Atomic Scale Processing Focus Topic
Room Union Station AB - Session AP-ThP

Atomic Scale Processing Poster Session

AP-ThP-1 Atomic Resolution Characterization of Atomic Layer Etching Normally-off AlGaN/GaN Hetrostructure Device by Using Aberration-corrected STEM*, **Chien-Nan Hsiao**,* Taiwan Instrument Research Institute, National Applied Research Laboratories, Taiwan, Republic of China*; C Lin, C Chen, M Chan, W Chen, F Chen,* National Applied Research Laboratories, Taiwan, Republic of China

An in-situ plasma enhanced atomic layer etching system has been design and fabricated. N_2O , BCl_3 and Ar plasma were used as the precursor for III-group epitaxy layer at various temperature. The optical detector was used to in-situ monitor the plasma spectrum during the step by step etching process. The AlGaN/GaN hetrostructure of normally-off high power GaN device (150 V) and etching per cycle of ALE were investigated using an aberration-corrected scanning transmission electron microscope with energy distribution spectrometer. It is found that the layer by layer etching feature shows the process is a controlled self-limited reaction. In addition, the influence of various aberration coefficients such as defocus, astigmatism, coma, spherical aberration and star aberration on the shape of the probe and more importantly on the electron intensity distribution within the probe was calculated. The accuracy required for compensation of the various aberration coefficients to achieve sub-angstrom resolution (0.078 nm) with the electron optics system was evaluated by the calculation of phase shift. Furthermore, the saturation curve of atomic etching rate and precursor pulsed time has been established. The etching per cycle of AlGaN is around 0.33 nm.

AP-ThP-2 Programmable Radical-Assisted Sputtering Enabling Designed Deposition Processes with Atomic Layer Accuracy*, **Hideo Isshiki**, Y Tanaka,* The University of Electro-Communications, Japan*; S Saisho,* Shincron Co. LTD., Japan

A programmable multi-cathode plasma generator (PMCPG), which consists of a high voltage DC power supply, a multichannel digital pattern generator (DPG), and a high voltage switch (HV-SW) attached to each cathode, was developed. We have applied PMCPG to radical-assisted sputtering (RAS) process, and called it "Programmable RAS (PRAS) ". The RAS system provided by Shincron has been widely used for mass production on the optical thin film coating of metal oxide compounds. RAS process is a process alternating metal ultra-thin layer deposition and radical reaction on the metal surface deposited just before. Conventional RAS system needs a large space to spatially separate above two steps. RAS process has a possibility to realize functional materials controlled with atomic layer accuracy. Therefore, the laboratory size RAS system is required to advance the development of functional material devices. We noticed that RAS process can be performed by switching between the metallic mode and the reactive mode found in reactive sputtering. So we have developed PMCPG to enable the time-separated RAS process.

DC pulse plasma on each cathode is generated by direct drive of DC power supply using DPG and the attached HV-SW, and a certain metal sputter is performed selectively under the metallic mode. On the other hand, radical source gasses are fed into the chamber synchronized with the plasma generation on the other cathode, generating the radicals. At the same time, the deposition rate decreases abruptly because of shift to the reactive mode with skipping over the hysteresis region. In this way, the radical reactions on a deposited metal surface proceed preferentially, and then RAS process is complete. The process cycle corresponding to a metal oxide monolayer was estimated to be a few seconds. We also confirmed that the plasma generation using the electronic switching system follows the pulse train more than 50kHz. From the fact that DPG can generate various pulse train for the plasma generation, it is suggested that PRAS enables designed deposition processes with atomic layer accuracy. In this work, YSZ and cubic $(Er_{0.1}Y_{0.9})_2Zr_2O_7$ were successfully synthesized by PRAS. Typical deposition rate of transparent YSZ was more than 1.5µm/hour, indicating the reproduction of RAS process. Layer-by-layer deposition of cubic $(Er_{0.1}Y_{0.9})_2Zr_2O_7$ was also confirmed through X-ray diffraction. This system has four cathodes and can meet the requirements for plasma generation on each cathode independently. We expect that PRAS system enables an artificial material synthesis driving “the materials informatics”.

You can find the demo of PMCPG at http://www.flex.es.uec.ac.jp/?page_id=243.

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