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14. ABSTRACT The University of California, Riverside (UCR), an accredited Hispanic Serving Institution (OPEID-00131600), used this grant toward the initial complement of Dr. Shane Cybart, a newly hired assistant professor in the Materials Science and Engineering program. Dr. Cybart's expertise is in superconducting materials, specifically complex oxide devices. His work has the potential to enable a new generation of high-performance electronic sensors, processors, and power electronics, specifically Advanced signals intelligence (SIGINT) broadband communications and direction finding; power and energy; electromagnetic maneuver warfare; and autonomy and unmanned systems.					
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Final Report

ONR N00014-16-1-2298

Expanding UCR's Interdisciplinary Materials Science and Engineering Faculty

1. Abstract

The University of California, Riverside (UCR), an accredited Hispanic Serving Institution (OPEID-00131600), used this grant toward the initial complement of Dr. Shane Cybart, a newly hired assistant professor in the Materials Science and Engineering program. Dr. Cybart's expertise is in superconducting materials, specifically complex oxide devices. His work has the potential to enable a new generation of high-performance electronic sensors, processors, and power electronics, specifically Advanced signals intelligence (SIGINT) broadband communications and direction finding; power and energy; electromagnetic maneuver warfare; and autonomy and unmanned systems.

2. Fulfillment of Objectives

The *Navy HBCU/MI Faculty Start-up Program in Materials* enhances infrastructure for historically black colleges and universities and minority institutions (HBCU/MIs) by providing \$200,000 in start-up funding for new, untenured faculty members whose teaching and research impact Department of Defense (DoD) needs in materials science/engineering. The Office of Naval Research intends for this support to be added to the initial complement of a new faculty member and not to be used to buy out teaching time.

The University of California, Riverside (UCR; legal name: The Regents of the University of California) is an accredited Hispanic Serving Institution (OPEID-00131600). We received this grant in 2016 and added it to the initial complement of Dr. Shane Cybart. Dr. Cybart is a new assistant professor in the Department of Mechanical Engineering and Materials Science and Engineering (MSE) program. UCR's MSE program encompasses more than 50 faculty members from eight science and engineering departments. As described in this report, the funds were used to support the start-up of Dr. Cybart's research and educational efforts at UCR in accordance with the Navy's objectives for the HBCU/MI Faculty Start-up Program.

3. Activities

We recruited Dr. Shane Cybart to our faculty as an Assistant Professor. Dr. Cybart joined us in 2016 from the University of California, San Diego, where he earned his Ph.D. in Materials Science and Engineering in 2005 under the supervision of Professor Robert Dynes.

Dr. Cybart's expertise is in superconducting materials, specifically complex oxide devices. His work has the potential to enable a new generation of high-performance electronic sensors, processors, and power electronics. These technologies are highly relevant to several Navy technology needs:

- Advanced Signals Intelligence (SIGINT) broadband communications and direction finding.
- Power & Energy: Efficient power electronics is a priority area for leading-edge Navy systems. Dr. Cybart's research will contribute directly to the need for increased efficiency and power density on platforms through advanced materials, devices, and architectures. It also has relevance for high-energy and pulsed-power systems.
- Electromagnetic Maneuver Warfare: Efficient use of the electromagnetic spectrum for communications and sensing relies increasingly on new generations of electronic materials. Dr. Cybart's basic research enables the use of new thermally robust materials and new information processing modalities that will take us beyond Moore's Law and enable information dominance in the marine environment.
- Autonomy and Unmanned Systems: The Navy envisions microrobotic systems that rely on nanotechnology, synthetic biology and microelectronic and photonic information processing to achieve capabilities at very small sizes. Dr. Cybart's research on nanoscale phenomena will contribute to this vision.

Selected information from Dr. Cybart's vita is provided below.

