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PRF# UNI656095-UNI6
Project Title: “Electrochemical Study of Electronic Properties of Organic Thin Films in Orthogonal Electrolytes.”
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Annual Report 2018

Project Summary.
One of the main experimental challenges for organic materials is a lack of adequate techniques to study their electronics properties. Due to the “soft nature” of organic (as well as organic/inorganics, so called hybrid) thin films, they are very sensitive to the environment (particularly oxygen and water) and can be easily degraded at elevated temperatures, extensive exposure to X-rays or UV radiation or electron beam. For example, application of electrochemical methods to study electronic properties of organic materials are so far almost exclusively limited to non-polar polymers, since conventional electrolyte solvents is known to dissolve polar polymeric or small molecules organic thin films. In our project *we propose to transform traditional electrochemistry to unleash its application for virtually all existing organic and hybrid semiconductors, including weakly bonded small molecule organic films*.

Publications.
1. P.A. Obraztsov, D. Lyashenko, P.A. Chizhov, K. Konishi, N. Nemoto, M. Kuwata-Gonokami, E. Welch, A.N. Obraztsov, A. Zakhidov “Ultrafast zero-bias photocurrent and terahertz emission in hybrid perovskites”, Comm. Physics 1, 14 (2018).
2. S. Venkatesan, M. Hasan, J. Kim, N.R. Rady, S. Sohal, E. Neier, Y. Yao, and A. Zakhidov, “Tailoring nucleation and grain growth by changing the precursor phase ratio for efficient organic lead halide perovskite optoelectronic devices” J. Mater. Chem. C 5, 10114 (2017).
3. M. Hasan, S. Venkatesan, D. Lyashenko, J.D. Slinker, and A. Zakhidov, “Solvent Toolkit for Electrochemical Characterization of Hybrid Perovskite Films,” Anal. Chem. 89, 9649 (2017).
4. D. Lyashenko, A. Perez, A. Zakhidov, “High-resolution patterning of organohalide lead perovskite pixels for photodetectors using orthogonal photolithography”, PSS A, 214, 1600302 (2017).
5. C. Manspeaker, S. Venkatesan, A. Zakhidov, and K.S. Martirosyan, “Role of interface in stability of perovskite solar cells”, Curr. Opin. Chem. Eng. 15, 1 (2017).
6. A.I. Chernov, V.A. Eremina, J. Shook, A. Collins, P. Walker, P. V. Fedotov, A.A. Zakhidov, and E.D. Obraztsova, “Field Effect Transistor Based on Solely Semiconducting Single-Walled Carbon Nanotubes for the Detection of 2-Chlorophenol” PSS B 1700139 (2017).
7. E. Neier, R.A. Ugarte, N. Rady, S. Venkatesan, T.W. Hudnall, A. Zakhidov, “Solution-processed organic light-emitting diodes with emission from a doublet exciton; using (2,4,6-trichlorophenyl)methyl as emitter”, Organic Electronics, 44 ,126 (2017).
8. E. Welch, L. Scolfaro, A. Zakhidov, “Density functional theory + U modeling of polarons in organohalide lead perovskites”, AIP Advances 6, 125037 (2016).

9. C. Manspeaker, P. Scruggs, J. Preiss, D.A. Lyashenko, and A. Zakhidov, “Reliable Annealing of $CH_3NH_3PbI_3$ Films Deposited on ZnO”, J. Phys. Chem. C 120, 6377 (2016)

Conference presentations.

1. A.A. Popkova, V.O. Bessonov, I.V. Soboleva, M. Hasan, D. Lyashenko, A.Zakhidov, A.A. Fedyanin, “Second Harmonic Generation in $CH_3NH_3PbI_3$ thin films.” OSA Frontiers in Optics 2018, Washington DC (2018).
2. M. Hasan, A. Perez, S. Venkatesan, D. Lyashenko, J. Slinker, A. Zakhidov, “Solution Processing Of $CH_3NH_3PbI_3$ in HFE Solvents.” WCPEC 7, Waikoloa, HI (2018).
3. J.D. Slinker, M. Hasan, D. Lyashenko, S. Venkatesan, A. Zakhidov, “A solvent toolkit for electrochemical characterization of hybrid perovskite films” MRS Spring 2018, Phoenix, AZ (2018).
4. A. Zakhidov, Orthogonal patterning and processing of organic perovskite semiconductors, TS APS 2017, Dallas, TX (2017). **Invited talk.**
5. M. Hasan, S. Venkatesan, J. Kim, N. Rady, S. Sohal, E. Neier, Y. Yao, A. Zakhidov, Scalable single step perovskite deposition technique for optoelectronic device fabrication, TS APS 2017, Dallas, TX (2017).
6. A. Zakhidov, Reliability of Perovskite Solar Cells, ISDRS2016, Washington DC, (2016). **Invited talk**.
7. A. Zakhidov, Role of Interface in Stability of Perovskite Solar Cells., TS APS 2016, Las Cruses, NM (2016). **Invited talk.**
8. C. Manspeaker, E. Welch, D. Lyashenko, S. Venkatesan, A. Zakhidov "Carrier transport and reliability issues in perovskite solar cells", XXV IMRC, Cancun, Mexico, (2016). **Invited talk.**
9. A. Zakhidov, C. Manspeaker, D. Lyashenko, "Reliable thermal processing of organic perovskite films deposited on ZnO", APS2016, Baltimore, MD, (2016).
10. E. Welch, P. Erhart, L. Scolfaro, A. Zakhidov, "DFT+U Modeling of Hole Polarons in Organic Lead Halide Perovskites", APS2016, Baltimore, MD, (2016).

Future research directions.

The PI has applied for two additional external proposals to fund this research.

Proposal #1.
Title: CAREER: High-Resolution Orthogonal Lithography for Hybrid Perovskite Optoelectronic Devices
Sponsor: National Science Foundation.
Budget: $500,000.
Period: 02/2019 – 09/2024.
Status: Pending

Proposal #2
Title: Origins of degradation of hybrid perovskites and their interfaces
Sponsor: The U.S. Department of Energy Office of Science.
Budget: $300,000.
Period: 09/2019 – 09/2022.
Status: Pending.