High Mobility and Highly Reliable Thin-Film Transistors (TFTs) for Next-Generation Flat-Panel Displays (FPDs)

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Objective:

Recently, high mobility, uniform, and stable thin-film transistor (TFT) technology for large-area electronics has attracted much attention for application in next generation flat-panel displays (FPDs) such as super-high-definition (SHD) TVs, organic light emitting diode (OLED) displays, and 3D displays. The aim of this project is to develop materials and processing technology for high-mobility TFTs for future electric device applications.

Project Outline:

(1) Zinc oxide based material and transparent TFT application

Recently, oxide semiconductors have attracted significant interest as candidate materials for next generation TFTs. Zinc oxide (ZnO) is a wide band gap (~3.3eV at 300K) transparent oxide semiconductor. We world-first demonstrated liquid crystal displays (LCDs) driven by ZnO TFTs, and received the distinguished paper award from the Society for Information Display (SID) in 2006.

Photo: LCD panel driven by ZnO TFTs

The field effect mobility of oxide-based TFTs has now surpassed 10 cm^{2}V^{-1}s^{-1}. This mobility value is over one order of magnitude higher than that of commercially produced amorphous silicon TFTs; however, further improvement of the mobility (>50 cm^{2}V^{-1}s^{-1}) is required for the realization of next generation of FPDs. Furthermore, the carrier transport in oxide semiconductors and reliability of oxide-based TFTs is scientifically important to the clarification of the device physics in oxide-based TFTs.

As mentioned above, we are now developing deposition processes for high-crystallinity ZnO-based oxide semiconductors on glass substrates for TFT applications. The effects of film crystallinity and defect density on the electrical properties of oxide-based TFTs will be investigated.

In addition, wide-band gap oxide semiconductors are “transparent” in visible light. Transparent electric devices can be created using an oxide semiconductor; however, photo-leakage current in oxide TFTs under visible light irradiation is one of the serious obstacles to achieving real transparent electronics. We have also investigated transport mechanisms of photo-induced carrier in oxide based TFTs based on experimental and device simulation results.

This research project is being developed in cooperation with companies, universities, and research institutes. If you join this project, you will have opportunities for discussion with distinguished researchers in this field.

(2) Research environment

KUT has a 285 m^2 clean room for research on semiconductor materials and devices. Processing apparatus, such as dc & rf sputtering, plasma-enhanced chemical vapor deposition (PECVD), wet & dry etching, photolithography, ramp & furnace annealing, are installed in the clean room. We can make electric devices on 4-inch ϕ substrate by ourselves using the developed materials.

Photo: Clean room in KUT

KUT also has X-ray diffraction (XRD), electron microscopy (SEM & TEM), spectroscopic ellipsometry, Raman spectroscopy and Fourier-transform infrared spectrometry (FT-IR) for material research.

(3) Required skills for SSP candidates

Semiconductor materials and device physics, material evaluation techniques, vacuum system, material processing techniques (PVDs and CVDs), device physics and evaluation techniques. The SSP candidate will be asked to synthesize and characterize of materials, and to fabricate TFTs by him/herself; therefore, it is recommended that only those who like experimental work should apply. Of course, English conversation and writing skills are necessary. Most important thing is that the SSP candidate must have the desire not only to work in material research but also to make devices by him/herself.

References:

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3) M. Furuta et al., *IEEE Electron Device Letters*, 31 pp.1257-1259 (2010)

4) M. Kimura, M. Furuta et al., *Applied Physics Letters*, 97 pp.163503-01~03 (2010)

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