Materials, Chemistry and Processes for Opto-Electronics, Bio-Electronics and Energy Devices

Facchetti Lab @ GT

Our work focuses on designing stretchable polymer, semiconductor and hybrid nanostructures for applications in high performance, ultra flexible optoelectronics, bioelectronics and energy applications. We explore the structure-property-performance relationships in inorganic, organic and hybrid materials using novel synthesis and device processing techniques.

For a full list of research areas and publications, visit us on our website:

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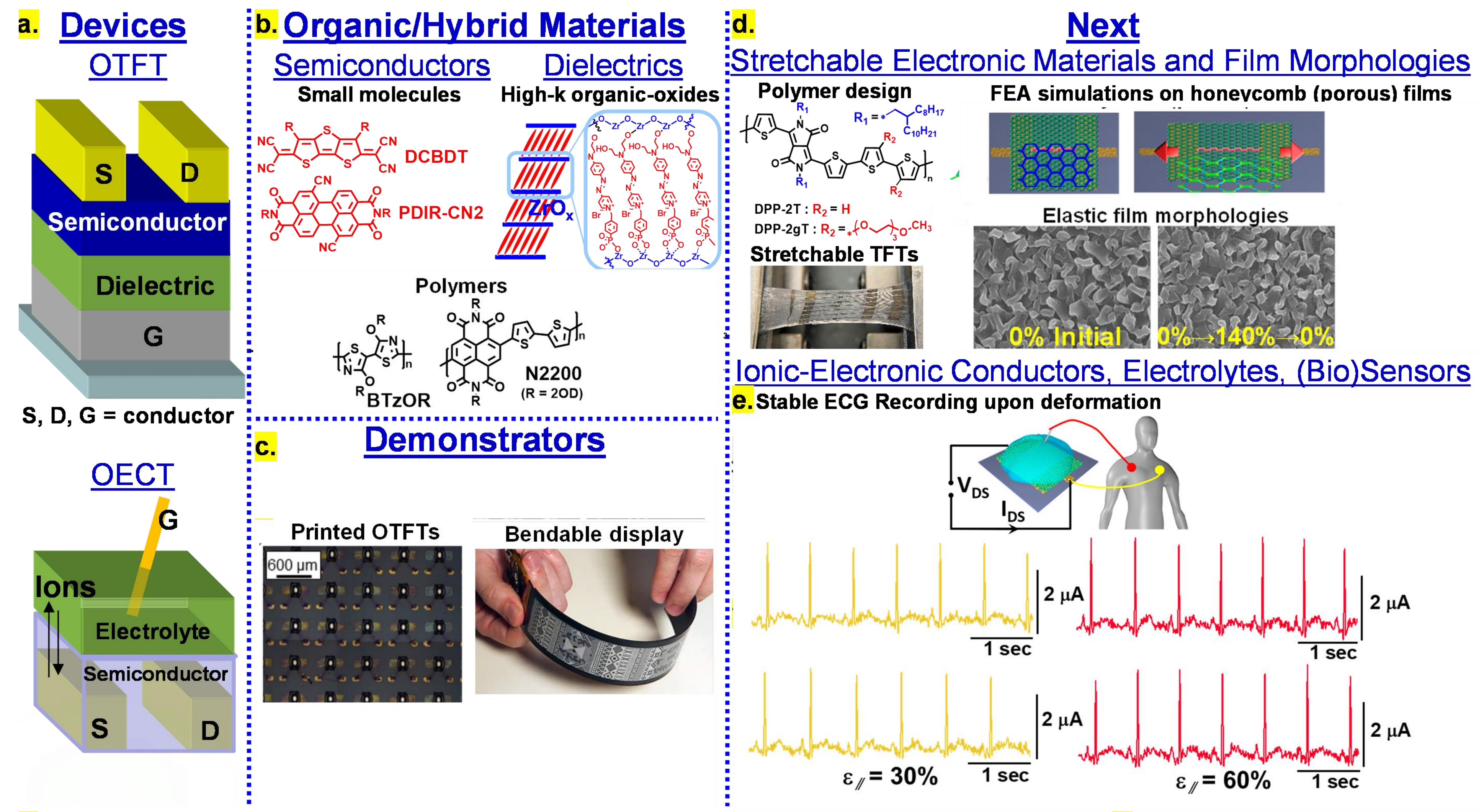
Organic/Printed/Soft Electronics

