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Impacts of Atom Probe Tomography on the Electronic and Photonic Device Technology

C. G. Park[1,2] , J.H.Lee[1], D.H. Jang[1], W.Y. Jung[1] and S. M. Park[1]

[1.] Dept. of Materials Science and Engineering, Pohang Univ. of Science and Technology (POSTECH), Pohang, Korea
[2.] National Institute for Nanomaterials Technology, POSTECH, Pohang, Korea

Solid-state microelectronics has been matured for more than 50 years. As the size of devices is getting smaller recently, the demands for structural and compositional characterization of the devices in sub-nanometer scale are getting increased. Conventional analytical techniques, such as TEM and SIMS for the structural and compositional analyses, however, have revealed limitation in acquiring the three-dimensional structural and compositional information in sub-nanometer scale. Atom Probe Tomography (APT) technology has been developed to overcome the technical limit of conventional analysis techniques, and thus, to provide three dimensional distributions of constituent elements at sub-nanometer region with high detection sensitivity (~ppm).

This presentation gives the various examples of atom probe tomography on the electronic and photonic devices. Since ppm-level distribution of constituent elements plays a critical role for the performance of nano-devices, demonstrating 3D compositional analysis is necessary to enhance the understanding of device characteristics. Thus, we have investigated the distribution of constituent elements, in the emerging memory such as finFET, RRAM(Resistive Switching Random Access Memory), PRAM(Phase Change Random Access Memory) and NAND flash memory. We observed the dopant distribution of a thermally annealed poly-silicon floating-gate in NAND flash memory (Fig. 1). The carbon atoms were tightly segregated at the grain boundaries and restrained grain growth. The phosphorus atoms tended to out-diffuse into the adjacent oxide layers. AP image proved that a 1-nm-thick nitride layer effectively blocked out-diffusion of P atom. And the ZnO nanostructures show the great potential for future applications such as electronic and photoelectronic devices. We also study the distribution of catalyst elements, including Al and Ni, to reveal the growth mechanism of ZnO nanostructure. Finally, we focus on the fluctuation of indium composition which play a crucial role on the quantum efficiency in InGaN based LEDs. The APT results, shown in Fig. 2, clearly represent discontinuous indium layer in MQWs. These results strongly support that the composition fluctuation of indium, enhancing the quantum efficiency of InGaN LEDs, can indeed occur.

