Field-Effect Transistors, Memory, and Logic Circuit using DNA-bases embedded dielectrics

Junyeong Lee, Jin Sung Kim, Ji Hoon Park, Young Tack Lee, Hee Sung Lee, Pyo Jin Jeon and Seongil Im*

Institute of Physics and Applied Physics, Yonsei University
50 Yonsei-ro, Seodaemun-gu, Seoul 120-749, Korea

E-mail: semicon@yonsei.ac.kr

Recently deoxyribonucleic acid (DNA) has been studied as one of the interesting candidates for future electronic materials due to its natural plentitude, biodegradability, low cost, and low toxicity. Since DNA has poor solubility in typical organic solvent, it can hardly be deposited on substrate for channel or gate dielectric layer, except few cases where DNA polymer dielectric showed unstable electrical properties in its thin-film transistor applications mainly due to ionic impurities. In contrast, DNA-base small molecules such as guanine, cytosine, adenine, and thymine, which are constructing components of DNA polymer, can be readily deposited by thermal evaporating system to be patterned by conventional method (i.e. shadow mask). Here, we report on charge-injection type memory property and inverter logic circuit using nucleobase (DNA-base) small molecules as a part of dielectric layer.

Amorphous In-Ga-Zn-O (IGZO) was deposited as active channel layer by using RF magnetron sputtering system on glass substrate. Titanium was used for source and drain electrodes. Atomic layer deposition (ALD) system was used for aluminum-oxide (Al_2O_3) as tunneling (3-4 nm) and blocking (30 nm) layers, where 20 nm-thin nucleobase material was applied as charge trapping layer between them. Finally, gold gate electrode was deposited. These processes, except for nucleobase deposition, were performed by conventional photolithography for patterning each component of our device.

By Fowler-Nordeim tunneling mechanism, electrons can be transferred from IGZO channel to nucleobase layer by positive voltage pulse on the gate, resultantly shifting the threshold voltage of our transistor as PROGRAM. Programmed and un-programmed transistors were connected to be an inverter (NOT) and our inverter showed a voltage gain as high as ~50 under 5 V supplied voltage. NAND and NOR gate logics are on the progress, to be discussed in the meeting.