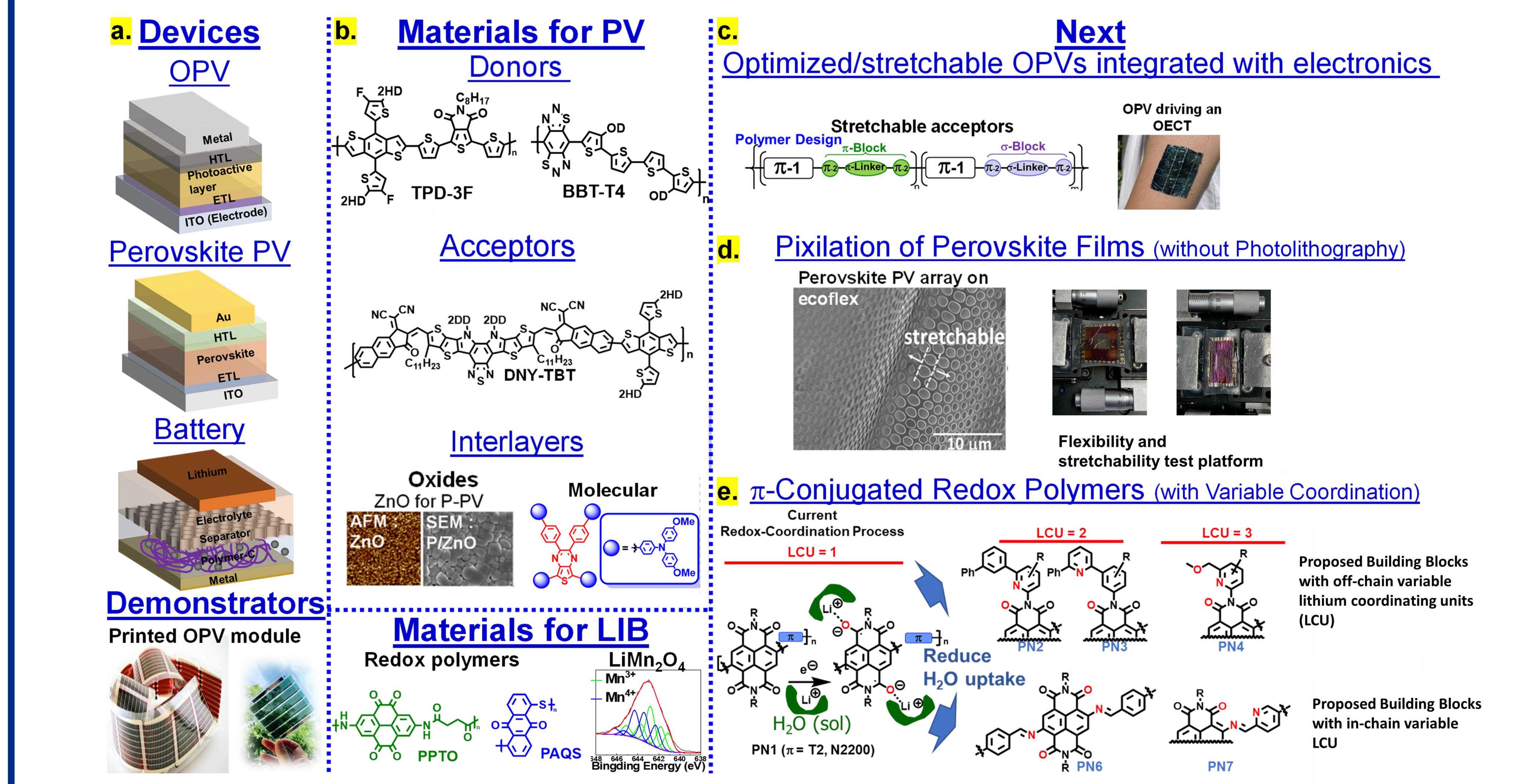
Goal: Advancing organic/printed/soft electronics, a novel approach to fabricating electronic devices on flexible plastics using soft organic/hybrid materials and printing methods. We aim to develop thin-film transistor (TFT) materials for flexible displays, electronic tags, and sensors with mechanical flexibility, impact resistance, and cost-effective production.



a. Structure and material components of a thin-film transistor (TFT) and electrochemical transistor (ECT). **b.** Examples of semiconductor and dielectric materials developed by our group at NU and at Polyera/Flexterra Corporation. **c.** Devices and demonstrators fabricated by our group. **d.** New stretchable semiconductors, elastic film morphologies, and TFTs. **e.** OECTs fabricated with new semiconductors and electrolyte for physiological sensing.

