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Work Function Analysis of GaN-based Lateral Polarity Structures by Auger Electron Energy Measurements

An important property of wurtzite GaN is its large spontaneous polarization and piezoelectric constants, which strongly affect the electrical and optical properties of GaN-based heterostructures and provide a novel degree of freedom in designing devices for modern micro- and nanoelectronic applications. A gradient in polarization induces bound surface charges and can create strong internal electric fields in GaN films. The sign of the bound charges at the surface and the direction of the electric field depend on the orientation of the polarization, which is determined by polarity; Ga- or N-face, respectively. Recently, intentionally grown GaN-based lateral polarity heterostructures (LPHs), in which Ga- and N-face domains were grown laterally beside each other, separated by inversion domain boundaries (IDBs), have become of interest for potential application in optoelectronic devices. Therefore the identification of polarity and the measurement of surface potential of thin nitride films and LPH structures with high spatial resolution and even at the nanoscale level is of considerable interest in order to determine its effects on device design and performance. Former investigations of lateral polarity GaN samples yielded in a difference of the work function of approximately 0.2 eV, where the N-face GaN was found to have a smaller work function. These investigations have been carried out by Kelvin Probe Force Microscopy (KPFM) and Photoelectron Emission Microscopy (PEEM).[1] AES measurements have been carried out by a Microlab 350 from Thermo with an energy resolution of 3 – 7 eV. The surface was cleaned by an ion beam etching with 1 keV Argon and 70° with respect to the surface normal. We performed two kinds of measurement, an area scan and a line scan. In the area scan two areas were measured on a Ga-face and on a N-face domain, respectively. Both areas were of approximately 80 μm^2. The linescan with a length of 27 µm was placed across an inversion domain boundary (IDB). The electron beam had a diameter of 15 nm. In Fig. 1 the peak positions of Nitrogen and of Gallium depending on the scanning position are shown. The broken line indicates the average value on each side. Due to the small electron beam diameter, particles and impurities at the surface strongly effect the measurement and cause the fluctuations in the peak position shown in Fig. 1.The average peak shift for Gallium was determined to 0.43 eV whereas the value for nitrogen was about 0.15 eV. The area of the inversion domain boundary has not been taken into account for the average value due to the fact that the junction of Ga- to N-face found not to be abrupt. The area scan confirmed the results of the line scan measurement. The normalized

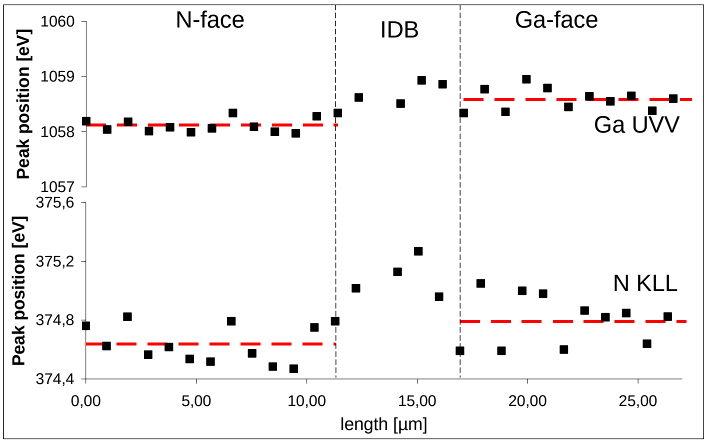

Fig. 1: Line scan across an IDB.

Auger peaks of Nitrogen and Gallium resulting from the area scans are shown in Fig. 2. A peak shift of approximately 0.25 eV from the N-face to the Ga-face domain towards higher energies is obvious for both, the nitrogen and gallium peak. The difference between the peak shift value of the area scan and the line scan is because of inaccuracy of the line scan. Here is the spot size of the electron beam smaller and because of this, particles and charging takes more effect. So the result of the line scan is a confirmation of the tendency measured with higher accuracy by the Auger area scan. In conclusion it could be shown, that Auger Electron Spectroscopy is able to measure the work function difference of lateral polarity heterostructure GaN samples.

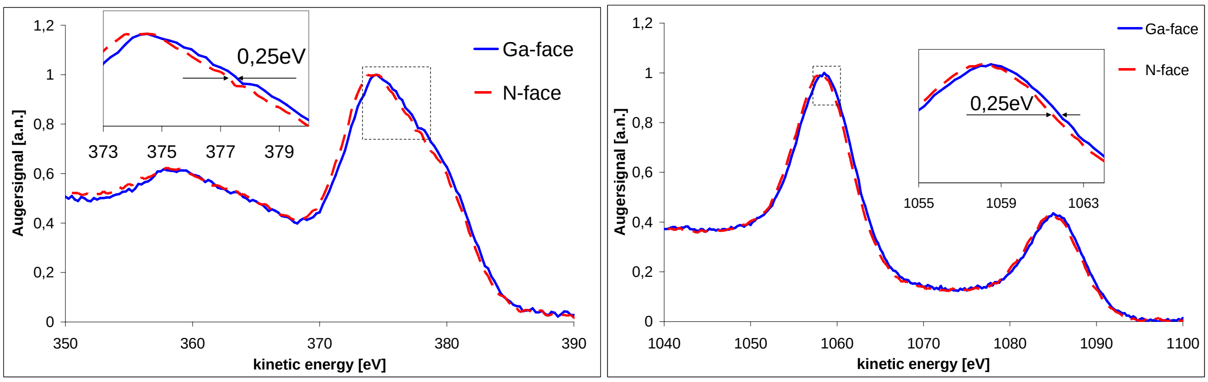

Fig. 2: Auger peak of Nitrogen [KLL] and Gallium [LMM] (normalized, area scan).

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