



**FACULTY OF ELECTRICAL ENGINEERING
AND INFORMATION SCIENCE**



**INFORMATION TECHNOLOGY AND
ELECTRICAL ENGINEERING -
DEVICES AND SYSTEMS,
MATERIALS AND TECHNOLOGIES
FOR THE FUTURE**

Startseite / Index:

<http://www.db-thueringen.de/servlets/DocumentServlet?id=12391>

Impressum

Herausgeber: Der Rektor der Technischen Universität Ilmenau
Univ.-Prof. Dr. rer. nat. habil. Peter Scharff

Redaktion: Referat Marketing und Studentische
Angelegenheiten
Andrea Schneider

Fakultät für Elektrotechnik und Informationstechnik
Susanne Jakob
Dipl.-Ing. Helge Drumm

Redaktionsschluss: 07. Juli 2006

Technische Realisierung (CD-Rom-Ausgabe):
Institut für Medientechnik an der TU Ilmenau
Dipl.-Ing. Christian Weigel
Dipl.-Ing. Marco Albrecht
Dipl.-Ing. Helge Drumm

Technische Realisierung (Online-Ausgabe):
Universitätsbibliothek Ilmenau
[ilmedia](#)
Postfach 10 05 65
98684 Ilmenau

Verlag:  Verlag ISLE, Betriebsstätte des ISLE e.V.
Werner-von-Siemens-Str. 16
98693 Ilmenau

© Technische Universität Ilmenau (Thür.) 2006

Diese Publikationen und alle in ihr enthaltenen Beiträge und Abbildungen sind urheberrechtlich geschützt. Mit Ausnahme der gesetzlich zugelassenen Fälle ist eine Verwertung ohne Einwilligung der Redaktion strafbar.

ISBN (Druckausgabe): 3-938843-15-2
ISBN (CD-Rom-Ausgabe): 3-938843-16-0

Startseite / Index:
<http://www.db-thueringen.de/servlets/DocumentServlet?id=12391>

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

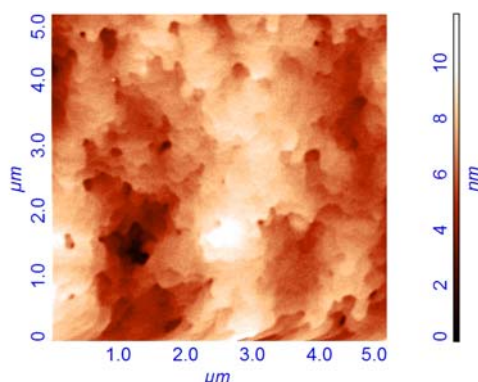


Fig.1. Morphology of an AlGaN/GaN surface after the growth using AFM in non-contact mode.

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 **human embryonic kidney cells (HEK 293FT)** and **chinese hamster ovary 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

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

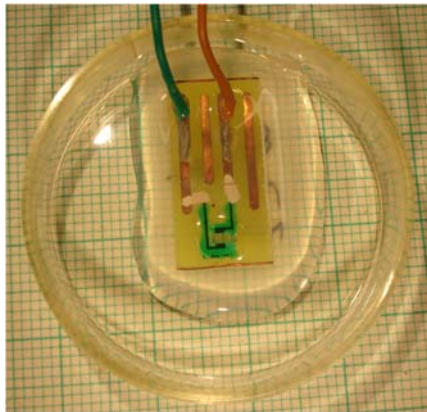


Fig. 2. Encapsulated sensor chip prepared for cells measurements.

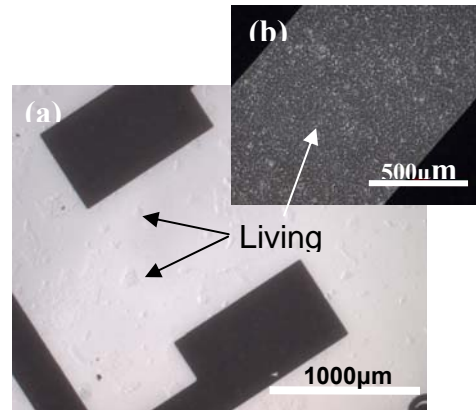


Fig. 3. Optical microscopy image of HEK 293FT cells on a GaN surface a) after one hour and b) after 5 days.

Some of the applied processing steps change the electrical properties of the AlGaIn/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 AlGaIn/GaN surfaces, too. We will present the observed changes of surface and device performance as well as possible recovering methods.

The authors would like to thank Maren Klett for her help with cells preparation. This work was supported by Federal Ministry of Education and Research MacroNano[®] Centre for Innovation Competence at the Technical University Ilmenau, the Thuringian Ministry of Culture (032IK062) and the European Union (GaNano NMP4-CT2003-505614).

References:

- [1] G. Steinhoff, O. Purrucker, M. Tanaka, M. Stutzmann, and M. Eickhoff, *Adv. Funct. Mater.* 2003, 13, No.11, November
- [2] G. Steinhoff, B. Baur, G. Wrobel, et al. *Appl. Phys. Lett.* 86, 033901 (2005)
- [3] K.N. Lee, S.M. Donovan, B. Gila, et al. *J. of the Electrochem Soc.*, 147, 3087 (2000)
- [4] M. A. Garcia, S. D. Wolter, T.-Ho Kim, et al. *Appl. Phys. Lett.* 88, 013506 (2006)
- [5] H-Soo Kim, Y-H Lee, G.-Young Yeom, J.-Won Lee, T.-Il Kim, *Materials Science and Engineering B50*, 82-87(1997)
- [6] T. Hashizume, H. Hasegawa, *App. Surf. Science* 234 , 387-394 (2004)

Authours:

Dipl.-Ing. Irina Cimalla, Dipl.-Ing. Florentina Will, Dipl.-Ing. Katia. Tonisch, Dr. Vadim Lebedev, Dipl.-Ing. Merten Niebelschütz, Dipl.-Ing. Marcel Himmerlich, Dr. Stephan Krischok, Dr. Volker Cimalla, Dipl.-Ing. Gabriel Kittler, Dipl.-Ing Christoph Kremin, PD. Dr. Thomas Friedrich and Prof. Dr. Oliver Ambacher

Institut for Micro- and Nanotechnologies, Technical University Ilmenau, P.O. Box 100565, 98684 Ilmenau, Germany

Phone: 00493677693386

Fax: 00493677693379

E-mail: irina.popa@tu-ilmenau.de