



器件制备及器件物理

基于并五苯/酞菁铅异质结的近红外光敏有机场效应管

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摘要：采用并五苯(Pentacene)和酞菁铅(PbPc)两种有机材料作为有源层,制备了异质结有机光敏场效应管。在波长为808 nm、强度为124 mW/cm²的近红外光照条件下,异质结phOFET获得最大的光暗电流比达 4.4×10^4 ,栅压为-50 V时的最大光响应度为118 mA/W,比单层酞菁铅phOFET分别高出766倍和785倍。在经过120 h后,器件的最大光暗电流比和最大光响应度分别稳定于 5.4×10^4 和326 mA/W附近。由于在异质结phOFET中采用了对近红外光具有高吸收效率的酞菁铅作为光敏层,而高空穴迁移率的并五苯材料作为靠近栅介质的沟道层,光生载流子的产生与传输能力得到了有效的提高。实验结果表明,基于并五苯/酞菁铅的有机异质结应用于光敏有机场效应管的结构设计中,可以使phOFET成为一种同时具有良好光敏性及稳定性的近红外光探测器件。

关键词：异质结 并五苯 酞菁铅 近红外 光敏有机场效应管

Near Infrared Photoresponsive Organic Field-effect Transistors by Utilizing Pentacene/Lead Phthalocyanine Heterojunction

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Abstract: Photoresponsive organic field-effect transistors (phOFETs) were fabricated by utilizing organic heterojunction based on pentacene and lead phthalocyanine (PbPc). Under a near-infrared light illumination (wavelength 808 nm and a power intensity of 124 mW/cm²), the heterojunction photoresponsive organic field-effect transistors (HJ-phOFETs) exhibited a maximum photosensitivity of 4.4×10^4 , and a maximum photoresponsivity of 118 mA/W, which were 766 times and 785 times higher than that of PbPc single-layer phOFET, respectively. It was observed that the maximum photosensitivity and the maximum photoresponsivity stabilized around 5.4×10^4 and 326 mA/W after 120 h, respectively. The high performance of HJ-phOFET is attributed to the utilization of PbPc as photosensitive layer which has high absorbance in near infrared region (NIR) and pentacene as channel layer with high hole mobility. These results indicate that the HJ-phOFET based on pentacene and PbPc is proved to be a NIR photodetector with excellent photosensitivity and stability.

Keywords: heterojunction pentacene PbPc near infrared photoresponsive organic field effect transistor

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参考文献:

- [1] Mukherjee B, Mukherjee M, Choi Y, *et al.* Control over multifunctionality in optoelectronic device based on organic phototransistor [J]. *ACS Appl. Mater. Interf.*, 2010, 2(6): 1614-1620.
- [2] Clark J, Lanzani G. Organic photonics for communications [J]. *Nat. Photon.*, 2010, 4(7): 438-446.
- [3] Chen D Q, Yao B, Fan G Y, *et al.* Influence of donor-acceptor layer sequence on photoresponsive organic field-effect transistors based on palladium phthalocyanine and C₆₀ [J]. *Appl. Phys. Lett.*, 2010, 102(16): 163303-1-5.
- [4] Marjanovič N, Singh T B, Dennler G, *et al.* Photoresponse of organic field-effect transistors based on conjugated polymer/fullerene blends [J]. *Org. Electron.*, 2006, 7(4): 188-194.
- [5] Kim F S, Guo X G, Watson M D, *et al.* High-mobility ambipolar transistors and high-gain inverters from a donor-acceptor copolymer semiconductor [J]. *Adv. Mater.*, 2010, 22(4): 478-482.
- [6] Lou Y H, Xu M F, Wang Z K, *et al.* Dual roles of MoO₃-doped pentacene thin films as hole-extraction and multicharge-separation functions in pentacene/C₆₀ heterojunction organic solar cells [J]. *Appl. Phys. Lett.*,