Energy Production and Storage Materials

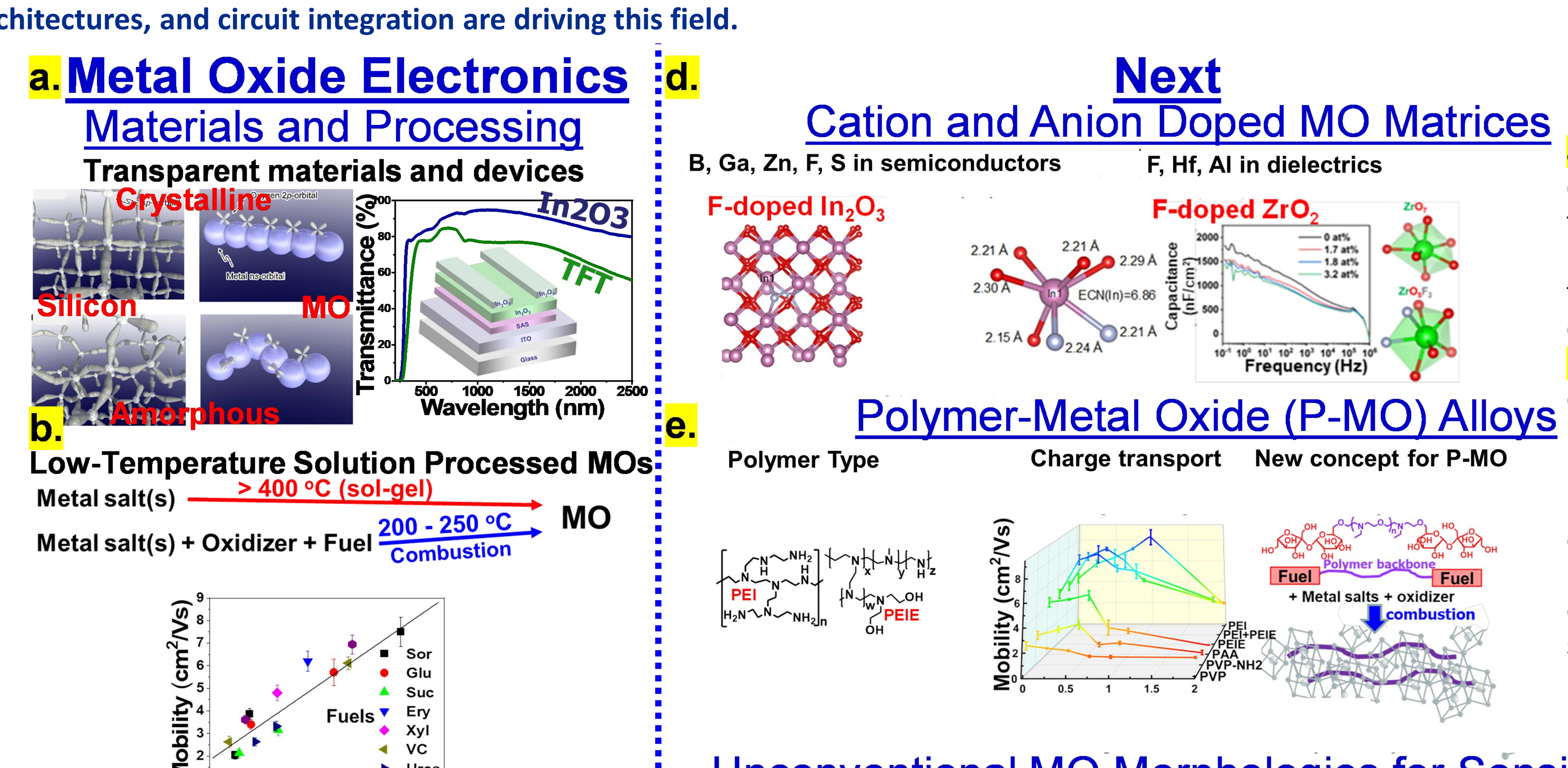
Goal: Sustainable, affordable energy production and storage, focusing on thin-film photovoltaic (PV) cells, including organic and perovskite types, optimizing photoactive/charge-carrying materials and battery tech for consumer electronics, electric vehicles, sensors, smart clothing, and e-skin. Emphasis is on targeting challenges such as reliance on critical raw materials and poor battery performance on deformable platforms.



