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Sandia National Laboratories

Project Accomplishment Summary

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Sandia National Laboratories

Operated for the U.S. Department of Energy by
Sandia Corporation
Albuquerque, New Mexico

PROJECT ACCOMPLISHMENTS SUMMARY

Cooperative Research and Development Agreement (#1573.46)

between **Sandia National Labs** and Lockheed Martin Corporation

Note: This Project Accomplishments Summary will serve to meet the requirements for a final abstract and final report as specified in Article XI of the CRADA.

Title: Self-Assembled Nanolaminate Coatings (SV)

Final Abstract:

Sandia National Laboratories (Sandia) and Lockheed Martin Aeronautics (LM Aero) are collaborating to develop affordable, self-assembled, nanocomposite coatings and associated fabrication processes that will be tailored to Lockheed Martin product requirements. The purpose of this project is to develop a family of self-assembled coatings with properties tailored to specific performance requirements, such as antireflective (AR) optics, using Sandia-developed self-assembled techniques.

The project met its objectives by development of a simple and economic self-assembly processes to fabricate multifunctional coatings. Specifically, materials, functionalization methods, and associated coating processes for single layer and multiple layers' coatings have been developed to accomplish high reflective coatings, hydrophoibic coatings, and anti-reflective coatings. Associated modeling and simulations have been developed to guide the coating designs for optimum optical performance.

The accomplishments result in significant advantages of reduced costs, increased manufacturing freedom/producibility, improved logistics, and the incorporation of new technology solutions not possible with conventional technologies. These self-assembled coatings with tailored properties will significantly address LMC's needs and give LMC a significant competitive lead in new engineered materials. This work complements SNL's LDRD and BES programs aimed at developing multifunctional nanomaterials for microelectronics and optics as well as structure/property investigations of self-assembled nanomaterials. In addition, this project will provide SNL with new opportunities to develop and apply self-assembled nanocomposite optical coatings for use in the wavelength ranges of 3-5 and 8-12 micrometers, ranges of vital importance to military-based sensors and weapons.

The SANC technologies will be applied to multiple programs within the LM Company including the F-35, F-22, ADP (Future Strike Bomber, UAV, UCAV, etc.). The SANC technologies will establish LMA and related US manufacturing capability for commercial and military applications therefore reducing reliance on off-shore development and production of related critical technologies.

If these technologies are successfully licensed, production of these coatings in manufactory will create significant technical employment opportunities.

Background:

Although conventional chemical vapor deposition (CVD) and sputtering techniques are used to produce useful optical coatings, they are all expensive and require harsh processing conditions that are not practical for temperature-sensitive or delicate optical and electrical devices. The self assembly technologies are simple and inexpensive, provide great potential for reduction of production cost, and offer in-field coating capability.

Lockheed Martin Corporation has requirements for fabricating optical and electrical coatings on a wider range and type of surfaces than are currently practical by conventional manufacturing processes. Factors influencing these requirements include cost reduction and increased productivity, especially on large and irregular shape products. This new technology will meet Lockheed Martin's needs by dramatically reducing costs and increasing productivity, thereby positioning the Lockheed Martin Corporation to be more highly competitive in both the national and international business environment.

Sandia holds the world leader in fabrication of multifunctional, self-assembled coatings. The team leverage Sandia's expertise and experience to adapt and modify the chemistries and processing parameters of self-assembling nanocomposite coatings that enable the development of engineered optical coatings with tunable properties (e.g., anti-reflective coatings) for LM applications. Through introduction of a variety functional elements, this program enables the development of engineered optical coatings with tunable properties, such as hydrophobicity. Deposition of multifunctional optical coatings at ambient conditions eliminates the need for long cycle times, expensive CVD capital equipment, and poor utilization while providing low stress deposits with improved yields. Programs benefiting LM Companies includes: Joint Strike Fighter EOTS, Advanced Targeting Pod, Joint Common Missile, Snake Eyes Ground Sensor, Aeronautics (classified), Space Systems, etc.

Description:

The objective of this project is to develop inexpensive, scalable methods and processes to produce manufacturing quantities of high quality, large-area optical coatings at/near atmospheric temperature/pressure.

The Sandia team had unique expertise in the technical areas of the project and performed all of the technical efforts. The Shared Vision program partner provided (1) targeted application areas and background information, such as practical problems and (2) certain coupons or substrates for deposition of the coatings. The program partner also involved technical discussions and provided feedback for all report presentations.

