Organic semiconductors - from a lab curiosity to high-performance devices

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The research on organic electronics is driven by new applications using properties like flexibility, easy manufacturing, biocompatibility, etc. While OLED displays and organic solar cells are commercially successful, organic electronic circuits have not yet reached broad application, mainly since device performance is lacking.

In this talk, I will review recent progress in organic semiconductors, leading to improved devices. One aspect are new approaches based on highly ordered organic multilayer structures which have the potential to increase device performance by orders of magnitude. Second, I will discuss improved organic solar cells and photodetectors.

For highly ordered layers, triclinic rubrene crystals are created by heating of amorphous layers and can be electrically doped during the epitaxial growth process to achieve hole or electron conduction. Analysis of the space charge limited current in these films reveals record vertical mobilities of 10cm^2/Vs. To demonstrate the performance of this materials system, pin-diodes with record threshold frequency of 3.7 GHz are built, paving the way for future high-performance organic electronic devices based on carefully designed heterostructures. Furthermore, these structures allow comparatively long minority carrier diffusion lengths, allowing to realize the first organic bipolar transistors.

Furthermore, I will discuss recent improvements of organic solar cells and organic photodetectors. Small-molecule multilayer devices are now ready for mass application. Furthermore, similar structures are also very efficient photodetectors. I will discuss recent progress in understanding the performance limiting factors of such detectors.