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Flexible, Ultra-Low Voltage, Large-Area Direct Radiation Detectors Based On Organic Semiconductors

A new generation of ionizing radiation sensors based on organic materials is attracting a large attention exploiting appealing features of such as ease of processing, low power supply and mechanical flexibility. Moreover, the equivalence of the typical density of organic molecules to that of human tissue makes them very suitable for medical X-ray direct dosimetry.
In the field of ionizing radiation detection, organic materials have been mostly employed so far in indirect radiation detection systems, either as scintillating material or as (organic) photodetectors.

Our approach is based on the use of organic semiconductors as the active material for the direct detection of ionizing radiation, implementing real-time and room temperature operating sensors. In the last years, a few works reported the proof-of-principle for direct X-ray detection based either on organic semiconducting single crystals [1] or on polymer thin-films blended either with π-conjugated small molecules, inorganic high-Z nanocomponents [2] to enhance the sensitivity to X-rays improving the charge carriers mobility and the stopping power of the material.

We fabricated direct, thin detectors based on micro-crystalline thin films of TIPS-pentacene deposited by inkjet printing onto flexible substrates and we assessed their high X-ray sensitivity (up to several hundreds of nC/Gy at ultra-low bias of 0.2 V). We investigated the direct X-ray photo-conversion process in order to interpret the detection mechanism and we developed a kinetic model that gives an important insight into the physical process that leads to highly sensitive response to ionizing radiation by such low-Z organic materials.

Finally, we assessed the possibility to use the detector under mechanical strain and gave the first demonstration of a 2×2 pixelated matrix organic detector [3].

These results open the way for novel flexible, large area and low voltage ionizing radiation detection systems, capable of providing quantitative and real time information on the dose rate and on the spatial distribution of impinging radiation.

References
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