studies of the physicochemical propertiesof the IGZO films. The a-IGZO TFTs of were fabricated on glass using a bottom gate top contact structure. In order to improve the contact between the S/D-semiconductor interfaces for a-IGZO TFTs,we have successfully incorporated multivalent metal atoms to channel layer for the fabrication of oxide

thin-film transistors (TFTs). For performance comparison, single layer and a multi-layer 1nm- thick metal film at the interface of IGZO TFT as control sample were also fabricated. The deposited metal / semiconductor films were characterized in terms of their physical and chemical properties, including their electrical characteristics. For the determination of the effects of the processing variables on the deposition of thin films of metal / semiconductor, sputtering technique at different process conditions were applied. The variables chosen were: the RF/DC power, the relative fraction of O_2/Ar, temperature and the working pressure. We started the work first on optimizing the gate (metal) and active layer (IGZO) material by varying above parameters and then fabricating and characterizing the device with optimized parameters. TFTs having the metal- IGZO-metal multilayer under the S/D region were also prepared and characterized.

The IGZO TFTs by RF (and DC) sputtering and also with doped IGZO with various concentration of dopant were prepared and investigated in this study were found to be satisfactory. The IGZO channel structure exhibited good TFT performance with high mobility (22 cm^2/V-sec). Compared with the a-IGZO TFTs, the metal doped a-IGZO TFTs showed a significant suppression of oxygen vacancies in the active layers. Moreover, the doped a-IGZO TFTs showed smaller VTH shift than that of undoped a-IGZO TFTs in hysteresis, implying that the doping could more effectively reduce the density of interface defects. The doping with a multivalent metalin the IGZO film at the interface(S/D-active layer) is expected to provide a feasible strategy for highly reliable performance of the oxidebased TFT devices.

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Program: **Long Term Training in the field of *Flexible Sensors***

(Supported by: Knowledge Incubation for TEQIP – IIT Kanpur and CoE - Macroelectronics, RVCE)

Venue: **National Centre for Flexible Electronics (NcFlexe), IIT-Kanpur**

Faculty Name: **Mr. Ravishankar Holla, Asistant Pofessor**
Dept. of ECE, RVCE Bengaluru.

Mentor Name: **Dr. Siddhartha Panda, Professor**
Dept. of Chemical Engineering, IIT-Kanpur

Duration & Dates: **6 months; 1st February to 31st July, 2017.**

Type of Document: **Short Report**

Sensing of chemicals is the key enabler for applications like air quality monitoring, water quality monitoring, food quality analysis, narcotics, medicine, agriculture etc. These applications of chemical sensing are of very much significance for the wellbeing of the society. In all these applications of chemical sensing, the requirement is to have reliable, accurate and selective sensing of the chemicals. Application driven trends in chemical sensors have resulted in higher order / orthogonal chemical sensors and chemical sensor array. The consideration here is the thin film chemical sensor array based on adsorption principle. An important fact here is that in ambient conditions the sensor would be exposed to a mixture of analytes out of which it is required to sense a particular analyte resulting in poor selectivity.

Source separation is one of the most relevant estimation problems found in sensing chemicals in an environment with more than one chemical present which are mixed together. The need is to separate the sources electronically for improving selectivity of the sensor array. The signals from such an array are processed using various signal processing and statistical techniques in order to estimate the concentration of each analyte in the mixture. This approach for sensing is called as cross-reactive sensing approach which is bio-inspired and involves data fusion techniques as well. Various techniques are put into implementation and validated for in situ working.

I would like to thank Dr. Siddhartha Panda for providing me the training opportunity and accepting for collaborative work. Heartfelt thanks to Dr. Deepak Gupta, Professor, Material Science and Engineering, IIT Kanpur for initiating the training and Dr. C.S. Upadhyay, Associate Professor, Department of Aerospace Engineering, IIT Kanpur for the concern & support. Despite being a self-financed private institution, Rashtreeya Shikshana Samithi Trust (RSST) and R. V. College of Engineering, Bangalore not only had the vision, but also encouraged and supported for this program. I take the opportunity to thank RSST, Principal of RVCE, Head of Electronics & Communication Department, ECE, PI for CoE in Macroelectronics at RVCE.

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