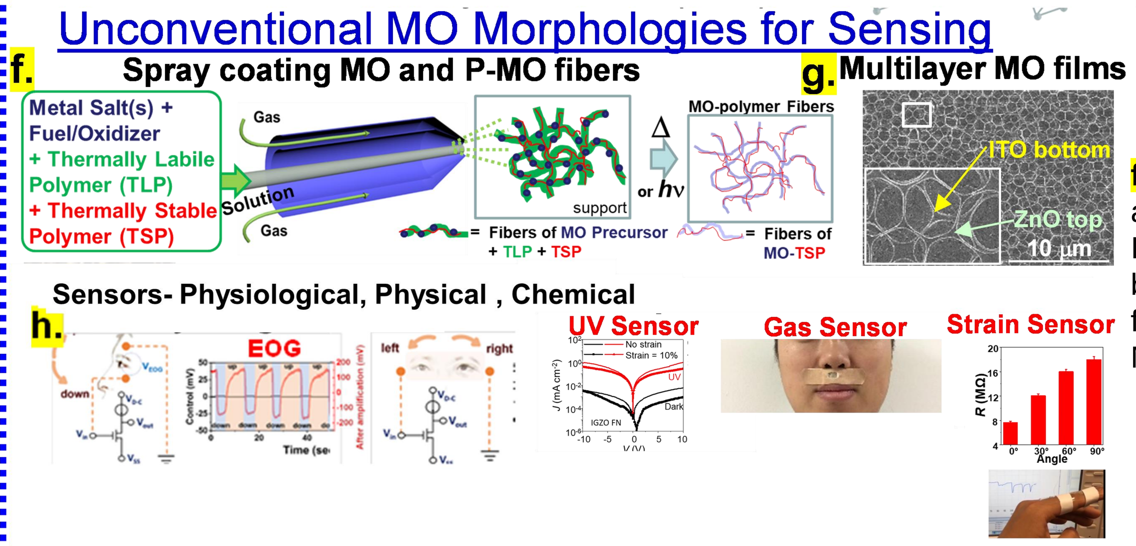
a. Structure and materials for devices and OPV demonstrators built at Raynergy. **b.** Example of materials developed in my groups for PV (top) and LIB (bottom) applications. **c.** Proposed acceptor semiconductors to enhance OPV elasticity and photograph of an OPV-OECT array on SEBS. **d.** Perovskite micro-dot array using polymer film template and fabrication of stretchable ultra-high resolution perovskite PV/photodiodes. **e.** Design of redox polymers for high electrical and ionic conductivities and suppressed water uptake for reducing film morphological variations during redox cycles.

Transparent/Solution Processable Metal Oxide Electronics

Goal: Advancing transparent electronics to create functional materials/devices for consumer electronics, energy harvesting, and transportation. Innovations transforming glass surfaces into electronic devices enhance security systems and enable electricity generation. Our progress in materials, processing, device architectures, and circuit integration are driving this field.



