ANL/ES-C1300201

Development of Capacitors for Power Electronics in Hybrid Vehicles

Energy Systems Division

About Argonne National Laboratory

Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC under contract DE-AC02-06CH11357. The Laboratory's main facility is outside Chicago, at 9700 South Cass Avenue, Argonne, Illinois 60439. For information about Argonne and its pioneering science and technology programs, see www.anl.gov.

DOCUMENT AVAILABILITY

Online Access: U.S. Department of Energy (DOE) reports produced after 1991 and a growing number of pre-1991 documents are available free via DOE's SciTech Connect (http://www.osti.gov/scitech/)

Reports not in digital format may be purchased by the public from the National Technical Information Service (NTIS):

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Rd
Alexandria, VA 22312
www.ntis.gov
Phone: (800) 553-NTIS (6847) or (703) 605-6000
Fax: (703) 605-6900
Email: **orders@ntis.gov**

Reports not in digital format are available to DOE and DOE contractors from the Office of Scientific and Technical Information (OSTI):

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
www.osti.gov
Phone: (865) 576-8401
Fax: (865) 576-5728
Email: **reports@osti.gov**

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor UChicago Argonne, LLC, nor any of their employees or officers, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of document authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, Argonne National Laboratory, or UChicago Argonne, LLC.

ANL/ES-C1300201

Development of Capacitors for Power Electronics in Hybrid Vehicles

prepared by
U. (Balu) Balachandran
Energy Systems Division, Argonne National Laboratory

February 16, 2016

Non Proprietary

Final CRADA Report

Date: 02/10/2016

CRADA Number: 1300201

CRADA Title: Development of Capacitors for Power Electronics in Hybrid Vehicles

CRADA Start/End Date: 03/18/2013 to 03/18/2014

Argonne Dollars: $350,000

Participant Dollars: $612,500

Argonne PI: U. (Balu) Balachandran

Participant(s):

Name	Participant Dollars
Delphi Automotive Systems, LLC	$612,500

Complete Address: 5725 Delphi Dr.Troy, MI 48098

DOE Program Manager: Steven Boyd

Summary of Major Accomplishments:

The purpose of this CRADA is to develop a fabrication process to reduce the manufacturing cost for a very compact, high temperature, film-on-foil high energy-density PLZT (Pb-La-Zr-Ti-O) capacitor. Motivation for this CRADA is derived from the DOE's Office of Vehicle Technologies (OVT) program, which seeks to advance technologies to improve vehicle fuel efficiency in the mid-term and facilitate the transition to electric drive vehicles over the long-term. The objective of Argonne's work is to develop and characterize high-performance capacitors on base-metal foils. The PLZT film-on-foil prepared using a spin-coating technique

exhibited benign failure, a very high dielectric constant, >64 (~30X greater than today's baseline polypropylene, PP, based capacitor), and relatively high breakdown voltage, >140 V/micron. The spin-coating process requires over 30 depositions and over 30 annealing steps and many hours of time to produce a single 5 μm coating suitable for a capacitor. Processes such as aerosol deposition, colloidal spray deposition, and screen printing are known to produce thick ceramic and metal films on various substrates at rates much faster than obtained with the spin-coating process (e.g. ceramic films of thicknesses over 5 μm are produced in a single coating step). However, sub-micron sized particles are essential for the success of these very fast deposition processes. To provide these sub-micron particles, the effort was focused first on the preparation of sub-micron-sized PLZT powders, followed by developing one of the above mentioned processes to fabricate thicker PLZT films in one single deposition step. The team developed a combustion synthesis route to produce sub-micron-sized PLZT powders and identified potentially low cost solutions for producing a high-temperature capable PLZT capacitor that is 90% smaller than today's baseline PP capacitor.

Summary of Technology Transfer Benefits to Industry:

Helps the industry to develop an economically attractive process to fabricate high-temperature, high-dielectric constant capacitors with high volumetric efficiency for use in advanced power inverters in electric drive vehicles. One of the technological challenges in the development of marketable advanced vehicles has been the size and weight of conventional batteries and the associated electrical components, including capacitor dependent inverters. The currently available PP capacitors have unfavorable sizes/volumes, weights, and dielectric constants. This CRADA work has developed high-performance capacitors with reduced size and weight for advanced vehicle electrification systems.

Other Information/Results: (Papers, Inventions, Software, etc.)

1) PLZT Capacitor on Glass Substrate, M. R. Fairchild (Delphi), R.S. Taylor (Delphi), C. W. Berlin (Delphi), C. W. K. Wong (Delphi), U. Balachandran (ANL), and B. Ma (ANL), US Patent 9,230,739, 9,230,739 B2, issued on Jan. 5, 2016.

Energy Systems Division
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 362
Argonne, IL 60439

www.anl.gov

Argonne National Laboratory is a U.S. Department of Energy
laboratory managed by UChicago Argonne, LLC