

# KYLE P. KELLEY

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## EDUCATION

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### North Carolina State University

May 2018

*Doctor of Philosophy*

*Department of Materials Science and Engineering*

Dissertation title: "Mid-infrared plasmonics in cadmium oxide thin films"

Advisor: Professor Jon-Paul Maria

### North Carolina State University

December 2017

*Master of Materials Science and Engineering*

### Appalachian State University

May 2014

*Bachelor of Science in Applied Physics*

## RESEARCH EXPERIENCE

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### Oak Ridge National Laboratory

September 2018 - Present

*Center for Nanophase Materials Science: Scanning Probe Microscopy Group*

*Postdoctoral Researcher*

- Developed automated and dynamic piezoresponse force microscopy techniques to explore ferroelectric and ionic phenomena.
- Worked closely with visiting scientists to develop and progress user proposals to achieve mission critical objectives.
- Implemented pulsed laser deposition (PLD) of ferroelectric complex oxides with in-situ chemical, structural and electronic characterization for fundamental studies.

### North Carolina State University

August 2014 - August 2018

*Graduate Student Researcher (Advisor: Prof. Jon-Paul Maria)*

- Synthesized doped oxide semiconductor thin films with tunable plasmonic modes for high performance infrared detectors.
- Identified promising dopants for the high mobility semiconductor cadmium oxide (yttrium, indium, tin) and feasible growth alternatives (reactive RF co-sputtering and reactive impulse DC co-sputtering).
- Predictive modeling and measuring of plasmonic modes available in oxide thin films (transfer matrix modeling method and infrared optical measurements).
- Built, designed, and implemented high vacuum chambers for the growth of high performance electronic thin films.

### Appalachian State University

August 2011 - May 2014

*Undergraduate Student Researcher (Advisor: Prof. Tonya S. Coffey)*

- Correlated nano-scale thermal properties of organic solar cells to efficiency mechanisms with the use of a Nano-TA2 thermal analysis system in conjunction with atomic force microscopy.

## SKILLS

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- Experienced in advanced scanning probe microscopy techniques including atomic force microscopy, piezoresponse force microscopy, scanning tunneling microscopy, and Kelvin probe microscopy.
- Proficient in multiple computational platforms including Python, Matlab, Mathematica, Lumerical, AutoCAD, Labview, and Igor.

- Thin film synthesis (PLD, sputtering, and molecular beam epitaxy), infrared and visible spectroscopies, X-ray spectroscopies, scanning electron microscopy, device and thin film electrical characterization.

## SELECTED PUBLICATIONS

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### Peer-Reviewed and Published Articles

- 22) R.K. Vasudevan, K.P. Kelley, H. Funakubo, S. Jesse, S.V. Kalinin, M. Ziatdinov, "Autonomous Experiments in Scanning Probe Microscopy and Spectroscopy: Choosing Where to Explore Polarization Dynamics in Ferroelectrics", *ACS Nano* Under Review (2021).
- 21) K.P. Kelley, V. Sharma, W. Zhang, A.P. Baddorf, V.B. Nascimento, R.K. Vasudevan, "Exotic Long-Range Surface Reconstruction on  $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$  Thin Films", *ACS Appl. Mater. Interfaces* Accepted (2021).
- 20) W. Zhang, S. Cheng, C.M. Rouleau, K.P. Kelley, J. Keum, E. Stavitski, Y. Zhu, M.F. Chisholm, Z. Gai, G. Eres, "Unusual electrical conductivity driven by localized stoichiometry modification at vertical epitaxial interfaces", *Mater. Horiz.* **7**, 12, 3217-3225 (2020)
- 19) A.N. Morozovska, E.A. Eliseev, K.P. Kelley, Y.M. Vysochanskii, S.V. Kalinin, P. Maksymovych, "Phenomenological description of bright domain walls in ferroelectric-antiferroelectric layered chalcogenides", *Phys. Rev. B* **102**, 17, 174108 (2020).
- 18) R.K. Vasudevan, K.P. Kelley, E. Eliseev, S. Jesse, H. Funakubo, A.N. Morozovska, S.V. Kalinin, "Bayesian inference in band excitation scanning probe microscopy for optimal dynamic model selection in imaging", *J. Appl. Phys.* **128**, 5, 054105 (2020).
- 17) K.P. Kelley,\* A. Dziaugys,\* J.A. Brehm, L. Tao, A. Poretzky, T. Feng, A. O'Hara, S. Neumayer, M. Chyashvichyus, E.A. Eliseev, J. Banyas, Y. Vysochanskii *et al.*, "Piezoelectric domain walls in van der Waals antiferroelectric  $\text{CuInP}_2\text{Se}_6$ ", *Nat. Commun.* **11**, 3623 (2020).
- 16) K.P. Kelley, M. Ziatdinov, L. Collins, M.A. Susner, R.K. Vasudevan, N. Balke, S.V. Kalinin, S. Jesse, "Fast scanning probe microscopy via machine learning: non-rectangular scans with compressed sensing and Gaussian process optimization", *Small* **16**, 2002878 (2020).
- 15) K.P. Kelley, Y. Ren, A.N. Morozovska, E.A. Eliseev, Y. Ehara, H. Funakubo, T. Giamarchi, N. Balke, R.K. Vasudevan, Y. Cao, S. Jesse, S.V. Kalinin, "Dynamic manipulation in piezoresponse force microscopy: creating non-equilibrium phases with large electromechanical response," *ACS Nano* **15**, 10569-10577 (2020).
- 14) K.P. Kelley, L. Li, Y. Ren, Y. Ehara, H. Funakubo, S. Somnath, S. Jesse, Y. Cao, R. Kannan, R.K. Vasudevan, S.V. Kalinin, "Tensor factorization for elucidating mechanisms of piezoresponse relaxation via dynamic piezoresponse force spectroscopy", *NPJ Comput. Mater.* **6**, 113 (2020)
- 13) J.A. Tomko, E.L. Runnerstrom, Y. Wang, W. Chu, J.R. Nolen, D.H. Olson, K.P. Kelley, A. Cleri, J. Nordlander, J.D. Caldwell, O.V. Prezhdo, J.P. Maria *et al.*, "Long-lived modulation of plasmonic absorption by ballistic thermal injection", *Nat. Nanotechnol.* **16**, 47-51 (2020).
- 12) J.R. Nolen, E.L. Runnerstrom, K.P. Kelley, T.S. Luk, T.G. Folland, A. Cleri, J.P. Maria, J.D. Caldwell, "Ultraviolet to far-infrared dielectric function of *n*-doped cadmium oxide thin films", *Phys. Rev. Materials* **4**, 025202 (2020).
- 11) K.P. Kelley, D.E. Yilmaz, L. Collins, Y. Sharma, H.N. Lee, D. Akbarian, A.C.T. van Duin, P. Ganesh, R.K. Vasudevan, "Thickness and strain dependence of piezoelectric coefficient in  $\text{BaTiO}_3$  thin films", *Phys. Rev. Materials* **4**, 024407 (2020).
- 10) Y. Yang, J. Lu, A. Manjavacas, T. S. Luk, H. Liu, K.P. Kelley, J.P. Maria, E.L. Runnerstrom, M. B. Sinclair, S. Ghimire, I. Brener, "High-harmonic generation from an epsilon-near-zero material", *Nat. Phys.* **15**, 1022–1026 (2019).