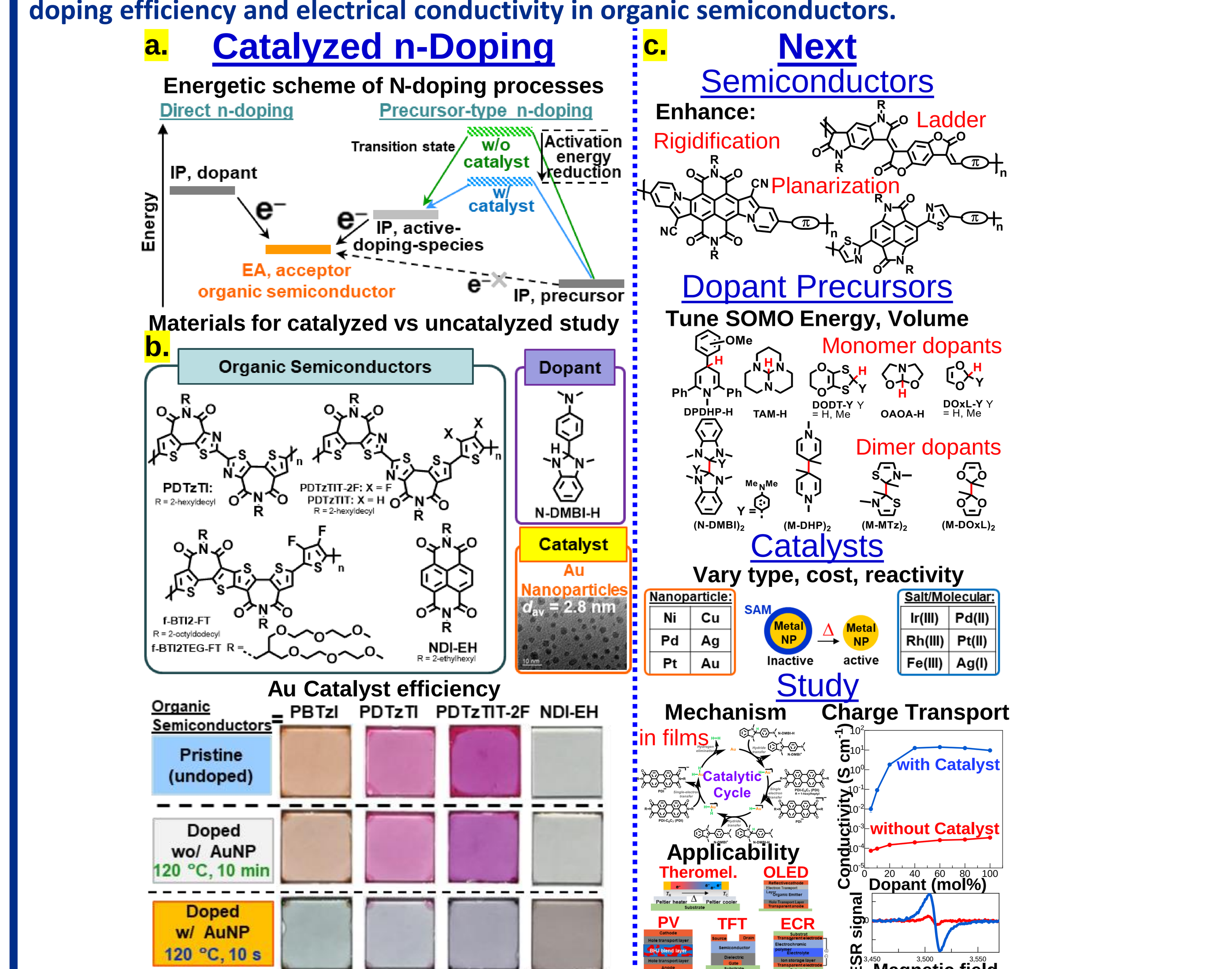
a. MO electronic structure (VB dominated by metal s-orbitals) vs Si for transparency and electron mobilities in amorphous phase (the first optically transparent TFT developed by our group). **b.** Fabrication of MO films by combustion synthesis- heat generated by oxidizer-fuel redox converts MO precursors into pure/dense films. **c.** MO devices fabricated with collaborators. **d.** Doping strategies for new solution-processed MO compositions. **e.** Fabrication of semiconducting and amorphous polymer-MO films and design of new polymers for combustion synthesis.



f. Spray coating of MO and P-MO fibers. **g.** ITO(bottom)/ZnO(top) bilayer by breath figure/lamination. **h.** MO fiber sensors.

