Final Report

New Meta and Nanomaterials for Photorefractive Enhancement and Photorefractive Two-Beam Coupling

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This Grant has an Extension, which had to be submitted as a new grant.

14. ABSTRACT

This grant has resulted in a highly collaborative effort between CIQA, AFOSR and several other institutions and involved experimental and theoretical work on the synthesis and characterization of ferroelectric nanoscale particles and their interactions with liquid crystal systems of interest to AFSOSR to form hybrid systems for photorefractive enhancement and photorefractive two-beam coupling in hybrid devices. Six international presentations resulted (4 invited, 1 contributed and one poster) along with two submitted papers (Optics Express (accepted) and Nano Letters). A U.S. provisional patent was filed "Stress Induced Phase Changes in Ferroic and Non-Ferroic Materials," Docket no. AFD 1053. The collaborative studies unequivocally demonstrated for the first time that crystalline ferroic materials such as barium titanate can exhibit ferroelectric properties in particles of 10 and less nanometers in size. State of the art high resolution transmission electron microscopy strain measurements of ball milled vs chemically precipitated nanoscale barium titanate suggest mechanical milling as the source of the strain and

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Grant Objectives: no changes.

Status of Effort, Summary, Accomplishments: This grant has resulted in a highly collaborative effort between CIQA, AFOSR and several other institutions and involved experimental and theoretical work on the synthesis and characterization of ferroelectric nanoscale particles and their interactions with liquid crystal systems of interest to AFSOSR to form hybrid systems for photorefractive enhancement and photorefractive two-beam coupling in hybrid devices. Six international presentations resulted (4 invited, 1 contributed and one poster) along with two submitted papers (Optics Express (accepted) and Nano Letters). A U.S. provisional patent was filed "Stress Induced Phase Changes in Ferroic and Non-Ferroic Materials," Docket no. AFD 1053. The collaborative studies unequivocally demonstrated for the first time that crystalline ferroic materials such as barium titanate can exhibit ferroelectric properties in particles of 10 and less nanometers in size. State of the art high resolution transmission electron microscopy strain measurements of ball milled vs chemically precipitated nanoscale barium titanate suggest mechanical milling as the source of the strain and subsequent ferroelectric behavior.

Continued research under this grant is ongoing under an extension to the grant, which had to be submitted as a separate and new grant.

Publications: two publications have resulted for the highly interactive and multi-institutional

studies. These are:

Asymmetric Freedericksz Transitions from Symmetric Liquid Crystal Cells Doped with Harvested Ferroelectric Nanoparticles, G. Cook[1,2], V. Yu. Reshetnyak[3], R. F. Ziolo[4], S. A. Basun[1,2], P. P. Banerjee[5], D. R. Evans[1] *[1]Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright-Patterson Air Force Base, Ohio [2] Universal Technology Corporation, 1270 North Fairfield Road, Dayton, Ohio,National Taras Shevchenko University of Kyiv, Kyiv, Ukraine,[4]Centro de Investigación en Química Aplicada, Saltillo, Coahuila, México,[5]University of Dayton, Dayton, Ohio*. (Accepted, *Optics Express*).

Harvesting Single Ferroelectric Domain Stressed Nanoparticles for Optical and Ferroic Applications, G. Cook[1,2], J. L. Barnes[1,3], R. F. Ziolo[4], A. Ponce[4], V. Yu. Reshetnyak[5], A. Glushchenko[6], S. A. Basun[1,7], P. P. Banerjee[8], D. R. Evans[1]. [1]Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright-Patterson Air Force Base, Ohio, [2]Azimuth Corporation, 4134 Linden Avenue, Suite 300, Dayton, Ohio, USA,[3]General Dynamics, Dayton, Ohio, USA, [4]Centro de Investigación en Química Aplicada, Saltillo, Coahuila, México, [5]National Taras Shevchenko University of Kyiv, Kyiv, Ukraine, [6]University of Colorado at Colorado Springs, Colorado, USA,[7]Universal Technology Corporation, 1270 North Fairfield Road, Dayton, Ohio, USA,[8]University of Dayton, Dayton, Ohio, USA. (Submitted, *Nano Letters*).

Interactions:

Participation / presentations at meetings, conferences, seminars, etc. -

"Harvesting of single ferroelectric domain nanoparticles and their use in hybrid photorefractives", G. Cook, J. L. Barnes, V. Yu. Reshetnyak, A. V., Glushchenko, R. Ziolo, S. A. Basun, P. P. Banerjee, D. R. Evans, OLC, Erice, Italy, September 2009 (Invited).

"Enhanced Beam Combination Using Harvested Ferroelectric Nanoparticles in Liquid Crystal Hybrid Devices", G. Cook, V. Yu. Reshetnyak, A. Ponce, R. Ziolo, S. A. Basun, and D. R. Evans, SPIE 2010. (Contributed)

"The Benefits of Single Domain Ferroelectric Nanoparticles in Disparate Optical Devices" D. R. Evans, G. Cook, S. A. Basun, V. Yu. Reshetnyak, A. Ponce, and R. Ziolo, IV Workshop on Photonic and Electronic Materials, San Sebastian, Spain, July 5-7, 2010. (Invited)

"Enhanced Optical Gain in Photorefractive Liquid Crystal Hybrids Using Ferroelectric Nanoparticles. D. R. Evans [1], G. Cook S. A. Basun , V. Yu. Reshetnyak, A. Ponce, and R. Ziolo, Alicante, Elche, Spain, 2010. (Invited)

"Harvesting Single Ferroelectric Domain Nanoparticles for Liquid Crystal Systems", G. Cook, V. Reshetnyak, A. Ponce, R. Ziolo, J. Barnes, A. V. Glushchenko, S. A. Basun, D. R. Evans. ILLC. (Invited)

"Improved Holographic Beam Coupling Through Selective Harvesting of Single Domain Ferroelectric Nanoparticles ," G. Cook, V. Yu. Reshetnyak, A. Ponce, R. F. Ziolo, S. A. Basun, D. R. Evans. (Contributed)

Personnel Supported: Dr. Ronald Ziolo, Dr. Dario Bueno Baques, Dr. Arturo Ponce, Dr. Veronica Corral Flores, Mr. Gilberto Hurtado and Mr. Gerardo Tadeo.

New Discoveries: "Stress Induced Phase Changes in Ferroic and Non-Ferroic Materials," Dean R. Evans, Gary Cook, Victor Yu Reshetnyak, Anatoliy Gluschenko, and Ronald F. Ziolo, US Provisional Patent Application, Filed April. 2009. New invention disclosure; Docket no. AFD 105.