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Summary of the dissertation:

Integration Techniques for Field-effect Transistors Using Semiconducting Nanoparticles: Single- and Multi-particle Devices

by Karsten Wolff

Integrated circuits on flexible and optical transparent substrates provide new applications for so-called low-cost//low-performance electronics. Efficient manufacturing methods (e.g. roll-to-roll printing techniques) enable mass-production of electronic circuits on plastic foils. Therefore, a high economic potential for printable integrated circuits is expected. Prospective applications are RFID transponders or flexible displays, for example. Since inorganic nanoparticles exhibit virtually non-deteriorating electrical properties, particularly charge carrier mobilities, they are suitable for the use as semiconductor material in field-effect transistors.

This thesis deals with the integration of field-effect transistors using silicon (Si) and zinc oxide (ZnO) nanoparticles. Both materials are relatively low-priced and furthermore available in sufficient quantities and of satisfactory purity grades. The nanoparticles can be cost-effectively deposited by spin-coating of colloidal dispersions. However, due to the particle morphology and the nanocrystalline structure, transistors generally show multiple parasitic effects. For instance, a decrease of the transistor performance can be observed, which is caused by interface states as well as by trap states. With regard to future manufacturing on temperature-sensitive foil substrates, basic devices were integrated on silicon substrates with a strongly limited thermal budget and characterized afterwards. Along with the integration of thin-film transistors, nanoscaled single particle transistors were fabricated in various lateral device architectures for the first time. Additionally, the electrical contacts to the semiconductor were optimized and hence the transistors showed reasonable on/off ratios, subthreshold slopes and charge carrier mobilities.

In order to make separated gate electrodes available, the gate dielectric was exchanged by an optical transparent polymer, while the most promising integration process was entirely performed on glass substrates. First logic inverters on glass substrates with a gain of 6.0 are demonstrated as basic integrated circuits.