THE 2013 FLC MID-CONTINENT REGION ANNUAL AWARDS

Nomination Form

Please note the specific criteria for the nominated award.

I nominate the following individual, technology, or organization for the following award (please √):

- ❑ Regional Laboratory Award
- ❑ Regional Partnership Award
- ❑ Representative of the Year Award
- ❑ STEM Mentorship Award
- X Notable Technology Development Award
- ❑ Excellence in Technology Transfer *Mimics FLC national*
- ❑ Notable State & Local Government Collaboration

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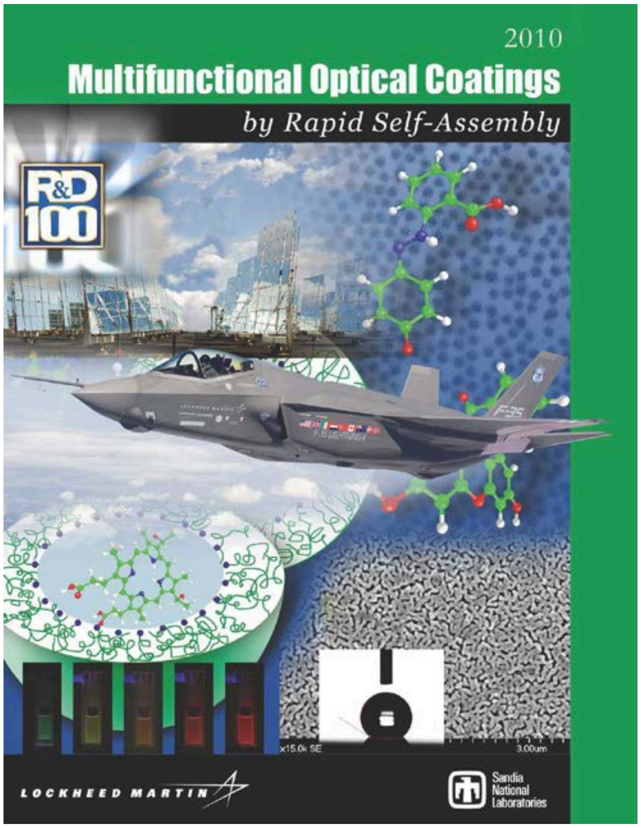
Self-Assembled Multifunctional Optical Coatings
Basis for Nomination—Notable Technology Development
Overview

Self-Assembled Multifunctional Optical Coatings (SAMOC) is an R&D 100 award-winning and patented technology that inexpensively and safely forms coatings already widely used in consumer electronics, semiconductor devices, and high-performance glass and ceramics. The new method disperses commercially available polymers by inserting them in common solvents under ambient conditions and then uses simple spin, dip, or spray techniques to coat surfaces. Evaporation of the solvents induces the polymers to self-assemble into multifunctional nanoparticle arrays as well as films with tailored optical properties and a nanostructured surface. Because the process is compatible with conventional spray processing, it can be applied directly to large or complex parts, which current commercial methods are less able to do. The main competitors to this new process are conventional chemical vapor deposition (CVD) processes and sputtering processes, both of which require restrictive environmental conditions such as high temperature and high vacuum. This process, in contrast, is conducted in mild, ambient conditions, lowers equipment costs, and increases safety. Applications that demonstrate the diverse impact of SAMOC technology include optical coatings, three-dimensional nanoscale capacitors, sensors, and photovoltaics.

Recently this work received the Outstanding Poster Award at the 2013 Spring Meeting of the Materials Research Society (MRS), and was chosen as one of three to represent the MRS at the International Materials Research Congress. The poster was selected from over 2,000 conference poster presentations.



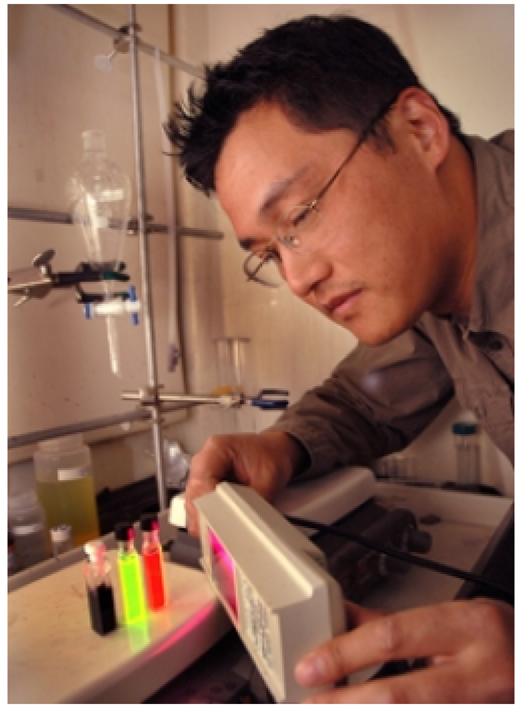


Figure 1. This technology won an R&D 100 award in 2010 (left); Hongyou Fan observes satisfactory fluorescence by well-trained nanocrystals in water solution. The dark vial holds gold nanocrystals; the orange and green are semiconductor nanocrystals.

