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Boosting direct X-ray detection in organic thin films by small molecules tailoring

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The attention on the application of organic electronics for the detection of ionizing radiation is rapidly growing among the international scientific community, due to the great potential of the organic technology to envisage the need of large-area conformable sensor flat panels.
In recent years, our group reported about the employment of solution-grown organic devices as reliable direct X-ray detectors, operating at room temperature [1], opening the way to the development of a new class of flexible organic direct X-ray detectors based on TIPS-pentacene thin films, with sensitivity values up to hundreds of nC/Gy at ultra-low bias of 0.2 V [2]. However, high-energy photon absorption is challenging as organic materials are constituted of atoms with low atomic numbers.
The blending into the organic matrix of high-Z nanoparticles, carbon nanotubes and inorganic micrometer-sized scintillating particles has been explored as a possible solution. However, although improvement in the detecting performance has been shown, for all of the above solutions, the presence of even small fractions of the "dopant"(i.e. nanoparticles, carbon nanotubes or scintillating particles) strongly degrade the electrical performance and the stability of the organic film. Moreover, the employment of thick films or bulky single crystals to increase the absorption, results in an increase of the operating voltage and limits the bendability of the device, thus sacrificing the potential advantages.
Here it is reported how, by synthesizing new solution-processable organic molecules derived from 6,13-bis(triisopropylsilylethynyl)pentacene (TIPS-pentacene) and 2,8-Difluoro-5,11-bis(triethylsilylethynyl)anthradithiophene (diF-TES-ADT), with Ge-substitution in place of the Si atoms to increase the material atomic number, it is possible to boost the X-ray detection performance of organic thin films on flexible plastic substrates [3]. TIPGe-pentacene based flexible OTFTs show high electrical performance with higher mobility (0.4 cm2 V-1 s-1) and enhanced X-ray sensitivity, up to 9.0 x 105 μC Gy-1 cm-3, with respect to TIPS-pentacene based detectors. Moreover, similar results are obtained for diF-TEG-ADT devices, confirming that the proposed strategy, i.e. increasing the atomic number of organic molecules by chemical tailoring to improve X-ray sensitivity, can be generalized to organic thin film detectors, combining high X-ray absorption, mechanical flexibility and large area processing.

[1] B. Fraboni et al., Adv. Mater.,24,2289 (2012).
[2] L. Basiricò et al., Nat. Commun., 7, 13063 (2016).
[3] A. Ciavatti et al., Adv. Funct. Mater., 1806119 (2018).

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