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I. Cimalla, F. Will, K. Tonisch, V. Lebedev, M. Niebelschütz, M. Himmerlich, S. Krischok, V. Cimalla, G. Kittler, C. Kremin, T. Friedrich and O. Ambacher

Impact of device processing on the surface properties and the biocompatibility of AlGaN/GaN HEMT sensors

AlGaN/GaN high electron mobility transistors (HEMTs) are subject of intense recent investigation and have emerged as attractive candidates for pH- and ion sensitive sensors or detectors for biochemical processes at cell membranes [1,2]. The processing of these devices consists of different steps like metallization, ohmic contacts preparation, passivation and wet chemical etching, as well as fluorine and chlorine based dry etching, which are known to influence the chemical and electronic properties of AlGaN surfaces [3-6].

In the present work we review the impact of these processing steps on performance and surface properties of our sensors with a main emphasis on the biocompatibility. The AlGaN/GaN heterostructures were grown on sapphire substrate by metal organic chemical vapor deposition (MOCVD). Fig. 1 shows a typical surface after the growth with an rms roughness of about 1.2 nm measured by atomic force microscopy (AFM). This structure was used to create HEMT based sensors with an open gate (Fig. 2). The widely distributed cell cultures **h**uman **e**mbryonic **k**idney cells (HEK 293FT) and **c**hinese **h**amster **o**vary cells (CHO-K1) both cell lines, which can adherently be grown in cell culture, served as model systems. As it is shown in Fig. 3 the good adhesion of the cells suggests a sufficient biocompatibility of group III-nitrides surface. By AFM a slightly altered surface morphology was observed after all processing steps. Especially the etching processes increased the surface roughness. In addition, by x-ray photoelectron spectroscopy (XPS) also a chemical modification of the surface was found. Depending on the processing

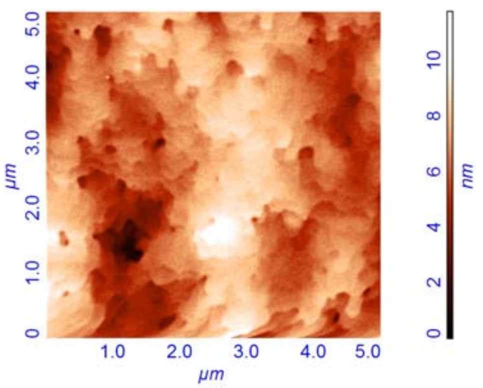

Fig.1. Morphology of an AlGaN/GaN surface after the growth using AFM in non-contact mode.

steps, other atoms (O, Cl, F, C) are incorporated into the surface, leading to a changed wetting behavior and biocompatibility.

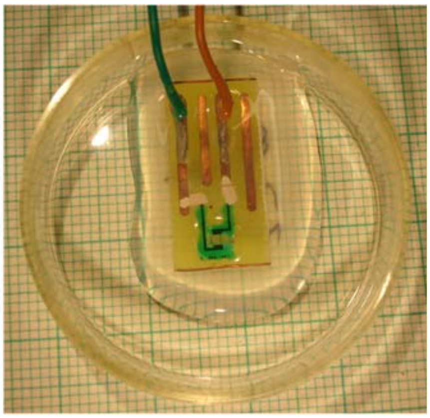

Fig. 2. Encapsulated sensor chip prepared for cells measurements.

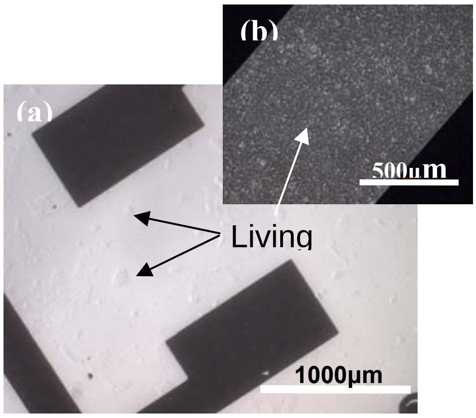

Fig. 3. Optical microscopy image of HEK 293FT cells on a GaN surface a) after one hour and b) after 5 days.

Some of the applied processing steps change the electrical properties of the AlGaN/GaN heterostructure as well contribute to a reduction of the sensors sensitivity. Such processes are high temperature annealing of the contacts and wet etching of the active area of the sensor. Moreover, the cultivation of living cells was observed to affect the properties of AlGaN/GaN surfaces, too. We will present the observed changes of surface and device performance as well as possible recovering methods.

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