- 9) K.P. Kelley, E.L. Runnerstrom, E. Sachet, E. Grimley, J. LeBeau, W.J. Padilla, J.D. Caldwell, J. Levy, J.P. Maria, “Multiple epsilon-near-zero resonances in multilayered cadmium oxide: designing metamaterial-like optical properties in monolithic materials”, *ACS Photonics* **6**, 5, 1139-1145 (2019).
- 8) K.P. Kelley\*, E.L. Runnerstrom\*, T. Folland, J.D. Caldwell, N. Engheta, J.P. Maria, “Polaritonic hybrid-epsilon-near-zero modes: beating the plasmonic confinement vs. propagation-length tradeoff with doped cadmium oxide bilayers”, *Nano Lett.* **19**, 948957 (2019).
- 7) E. Radue, E.L. Runnerstrom, K.P. Kelley, C. Rost, B. Donovan, E.D. Grimley, J.M. LeBeau, J.P. Maria, P. Hopkins, “Charge confinement and thermal transport processes in modulation-Doped epitaxial crystals lacking lattice interfaces”, *Phys. Rev. Mat.* **3**, 032201(R) (2019).
- 6) D. de Ceglia, M. Scalora, M.A. Vincenti, S. Campione, K.P. Kelley, E.L. Runnerstrom, J.P. Maria, G.A. Keele, T.S. Luk, “Viscoelastic optical nonlocality of doped cadmium oxide epsilon-near-zero thin films”, *Sci. Rep.* **8**, 9335 (2018).
- 5) E.D. Grimely, A.P. Wynn, K.P. Kelley, E. Sachet, J.S. Dean, C.L. Freeman, J.P. Maria, J.M. LeBeau, “Complexities of atomic structure at CdO/MgO and CdO/Al<sub>2</sub>O<sub>3</sub> interfaces”, *J. Appl. Phys.* **124**, 205302 (2018).
- 4) H. Khamh, E. Sachet, K.P. Kelley, J.P. Maria, S. Frazen, “Insights derived from infrared surface plasmon polariton resonance in conducting metal oxides”, *J. Mater. Chem. C.* **6**, 8326-8342 (2018).
- 3) K.P. Kelley, E. Sachet, C.T. Shelton, J.P. Maria, “High mobility yttrium doped cadmium oxide thin films”, *APL Mater.* **5**, 076105 (2017).
- 2) E.L. Runnerstrom, K.P. Kelley, E. Sachet, C.T. Shelton, J.P. Maria, “Epsilon-near-zero modes and surface plasmon resonance in fluorine-doped cadmium oxide”, *ACS Photonics* **4**, 1885-1892 (2017).
- 1) Y. Yang, K. Kelley, E. Sachet, S. Campione, T.S. Luk, J.P. Maria, M.B. Sinclair, I. Brener, “Femtosecond optical polarization switching using a cadmium oxide-based perfect absorber”, *Nat. Photonics* **11**, 390-395 (2017).

## Patents

- 1) E. Sachet, C. Shelton, J.P. Maria, K.P. Kelley, E.L. Runnerstrom (2018), “High mobility doped metal oxide thin films and reactive physical vapor deposition methods of fabricating the same,” US10741649B2.