Desorption and Sputtering on Polarity Controlled GaN Surfaces by Irradiation of Low-energy Ar^{q+} (q = 3–8) Ions

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The mechanism of desorption and sputtering at solid surfaces when slow multiply charged ions are irradiated have been attracting a great deal of interest from both fundamental and engineering viewpoints. Explosive emission of hydrogen atoms, hydrocarbon molecules, and other chemisorbed molecules from solid surfaces has been observed in many systems [1]. Emission mechanism of secondary particles, however, has not been clarified yet. In particular, experimental data on the velocity of secondary particles are needed to understand the atomic processes.

Coincidence measurements between secondary ions and scattered atoms/ions have been carried out under glancing incidence on GaN single crystalline surfaces. Clear Ga^+ or N^+ emission from lattice-polarity controlled GaN single crystals were observed under a glancing incidence angle (~2°) [2], indicating selective sputtering of the topmost atoms. The momentum vectors of emitting protons were analyzed by the velocity-map imaging technique [3]. We have developed a novel SIMS analyzer for coincidence measurement of secondary ions, scattered atoms/ions, and secondary electrons. [4-5]. This instrument (Fig. 1) can also measure the time of flight (TOF) of secondary ions in coincidence with the kinetic energy change of scattered ions with a specific charge state. This method is also applicable to study desorption induced by electronic transition (DIET).

Figure 2 shows the correlation plot between the kinetic energy of Ar^+ and the time difference T_1-T_2 in collision between Ar^{6+} (15 keV) ions and a GaN(0001) surface, where T_1 and T_2 are the flight times of secondary ions and scattered Ar^+ ions, respectively. The most dense spot around E = 14.7 keV and T_1–T_2 = 2.9 μs corresponds to proton desorption induced by 5-electrons transition from the surface to the incident Ar^{6+} ions. The kinetic energy loss (~300 eV) of the Ar^+ in this area was attributed to the elastic binary collision with the topmost gallium atoms [5]. On the other hand, the second dense spot around E = 13.9 keV and T_1–T_2 = 2.7 μs was attributed to the elastic binary collision with nitrogen atoms in the second atomic layer.

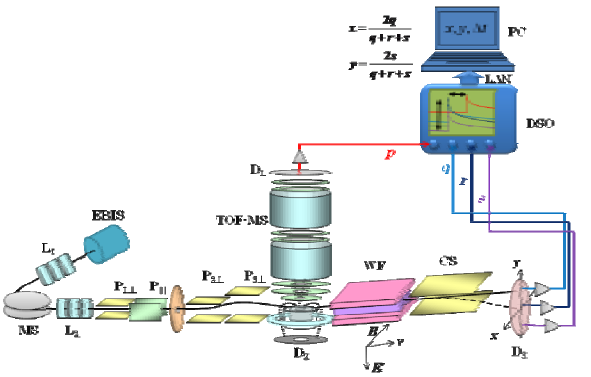

Fig. 1 The schematic illustration of experimental setup. EBIS, Electron Beam Ion Source; L, Einzel lenses; MS, *m*/*q* selector; P; Parallel plate deflectors; D, MCP (Multi-channel plate)detectors of secondary ions, secondary electrons, and scattered ions; WF, Wien filter; CS, Charge separator; DSO, Digital storage oscilloscope; LAN, Local area network; PC, Personal computer

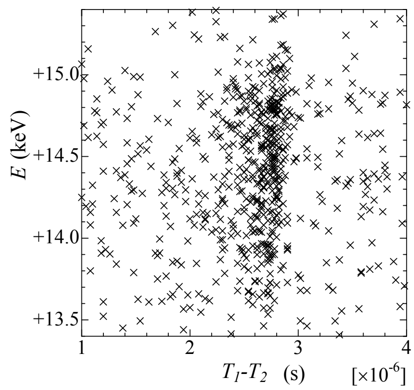

Fig. 2 Correlation plots between the kinetic energy of scattered Ar^+ ions and the difference between time of flight of secondary ion T_1 and one of Ar^+ ion T_2 in collision between Ar^{6+} (15 keV) and a GaN(0001) surfaec.

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