



**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>

B. Lübbers, G. Kittler, V. Cimalla, M. Gebinoga, C. Buchheim, D. Wegener,
A. Schober and O. Ambacher

Setup for colorimetric measurements of aqueous micro- and nanoliter droplets

The analysis of liquids represents one of the most important fields in clinical and pharmaceutical laboratory everyday work and research. Common analysis systems utilize cuvettes with a typical volume of a few 100 μl or are based on closed fluidic systems (lab-on-a-chip). With regard to cost- and analysis efficiency the reduction of sample volume is of great interest [1].

We present a setup for colorimetric measurements in an open fluidic system for micro- and nanoliter droplets. The setup is part of a novel integrated GaN-based system for physical, biological and chemical analysis. Combined with a transparent AlGaIn/GaN-based pH-sensor [2] it allows simultaneous electronic and optical analysis of droplets.

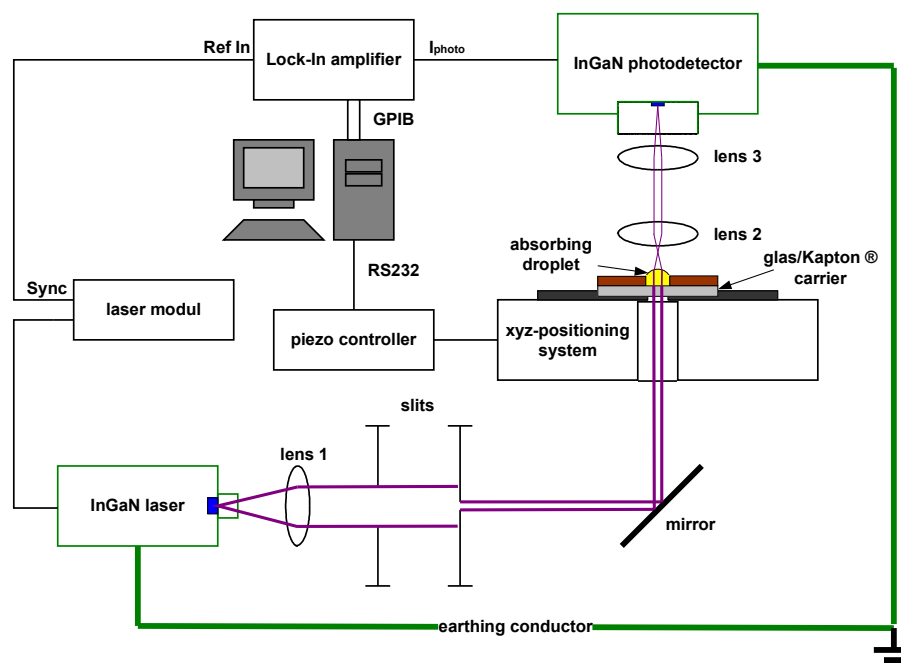


Figure 1: Experimental setup for optical analysis of water based droplets.

A combination of an InGaN laser diode and a novel selective sensitive InGaN photodetector [3] is used to measure optical absorbance of droplets (Fig. 1). The sample droplet is pipetted and positioned manually in the collimated laser beam. To account for the influence of the droplet geometry on the path of light a model for describing the focal length as a function of droplet volume and radius is derived (Fig. 2). The detector optics were adjusted accordingly to focus the transmitted light onto the detector.

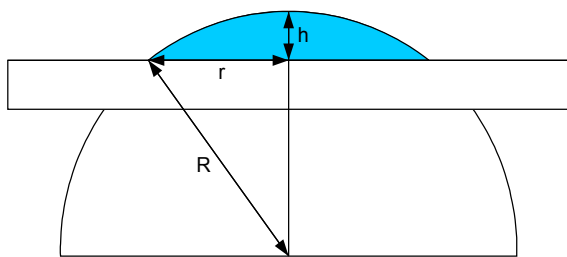


Figure 2: Model of droplet geometry.