Specific technical accomplishments include: (1) a solution-based nano-engineering process was developed as an alternative for conventional CVD and sputter deposited processes to produce single layer and multiple layers of coatings for accomplishments of high reflective coatings. It involves chemical synthesis and functionalization of nanoparticles with controlled chemical composition, particle size, shape, and their further assembly into engineered nanoparticle composite films. (2) A rapid and versatile self-assembling process that employs nanotechnology as an alternative to current methods was developed to produce anti-reflective coatings and hydrophobic coatings. The technology involves the self-assembly of polymers to form nanostructured coatings with tailored properties. The process uses commercially available polymers, which are dispersed in common solvents, allowing easy and cost-effective routes to produce films through spin, dip, or spray coating in ambient conditions. During coating, evaporation of the solvents induces self-assembly, forming multifunctional films with a nanostructured surface, low surface energy, controllable porosity, and a refractive index ranging from n = 1.2 to 3.0. These films possess physical properties approaching those of materials that are typically fabricated using expensive processes such as CVD and sputtering. Additionally, the chemical and physical nature of the self-assembled polymer films can be further modified

through a variety of near-ambient processes that allow us to tailor unique functions and properties. The ability to adjust the material parameters of the film at different stages (synthesis, deposition, or post-deposition) provides a powerful new degree of freedom over conventional deposition approaches. (3) Associated modeling and simulations have been developed to guide the coating designs for fabrications of single and multiple layer coatings for optimum optical performance.

Benefits to the Department of Energy:

This work will compliment Sandia/DOE's LDRD and Basic Energy Sciences programs aimed at developing multifunctional nanomaterials for microelectronics and optics as well as structure/property investigations of self-assembled nanomaterials. In addition, this project will provide Sandia with new opportunities to develop and apply self-assembled nanocomposite optical coatings for use in the wavelength ranges of 3-5 and 8-12 micrometers, ranges of vital importance to military-based sensors and weapons, as well as new materials for photovoltaic applications.

Economic Impact:

This technology resolves the long sought problems the conventional processes suffered from like, such as significant cost, logistics, and environmental, safety, and health areas, as well as increasing productivity. Large footprint, expensive capital equipment and highly paid systems operators will be replaced by inexpensive equipment and personnel. Furthermore, these coatings may be applied on or near production lines, thereby reducing manufacturing timeline. The expensive sputtering targets and toxic CVD chemicals used in current processes will be replaced by environmental and OSHA compliable chemistries. The supportability of components will be significantly enhanced by the ability to repair some coatings in the field, thereby reducing the required spare parts.

The potential applications areas are for windows and photovoltaics that reduces manufacturing costs, increases optical and electrical efficiency, cleans itself with a hose or natural rain.

These technologies will establish LMA and related US manufacturing capability for commercial and military applications therefore reducing reliance on off-shore development and production of related critical technologies, If these technologies are successfully licensed, production of these coatings in manufactory will create significant technical employment opportunities.

Project Status:

Successfully completed. Evidence of satisfaction from LMC are listed below:

The work has been well received by both Lockheed Martin Corporation who identified multiple applications across several business sectors and Sandia National Laboratories, evidenced by the winning of many prestigious both internal and international awards and journal publications.

"The method enables the improved design and fabrication of the affordable nanocomposite coatings that we developed in earlier research," said Dr. John D. Evans, Lockheed Martin vice president, business innovation. "The process improves the material's performance and allows the coatings to be more easily tailored to specific applications."

"This award provides exciting affirmation of our commitment to collaborative, world-class research," said Dr. Ray O Johnson, Lockheed Martin senior vice president and chief technology officer. "Lockheed Martin and Sandia National Laboratories' joint research is driving innovation and creating important new business opportunities."

“This is boundary-pushing research that revolutionizes the development and manufacture of multifunctional optical coatings,” said Stromberg. “We’ll be reaping the benefits of these advances from both a technology and a business perspective long into the future.”

ADDITIONAL INFORMATION

Laboratory/Department of Energy Facility Point of Contact for Information on Project

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Company Size and Points of Contact

Lockheed Martin Co. 100,000 employees.

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CRADA Intellectual Property

Three TAs were submitted, but no patents were filed yet.

Technology Commercialization

In discussion and negotiation with LMC

Project Examples

N/A

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Cooperative Research and Development Agreement (SC99/01573.46)
between **Sandia National Laboratories** and **Lockheed Martin Corporation**

This summary has been approved for public release by Sandia and Lockheed Martin Corporation

Sandia National Laboratories

By _____ 8/24/2011
Hongyou Fan — Date
Principal Investigator

Sandia National Laboratories

By _____ 8/23/2011
Manager — Date
WFO/CRADA Agreements

Lockheed Martin Corporation

By _____
Title: — Date

In order to expedite the process, if we do not receive your signed reply by 9/24/2011 we will assume your concurrence for the release of this document to the public.