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- [7] Wang H B, Wang X J, Huang H C, *et al.* Isotype heterojunction between organic crystalline semiconductors [J]. *Appl. Phys. Lett.*, 2008, 93(10):103307-1-3.
- [8] Wang H B, Wang X J, Yu B, *et al.* p-p isotype organic heterojunction and ambipolar field-effect transistors [J]. *Appl. Phys. Lett.*, 2008, 93(11):113303-1-3.
- [9] Yi M D, Huang J Y, Ma D G, *et al.* High gain in hybrid transistors with BAQ₃/AlQ₃ isotype heterostructure emitter [J]. *Appl. Phys. Lett.*, 2008, 92(24):243312-1-3.
- [10] Pan F, Tian H K, Qian X R, *et al.* High performance vanadyl phthalocyanine thin-film transistors based on fluorobenzene end-capped quaterthiophene as the inducing layer [J]. *Org. Electron.*, 2011, 12(8):1358-1363.
- [11] Shen L, Xu Y, Zhang X D, *et al.* Short-circuit current density improvement of inverted polymer solar cells using PbPc to enhance photon absorption over 600 nm [J]. *Sol. Energy Mater. Sol. C.* 2010, 94(12):2451-2454 [crossref](#)
- [12] Kim H J, Shim H S, Kim J W, *et al.* CuI interlayers in lead phthalocyanine thin films enhance near-infrared light absorption [J]. *Appl. Phys. Lett.*, 2012, 100(26):263303-1-4.
- [13] Jurchescu O D, Popinciuc M, Van Wees B J, *et al.* Interface-controlled, high-mobility organic transistors [J]. *Adv. Mater.*, 2007, 19(5):688-692.
- [14] Yao B, Lv W L, Chen D Q, *et al.* Photoresponsivity enhancement of pentacene organic phototransistors by introducing C₆₀ buffer layer under source/drain electrodes [J]. *Appl. Phys. Lett.*, 2012, 101(16):163301-1-4.
- [15] Hamilton M C, Martin S, Kanicki J. Thin-film organic polymer phototransistors [J]. *IEEE Trans. Elect. Dev.*, 2004, 51(6):877-885.
- [16] Suchand Sangeeth C S, Stadler P, Schaur S, *et al.* Interfaces and traps in pentacene field-effect transistor [J]. *J. Appl. Phys.*, 2010, 108(11):113703-1-7.
- [17] Park J H, Cho S W, Park S H, *et al.* The effect of copper hexadeca fluorophthalocyanine (F₁₆CuPc) inter-layer on pentacene thin-film transistors [J]. *Synth. Met.*, 2010, 160(1):108-112.
- [18] Kagan C R, Afzali A, Graham T O. Operational and environmental stability of pentacene thin-film transistors [J]. *Appl. Phys. Lett.*, 2005, 86(19):193505-1-3.
- [19] Kumaki D, Yahiro M, Inoue Y, *et al.* Air stable, high performance pentacene thin-film transistor fabricated on SiO₂ gate insulator treated with β-phenethyltrichlorosilane [J]. *Appl. Phys. Lett.*, 2007, 90(13):133511-1-3.
- [20] Baran J D, Larsson J A. Theoretical and experimental comparison of SnPc, PbPc, and CoPc adsorption on Ag(111) [J]. *Phys. Rev. B.* 2010, 81(7):075413-1 [crossref](#)
- [21] Ahmad A, Collins R A. FTIR characterization of triclinic lead phthalocyanine [J]. *J. Phys. D: Appl. Phys.*, 1991, 24(10):1894-1897.
- [22] Wang H B, Yan D H. Organic heterostructures in organic field-effect transistors [J]. *NPG Asia Mater.*, 2010, 2(2):69-78.[JP]
- [23] Zaumseil J, Sirringhaus H. Electron and ambipolar transport in organic field-effect transistors [J]. *Chem. Rev.*, 2007, 107(4):1296-1323.
- [24] Chen F C, Kung L J, Chen T H, *et al.* Copper phthalocyanine buffer layer to enhance the charge injection in organic thin-film transistors [J]. *Appl. Phys. Lett.*, 2007, 90(7):073504-1-3.
- [25] Heremans P, Cheyns D, Rand B P. Strategies for increasing the efficiency of heterojunction organic solar cells: Material selection and device architecture [J]. *Acc. Chem. Res.*, 2009, 42(11):1740-1747.