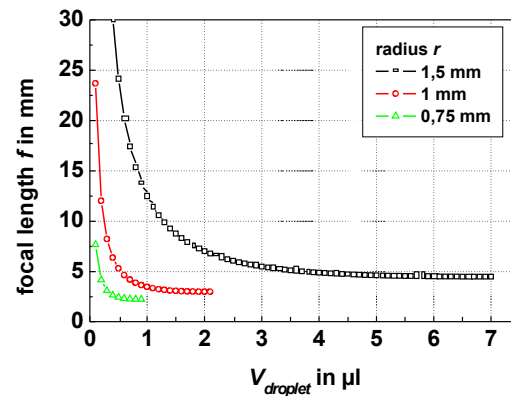


Figure 3: Calculated focal length for different droplet volumes $V_{droplet}$ and radius r .

Positioning accuracy, droplet evaporation and the regulation of humidity as well as the influence of light, temperature and electromagnetic fields limit the accuracy and sensitivity of the setup. To guarantee reproducibly formed droplets a polyimide film with a thickness of 125 μm was structured onto a glass carrier (Fig. 4). The positioning of the droplet with respect to the laser beam was performed by a piezo-driven xyz-positioning system. Droplet evaporation was limited by installing the setup into a glove-box and increasing the humidity to 70 %rH. Ambient light had no influence on the detector signal due to bandpass like sensitivity of the employed InGaN photodetector. Changes in ambient temperature resulted in fluctuations of the measured signal as the laser diode was not stabilized. They were minimized by the temperature control of the glove-box. High frequency electromagnetic interference from the pulsed laser diode could only be suppressed partially and turned out to be the limiting factor for measuring absorbance greater than 1. The temporal stability of the detector signal was measured for different droplet volumes over several minutes and was determined to be ± 1 % (Fig. 5).

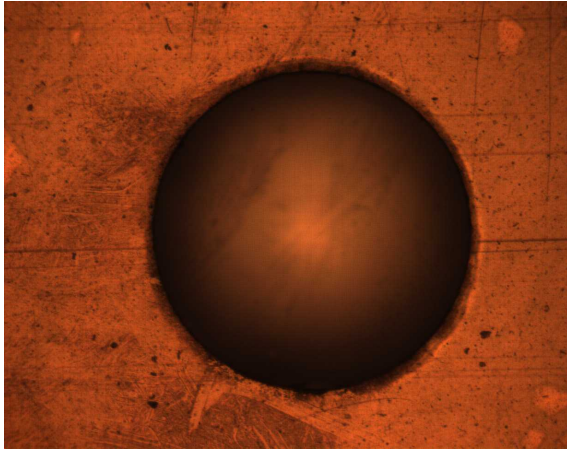


Figure 4: Structured polyimid film with a 5 μ l droplet of water.

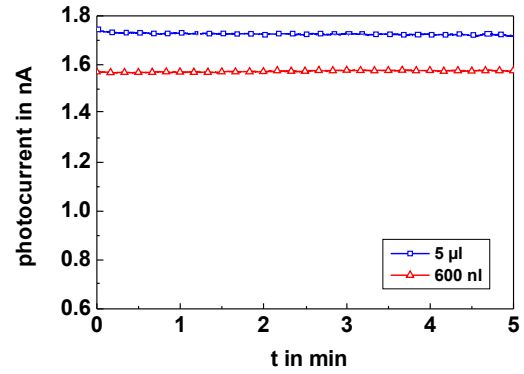


Figure 5: Stability of detector signal for different droplet volumes.

Paranitrophenol (Sigma-Aldrich) was used as a model system for colorimetric measurements. This dye is released in various enzymatic assays and can also be used as a pH indicator. Measurements for different concentrations show that the error in calculated concentration increases dramatically for absorbance lower than 0.1 (Fig. 6). Therefore the working range of this experimental setup with an error of less than 10 % is from 0.1 to 1 absorbance. It could be noticed that in this range the measurements agreed very well with values obtained by a state-of-the-art spectrophotometer (Fig. 7).

