Functionalized and Oxidized Silicon Nanosheets for Sensors and Optoelectronics

Alina Lyuleeva
A. Rivadeneyra, P. Holzmüller, T. Helbich, B. Rieger, P. Lugli, M. Becherer
Technical University of Munich, Chair of Nanoelectronics, Theresienstr 90/I, 80333 Munich, Germany

Alina.lyuleeva@mytum.de

Until now, the number of transistors in a semiconductor circuit follows quite well Moore*s law. However, the scaling of silicon devices, on which the growth of semiconductor industry is currently based on, reaches its limits. Thus, research needs to find alternative solutions.

2D materials and with them also the monolayered silicon nanosheets (SiNSs) have much to offer. Novel physical properties, such as band gap and conductivity control can be very useful for device fabrication.[1] Nevertheless, ambient conditions, such as oxygen and UV light can easily destroy the SiNSs and convert it into silicon (di)oxide.[2], [3] Surface protection is therefore one of the crucial steps in 2D silicon treatment, before it can be applied in nanotechnology. Different covalent hydrosilylation reactions, either thermal, or initiated with various radical initiators, can be carried out with a variety of functional molecules. This modification step offers stabilization of the sheets for subsequent use. As a result, hybrid systems based on covalently bound molecules on SiNSs were synthesized, offering both materials' properties, which are present in the system.[5]

First, the hereby described hybrid materials were used for the fabrication of solution-gated field-effect transistors, which performance and physical properties are controllable *via* SiNSs' surface groups.[6] Additionally, a highly sensitive photonic sensor was built, showing light absorption starting with wavelengths lower than 450 nm.[7] Finally, the fabrication of a capacitive humidity sensor was performed, which sensitivity can also be easily tuned *via* surface molecules.

In summary, an introduction into a wide range of opportunities will be presented, which come with the ability of surface engineering of 2D silicon and the combination of different disciplines, such as Chemistry, Physics, Electrical Engineering and Nanotechnology.

References

[1] H. Okamoto et al., *Chemi. Eur. J.*, 17, 36, 9864–87, Aug. 2011.
[2] T. Helbich *et al., Chem. - A Eur. J.*, Chem. Eur. J., 2016.
[3] T. Helbich et al., *Nanoscale*, 9, 23, 2017.
[4] T. Helbich *et al., Adv. Funct. Mater.*, 26, 37, 6711–6718, 2016.
[5] T. Helbich *et al.*, *Adv. Funct. Mater.*, 1606764, 2017.
[6] A. Lyuleeva et al., *J. Phys. D. Appl. Phys.*, 50, 13, 135106, 2017.

Figures

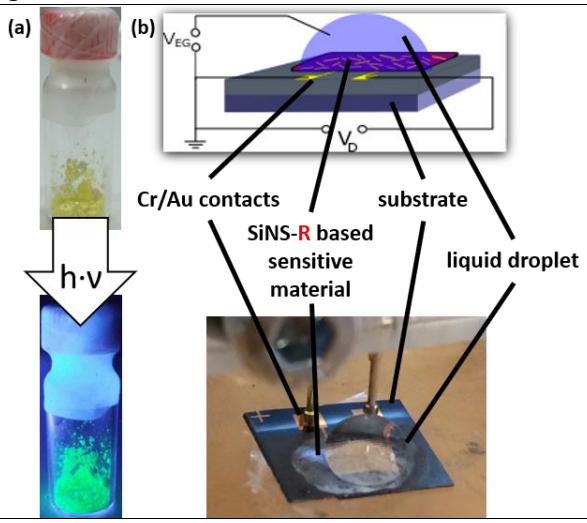

Figure 1: (a) Images of Silicon Nanosheets (SiNSs) under visible light (top) and UV radiation (bottom). The SiNSs emit green photoluminescence at λ = 510 nm. (b) Solution-gated field-effect transistor (SGFET) based on modified SiNSs, which were functionalized *via* hydrosilylation reaction. Properties of the SiNSs can be adjusted for the required application with the covalent modification of the surface.