Problems it solves and benefits

Optical films are widely used in the manufacture of consumer electronics, semiconductor devices, and high-performance glass, and ceramic materials. Presently most of these films are manufactured using complicated and costly processes like sputter deposition and CVD, which require high temperature and/or high vacuum. A simpler and less expensive method has been developed—a rapid and versatile process that involves the self-assembly of polymers to form nanostructured coatings. The SAMOC 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.

The value of this new technology can be measured in four categories: cost reduction, increased producibility, improved logistics, and incorporation of new techniques.

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 functions and properties to be tailored for different applications. 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.

Expensive, large-footprint equipment and highly trained system operators will be replaced by inexpensive equipment and versatile personnel. Furthermore, these self-assembling coatings can be applied on or near production lines, thereby reducing the manufacturing timeline. Expensive sputtering targets and toxic

CVD chemicals used in current processes will be replaced by environmentally benign, OSHA-compliant chemistries. The supportability of components will be significantly enhanced by the ability to repair some coatings in the field, thereby reducing downtime and the number of spare parts required.

The simple, safe and economical SAMOC coating process, with equipment costs in the thousands instead of millions of dollars (as is the case for the competing methods) enables the development of multifunctional nanomaterials and optical coatings with architectures and properties regions not attainable by current processing methods.

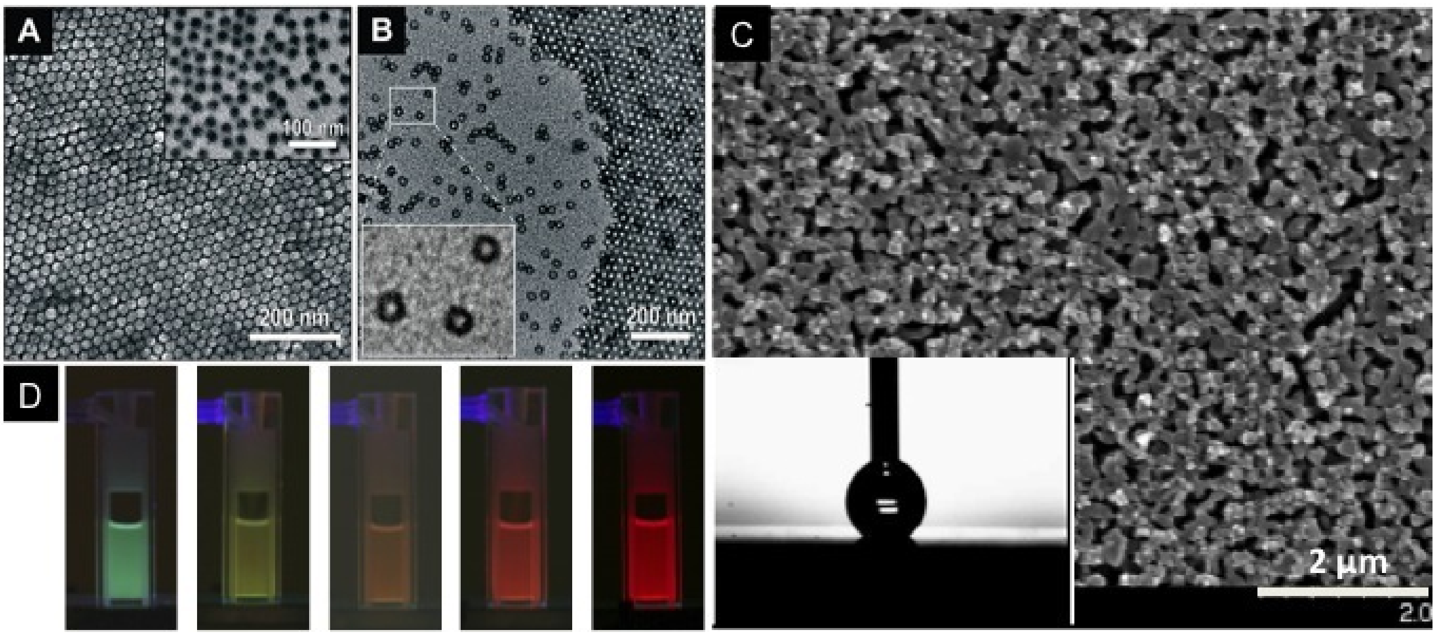


Figure 2. Multifunctional polymer nanoparticles and coatings. (A) nanostructured film of monodisperse polystyrene nanoparticles; (B) monodisperse hollow polymer nanoparticles with controlled porosity (or refractive index); (C) nanostructured hydrophobic polymer coatings.

