**Unconventional and stretchable semiconductor materials and devices by molecular design, doping and film morphology tuning**

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**Abstract** Organic electronics is a technology enabling the fabrication of mechanically flexible/stretchable electronic circuits and devices using low-temperature, possibly additive, processing methodologies. In this presentation we report the development of novel semiconductors, as well as thin-film engineering, for flexible and stretchable organic and inorganic thin-film transistors, electrochemical transistors, and circuits. In particular we show that “soft” polymers comprising naphthalenediimide units co-polymerized with “rigid” and “flexible” organic units can change how charge transport is affected by mechanical stress, demonstrating that polymer backbone composition is more important then film degree of texturing. Furthermore, molecular design of polymers enables plasticization of small molecule semiconductor used in thin-film transistors. Finally, we report new “soft” transistor architectures using porosity as key element enhancing mechanical flexibility and tune charge transport. The resulting devices can better sustain mechanical stress, sense analytes, intercalate ions, and be chemically doped. Finally, we report our recent work on n-doping organic semiconductors using a novel strategy involving catalysts.

Reference

1. Wang, B.; Huang, W.; Lee, S.; Huang, L.; Wang, Z.; Chen, Y.; Chen, Z.; Feng, L.-W.; Wang, G.; Yokota, T.; Someya, T.; Marks, T. J.; Facchetti, A. Foundry-compatible high-resolution patterning of vertically phase-separated semiconducting films for ultraflexible organic electronics. *Nat. Commun.* **2021**, *12*, 4937.

2. Huang, L.; Wang, Z.; Chen, J.; Wang, B.; Chen, Y.; Huang, W.; Chi, L.; Marks, T. J.; Facchetti, A. Porous Semiconducting Polymers Enable High-Performance Electrochemical Transistors. *Adv. Mater. (Weinheim, Ger.)* **2021**, 33(14), 2007041.

3. Velusamy, A.; Yu, C.-H.; Afraj, S. N.; Lin, C.-C.; Lo, W.-Y.; Yeh, C.-J.; Wu, Y.-W.; Hsieh, H.-C.; Chen, J.; Lee, G.-H.; Tung, S.-H.; Liu, C.-L.; Chen, M.-C.; Facchetti, A., Thienoisoindigo (TII)-Based Quinoidal Small Molecules for High-Performance n-Type Organic Field Effect Transistors. *Adv. Sci. (Weinheim, Ger.)* **2021,** *8* (1), 2002930.

4. Yao, Y.; Huang, W.; Chen, J.; Wang, G.; Chen, H.; Zhuang, X.; Ying, Y.; Pinga, J.; Marks, T. J.; Facchetti, A. Flexible Complementary Circuits Operating at Sub-0.5 Volt via Hybrid Organic-Inorganic Electrolyte Gated Transistors *Proc. Natl. Acad. Sci. U. S. A.* **2021**, *118* (44) e2111790118.

5. Guo, H.; Yang, C.Y.; Zhang, X.; Motta, A.; Feng, K.; Xia, Y.; Shi, Y.; Wu, Z.; Yang, K.; Chen, J.; Liao, Q.; Tang, Y.; Sun, H.; Woo, H. Y.; Fabiano, S.; Facchetti, A.; Guo, X. Transition metal catalysed molecular n-doping of organic semiconductors. *Nature* **2021**, *599*, 67.

6. Chen, J.; Huang, W.; Zheng, D.; Xie, Z.; Zhuang, X.; Zhao, D.; Chen, Y.; Su, N.; Chen, H.; Pankow, R. M.; Gao, Z.; Yu, J. Guo, X.; Cheng, Y.; Strzalka, J.; Yu, X.; Marks, T. J.; Facchetti, A. Highly-Stretchable Organic Electrochemical Transistors with Strain-Resistant Performance *Nature. Mater.* **2022**, *21*, 564–571.

**Author Introduction** Antonio Facchetti is a co-founder and currently the Chief Technology Officer of Flexterra Corporation. He is also an Adjunct Professor at Northwestern University and a Guest Professor at Linkoping University. He has published more than 550 research articles, 14 book chapters, and holds more than 130 patents. He received the ACS Award for Creative Invention, the Giulio Natta Gold Medal of the Italian Chemical Society, the team IDTechEx Printed Electronics Europe Award, the corporate Flextech Award. He is a Fellow of the European Academy of Sciences, National Academy of Inventors, MRS, AAAS, PMSE, Kavli, and RSC.

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