Education and Training

University of Michigan	Physics	B.S. 2000
University of California San Diego	Materials Sciences and Engineering	M.S. 2001
University of California San Diego	Materials Sciences and Engineering	Ph.D. 2005
University of California Berkeley	Physics	2006-2009

Research and Professional Experience

Assistant Professor, Mechanical Eng., University of California Riverside	2016-present
Assistant Professor, Materials Science Eng., University of California Riverside	2016-present
Cooperating Faculty, Physics, University of California Riverside	2016-present
Cooperating Faculty, Electrical Engineering, University of California Riverside	2017-present
Affiliate, Lawrence Berkeley National Lab	2007-present
Project Scientist, University of California San Diego	2013-2016
Associate Project Scientist, University of California Berkeley	2009-2013
Post Doctoral Scholar, University of California Berkeley	2006-2009
Graduate Student Researcher, University of California San Diego	2000-2005

Selected Publications

- **Nano Josephson superconducting tunnel junctions in $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ directly written with a focused helium ion beam**, S. A. Cybart, E. Y. Cho, T. J. Wong, B. H. Wehlin, M. K. Ma, C. Huynh, and R. C. Dynes, *Nature Nanotechnology* 10, 598, 2015.
<http://www.nature.com/nnano/journal/v10/n7/full/nnano.2015.76.html>
- **$\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ superconducting quantum interference devices with metallic to insulating barriers written with a focused helium ion beam**, E. Y. Cho, M. K. Ma, C. Huynh, K. Pratt, D. N. Paulson, V. N. Glyantsev, R. C. Dynes, and S. A. Cybart, *Appl. Phys. Lett.* 106, 252601, 2015.
<http://dx.doi.org/10.1063/1.1803620>

- **Large scale two dimensional arrays of magnesium diboride superconducting quantum interference devices**, S. A. Cybart, T. J. Wong, E. Y. Cho, C. S. Yung, B.H Moeckly, J. W. Beeman, R. C. Dynes *Appl. Phys. Lett.* 104 182604, 2014. <http://aip.scitation.org/doi/full/10.1063/1.4876129>
- **Very large scale integration of nanopatterned YBa₂Cu₃O_{7-δ} Josephson junctions in a two-dimensional array**, S. A. Cybart, S. M. Anton, S. M. Wu, J. Clarke, and R. C. Dynes, *Nano Letters*, nl901785j, 2009. <http://pubs.acs.org/doi/abs/10.1021/nl901785j>
- **Large voltage modulation in magnetic field sensors from two-dimensional arrays of Y-Ba-Cu-O nano Josephson junctions**, S. A. Cybart, E. Y. Cho, T. J. Wong, V. N. Glyantsev, J. U. Huh, C. S. Yung, B.H Moeckly, J. W. Beeman, E. Ulin-Avila, S. M. Wu, R. C. Dynes, *Appl. Phys. Lett.* 104, 062601, 2014. <http://scitation.aip.org/content/aip/journal/apl/104/6/10.1063/1.4865216>
- **Reversible control of exchange bias in a multiferroic field effect device**, S. M. Wu, S. A. Cybart, P. Yu, M. D. Rossel, J. X. Zhang, R. Ramesh and R. C. Dynes, *Nature Materials*, nmat2803, 2010. <http://www.nature.com/nmat/journal/v9/n9/abs/nmat2803.html>
- **Full Electric Control of Exchange Bias**, S. M. Wu, S. A. Cybart, D. Yi, J. M. Parker, R. Ramesh, and R. C. Dynes, *Phys. Rev. Lett.*, 067202, 2013. <http://dx.doi.org/10.1103/PhysRevLett.110.067202>
- **Series array of incommensurate SQUIDS from YBaCuO ion damage Josephson junctions**, S. A. Cybart, S. M. Wu, S. M. Anton, I. Siddiqi, J. Clarke and R. C. Dynes, *Appl. Phys. Lett.*, vol 93, 182502, 2008. <http://dx.doi.org/10.1063/1.3013579>
- **Planar thin film YBa₂Cu₃O_{7-δ} Josephson junction pairs and arrays via nanolithography and ion damage**, K. Chen, S. A. Cybart and R. C. Dynes, *Appl. Phys. Lett.*, vol.85, pp. 2863, 2004. <http://dx.doi.org/10.1063/1.1803620>
- **Planar MgB₂ Josephson junctions and series arrays via nanolithography and ion damage**, S. A. Cybart, K.Chen, Y. Cui, Qi Li, X. X. Xi and R.C. Dynes, *Appl. Phys. Lett.*, vol 88, 012509, 2006. <http://dx.doi.org/10.1063/1.2162669>