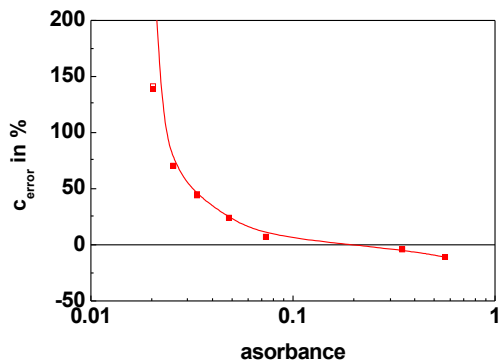


Figure 6: Error in measured concentration with regard to droplet absorbance.

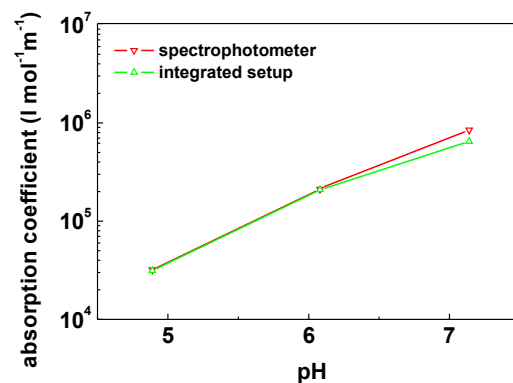


Figure 7: Measured absorption coefficient of paranitrophenol for different pH-values of the droplets.

The setup was sufficiently stable to observe dynamic chemical reactions. The release of paranitrophenol in an enzymatic assay was measured and the reactivity of the enzyme was determined (Fig. 8).

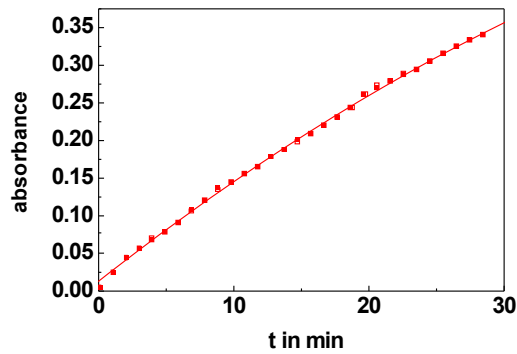


Figure 8: Increase of absorbance due to release of paranitrophenol during enzymatic conversion of acetylparanitrophenylphosphat.

The developed fluidic setup is capable of measuring absorbance in μl - and sub- μl droplets. Stable and reproducible measurements of dye concentration were made between 0.1 and 1 absorbance. Dynamic chemical reactions in μl reaction volumes could be measured.

This work was supported by the Thuringian ministry of culture (TKM) and the European Union (EFRE program: B 678-03001, 6th framework program: GaNano NMP4-CT2003-505614).

References:

- [1] N. Lion, F. Reymond, H.H. Girault and J.S. Rossier, *Current Opinion in Biotechnology*, 15, 31 (2004).
- [2] R. Neuberger, G. Müller, O. Ambacher, and M. Stutzmann, *phys. stat. sol. (a)* **185**, 85 (2001).
- [3] C. Rivera, J.L. Pau, F.B. Naranjo and E. Munoz, *phys. stat. sol. (a)* 201, 2658 (2004).

Authors:

Dipl.-Ing. Benedikt Lübbers¹
 Dipl.-Ing. Gabriel Kittler¹
 Dr. Volker Cimalla¹
 Dr. Michael Gebinoga¹
 Dipl.-Ing. Carsten Buchheim¹
 Dr. Dennis Wegener²
 Dr. Andreas Schober¹
 Prof. Dr. Oliver Ambacher¹

¹Center for Micro- and Nanotechnologies, Technical University Ilmenau, G.-Kirchhoff-Str. 7, 98693 Ilmenau, Germany

Phone: +49 3677 691172, E-mail: benedikt.luebbers@tu-ilmenau.de

²Institute for Physical High Technology Jena, P.O. Box 100239, 07702 Jena, Germany