N-Doping of Organic Semiconductors

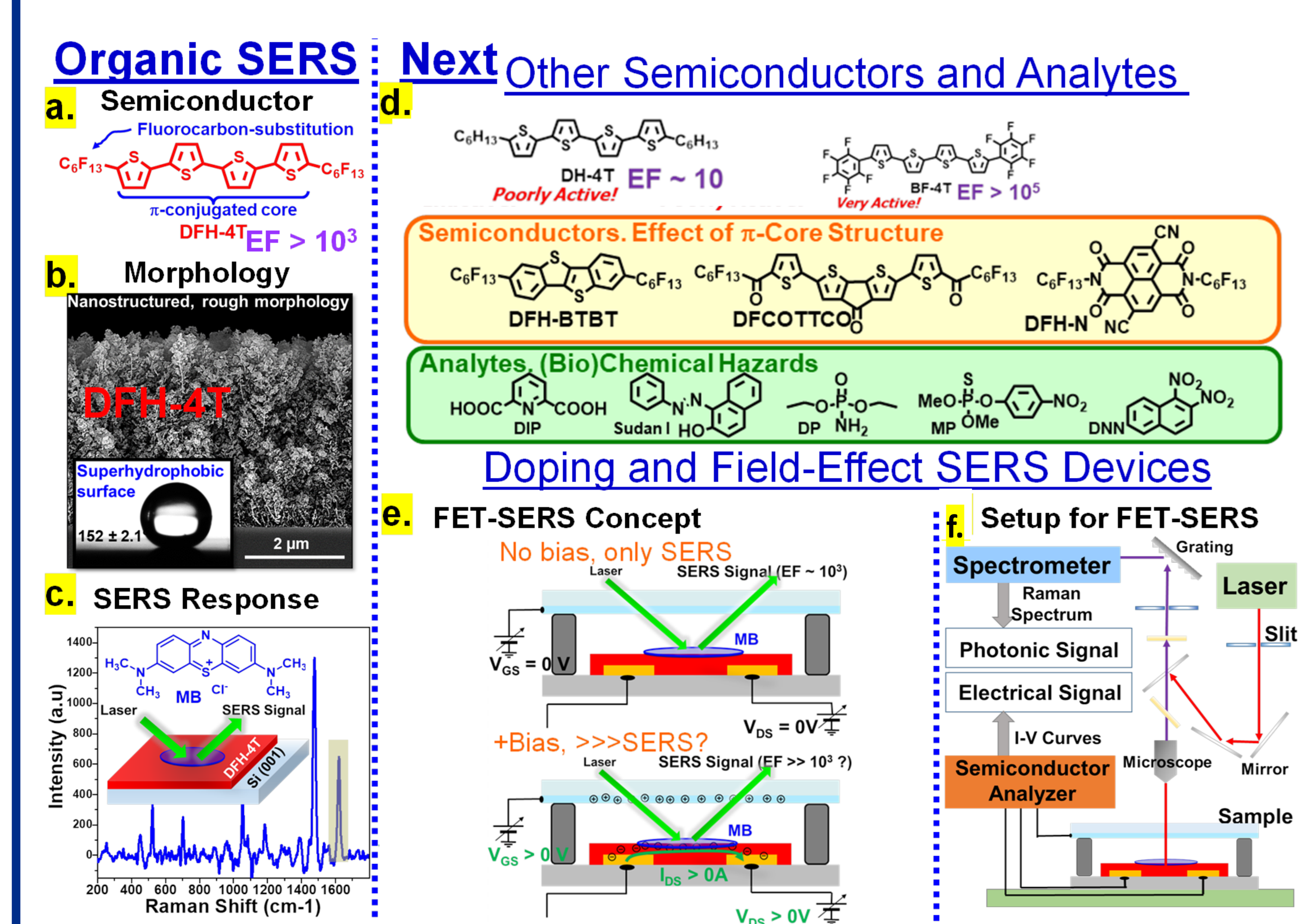
Goal: To address limitations in chemical accessibility, doping efficiency, electron mobility, and conductivity for n-doped materials. Our recent discovery that Au nanoparticles can catalytically accelerate the doping of organic semiconductors with a molecular dopant (N-DMBI-H), enhancing n-doping efficiency and electrical conductivity in organic semiconductors.



a. Schematic of the reaction coordinate for n-doping via direct and precursor n-dopants. **b.** Structures of semiconductors, dopant and SEM of the Au catalyst used for the doping experiments shown in the photos at the bottom. **c.** Proposed materials and catalysts for additional experiments to broaden the scope and applicability of catalyzed n-doping.

Organic SERS Sensors

Goal: Surface-enhanced Raman spectroscopy (SERS) is a powerful surface-sensitive technique. While nanostructured metal films are high performing with enhancement factors > 10^10, they are limited by high cost, complex fabrication, and chemical aging. Our research has identified certain organic semiconductors as efficient SERS-active platforms for molecular detection.



a. Structure of DFH-4T with highlighted key molecular components. **b.** SEM and contact angle of a DFH-4T film featuring the rough and hydrophobic surface. **c.** Raman spectra of MB on top of a DFH-4T films with highlighted the enhanced Raman line. **d.** Chemical structure of recent SERS results for the indicated compounds (MB as probe) and of the organic semiconductor and analytes to be studied. **e.** Design and the new FET-SERS devices where application of a bias will enhance the carried density in the semiconductor (TFT channel) varying both SERS response and conductivity. **f.** Measurement setup.

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