Organic Semiconductors in Stretchable Electronics

In the project, the role of stretching strains on the electrical performance of organic semiconducting films in field-effect transistors is investigated. Semiconducting conjugated polymers and small molecules show a variety of structures from nano- to macro-scale depending on their chemical structure and applied film fabrication. For future applications of these materials, it is important to understand how a given film microstructure correlates with changes in electrical performance of a transistor during stretching. Another key objective is to increase stretchability of the semiconducting films, so that their electrical properties do not deteriorate during tensile stress. The gained knowledge will allow the fabrication of integrated circuits based on fully stretchable components. The project will provide technological solutions for implementation of stretchable transistors and circuits in electronic applications.

The supramolecular organization and the electrical properties of stretched organic semiconducting films will be systematically studied. The molecular organization and film morphology are investigated using a broad range of analytical methods including X-ray scattering regarding the molecular arrangement, electron and atomic force microscopy to characterize the domains and optical microscopy to determine the macroscopic ordering. The electrical studies of organic field effect transistors will allow the identification the charge carrier transport before, during and after applying the tensile strain to the semiconducting film. Correlation of the structural and electrical behavior of the films will reveal the most resistant morphology and molecular organization to external strains and will expose principles determining this relation. Conjugated polymers and small molecules as the semiconductors with different type of charge carrier transport will be investigated. To achieve a broad variety of film ordering their chemical structures and the deposition techniques will be systematically varied. To increase the stretchability of the films, the elastomeric properties of the active films will be increased suitable substituents will be introduced to the chemical structures and the semiconductors will be blended into elastomer matrixes. Transistors with high stability and performance during stretching will be used to fabricate electronic circuits.

Development of organic electronics will allow the development of novel and unique technologies, which are not possible with traditional silicon-based systems. One of the most crucial challenges for organic electronics is the fabrication of fully stretchable devices. Therefore, this project will provide important insights into the functionality of organic semiconductors in stretchable electronics. This will open the door towards for instance biomedical sensors that are placed on the human skin of even directly on internal organs during surgeries.