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Organic and Printed Large-area Electronics: Disruptive Technologies for Innovative Applications

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Organic electronics is manufactured with carbon-based semiconductors that are processed at low temperature, and thus can be deployed on thin, flexible substrates like plastic foils and paper. Organic semiconductors are often available as ink-like solutions, thus high throughput fabrication of electronics using processes normally designed for graphical printing is feasible and has been the objective of an intense research activity [1-3].
The material properties of organic semiconductors have been improving at an impressive pace in the last two decades: from mobility in the order of 10-5cm2/Vs we reach now state of the art values beyond 1cm2/Vs. Traditionally n-type semiconductors were very sensitive to environmental influence, and thus only p-type transistors were air-stable. This has also changed in the last five years, leading to the development of air-stable complementary organic technologies offering both n and p transistors [4].
Organic transistors are made patterning staggered thin-films of conductive, semi-conductive and insulating materials, and are thus called "thin film" transistors. Device stacks where the gate is either the lowest or the topmost contact are equally common, and the mutual position of source and drain with respect to the semiconductor layer may vary, providing different device geometries.
Due to the limited stability traditionally available from n-type semiconductors, circuits based on organic TFTs (OTFTs) have been mostly developed with p-only technologies. This, together with fact that no standard method exists to precisely dope organic semiconductors and thus to control the threshold voltage of OTFTs, led to a rather slow development of circuits based on organic transistors [5]. The appearance of double-gate structures, which allow electrical tuning of the threshold, together with the availability of the first complementary technologies, has given a strong impulse to circuit development in the last couple of years. Nowadays digital circuits with a complexity level of about five thousands gates [6] are state of the art, together with elementary analogue functions and data converters with an effective resolution of 4 bit [7].
Applications of organic electronics cover all domains where mechanical flexibility, large area capability and very high production throughput, together with potential low cost per area, are of interest. Flexible and roll-up displays, item-level RFID tags, intelligent sensor labels, OLED lighting, solar cells, etc. are some examples. For particle physics applications the large area capability could be a very interesting asset, but the intrinsic thin-film form factor of organic electronics makes it rather unsuited for particle detectors. Future developments will probably see an increasing popularity of (n-type) metal oxides (like ZnO or GaInZnO) used as high mobility, large-area compatible, low-temperature semiconductors, probably coupled to organic materials as p-type semiconductors.
The presentation will give an overview of devices, circuits and applications based on OTFTs, and will stimulate a debate on the possible use of this technology in high energy physics.

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