Synergistic Activities

- Program committee member for the Electron, Ions, Photons and Nanofabrication conference (EIPBN).
- Faculty participant in Leadership Excellence through Advanced Degrees (UC LEADS) program. UC Leads is a two-year program designed to provide support for educationally or economically disadvantaged undergraduates in science, mathematics or engineering.
- Guest Editor for Superconductor Science and Technology.
- Scientific advisor for small and large businesses, (Leidos, Qualcomm, Tristan Technologies Inc, Quantum Design, Carl Zeiss Microscopy).
- Collaborating with medical faculty at UCSD, UCSF and the VA hospital to develop non-invasive imaging machines for research in Autism Spectrum Disorder, childhood epilepsy, traumatic brain injury and post-traumatic stress disorder.

4. Results

Dr. Cybart and his students have presented results of their research in several conferences and workshops. The most notable were Electron, Ion, and Photon Beams in Nanofabrication (EIPBN) in May 2017, United States Committee for Superconductor Electronics Workshop Organized by SPAWAR October 2017, and the Materials Research Society Meeting, November 2017. A graduate student, Yuchao Zhou, was awarded the Best Poster at EIPBN 2017. Anthony Cortez is another graduate student who has been recruited to the Cybart lab. One undergraduate student, Ms. Holly Grezdo, also works in the Cybart lab. One postdoctoral researcher, Ethan Cho, also works in the Cybart lab.

Two manuscripts are in preparation.

Dr. Cybart has several active research projects under Department of Defense support, including some as a subawardee on SBIR/STTR projects. He has not yet been awarded any ONR grants as Principal Investigator.

A brief note on project administration: When this project was awarded, Paul D’Anieri was Provost of UCR, and Reza Abbaschian was Dean of the Bourns College of Engineering. Originally, they were Principal Investigator and Co-Principal Investigator on this award, respectively. Since then, Cindy Larive has become Provost, and in May 2017 the award was amended to show her as PI. Dr. Abbaschian stepped down as Dean in the summer of 2016.

5. Financial and Property Report

The table below summarizes expenditures on this project. The budget in the original proposal was pro-forma; Dr. Cybart exercised discretion over the expenditures after he joined the faculty.

Category	Originally budgeted	Actual
Personnel	\$40,000	\$24,107
Benefits	\$5,080	\$2,946
Equipment	\$125,000	\$145,041
Travel	\$29,920	\$8,873
Materials/supplies	0	\$19,033
Total	\$200,000	\$200,000

The University waived indirect costs on this project.

Dr. Cybart purchased the following items of equipment (a single item costing more than \$5,000 and having a useful life of more than one year). All of these items have been installed in the Cybart laboratory and are property of the University.

- KLA Tencor P7 3D Stylus Profilometer (creates a 3D topographical picture at the micron scale, used to determine etch rates and profiles of different layers).
- Stanford Research Residual Gas Analyzer (installed on an ion beam etcher to detect the atoms being etched. Used to determine when a particular layer is done etching. for multi-level circuits).

- Stanford Research Lock-in Amplifier (instrument for low-noise measurements of superconducting electronic devices).
- Brewer Scientific CEE 100 Spin bake system (instrument for coating and baking photo resist onto wafers), purchased from Abrasax.
- Agilent Varian Helium Leak Checker (instrument used to find leaks in ultra-high vacuum systems).
- ETS Lindgren Shielded Enclosure for electrical magnetic interference isolation (used for advanced electrical measurements of sensors).