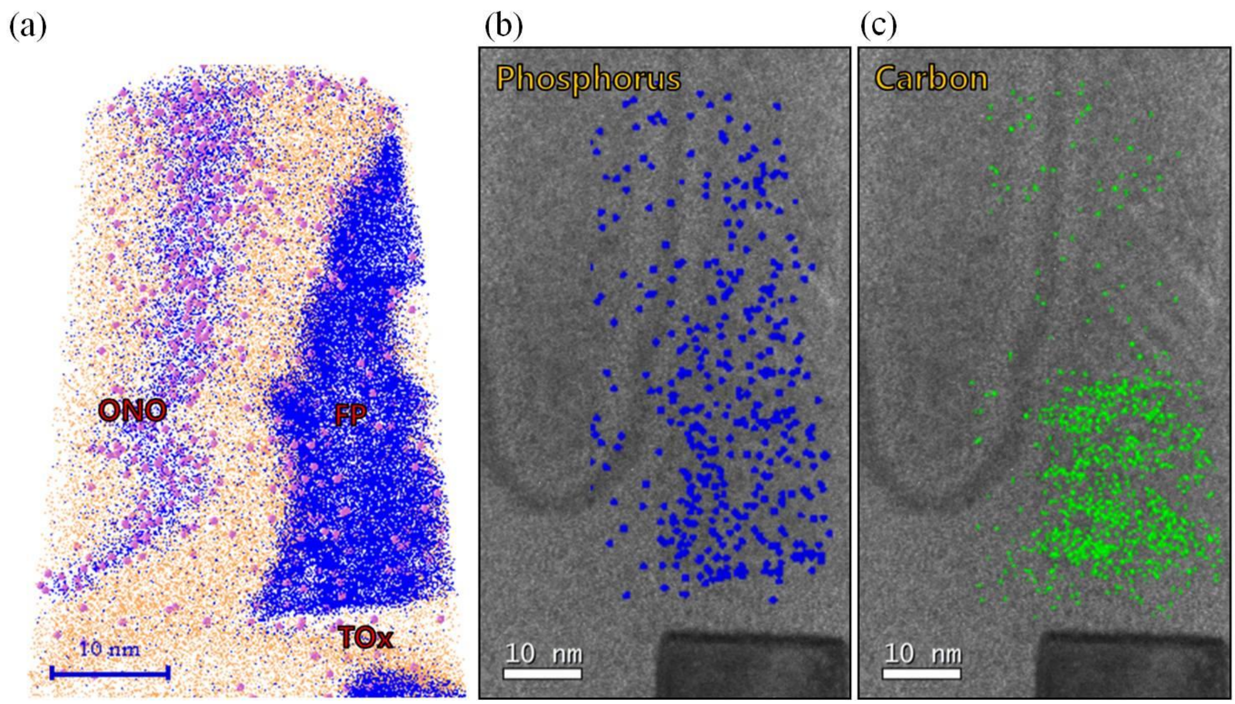

Fig.1 (a) APT image of NAND floating gate interface structure. (b) Phosphorus map and (c) carbon map of floating gate area.

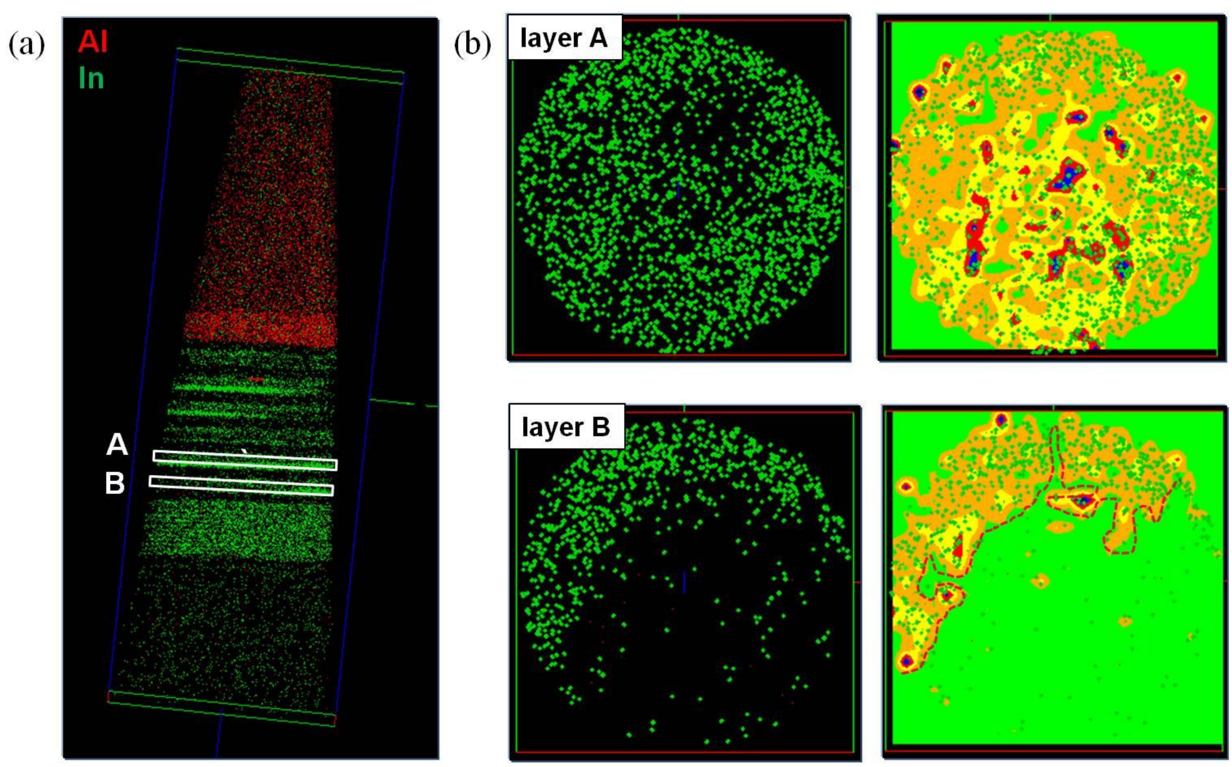

Fig.2 (a) Three dimensional atom map of green LED (red dots and green dots represent Al and In atoms, respectively) and (b) lateral distribution of indium (In) in the layer A and layer B.

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