This rapid self-assembly process has several competitive advantages over current processes:

- The intrinsic hydrophobic nature of the polymer eliminates surface tension and drying stress that can cause cracking in conventional film deposition processes.
- It can produce porous films with controlled porosity (or refractive index) in ambient conditions without using expensive specialized equipment.
- It is compatible with conventional spray processing and can be directly applied to large or complex parts.
- Hybrid coatings with desirable chemical and physical properties unavailable through conventional processes can be formed.
- Multiple-layered coatings exhibit tunable reflectivity over the visible and far infrared regions.

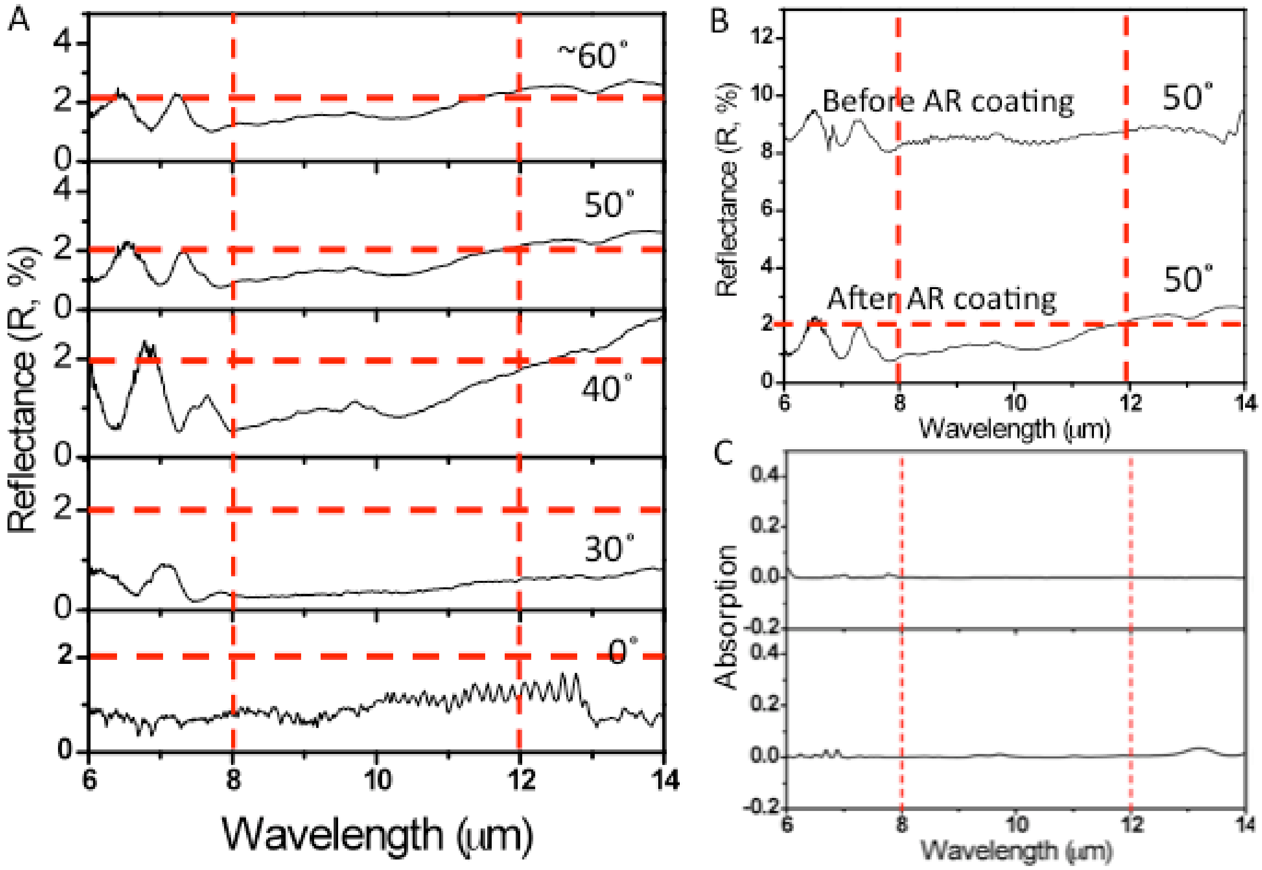


Figure 3. Measured reflectivity of multiple layered anti-reflective coatings on polyethylene at varied incident angles (A &B) and absorption (C) of the anti-reflective coatings.

Markets and consumers

Applications that demonstrate the diverse impact of SAMOC technology include optical coatings (e.g., anti-reflective coatings that cover the spectrum from visible to far infrared), three-dimensional nanoscale capacitors, sensors, and photovoltaics. Here are a few sample applications:

Aircraft Transparencies

A typical jet fighter aircraft canopy loses 8-10% of its optical transmission depending on the refractive index of the plastic or glass material. Applying an optimized anti-reflective coating can inexpensively add an additional 8-9% transmission through the canopy, providing an additional margin of safety to the pilot. This optimized coating is also adaptable to field repairs, unlike conventional anti-reflective coatings.

Architectural windows

The low cost of application of this optical coating lends itself to all forms of architectural windows—both glass and plastic. Greater optical transmission reduces glare and the need for artificial light. The hydrophobic properties add a self-cleaning feature that reduces maintenance.

Photovoltaics

Anti-reflective and hydrophobic properties mean the coating can be used to significantly increase the efficiency of photovoltaic devices, both rigid and flexible thin film, by nearly eliminating Fresnel losses. Simple processing will reduce manufacturing costs compared to conventional anti-reflective coating processes.

Corrosion reduction

Although primarily developed as an anti-reflective coating, the inherent barrier properties and super hydrophobic characteristics of this material coating system should provide a level of resistance for many materials.

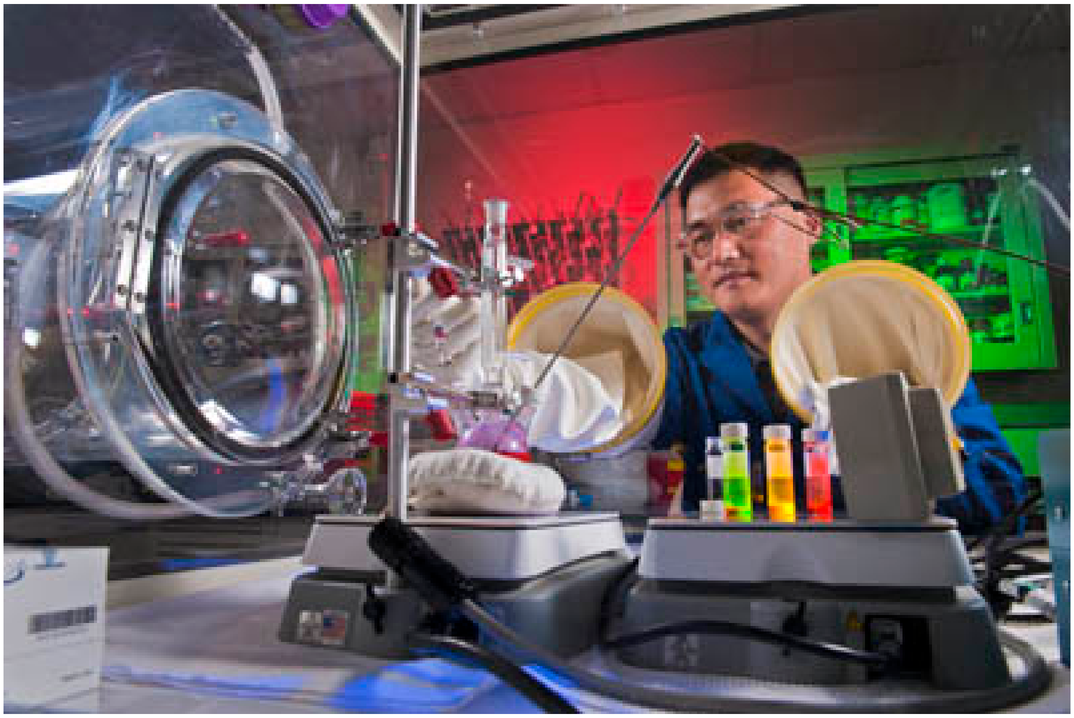


Figure 4. Hongyou Fan makes solutions for multifunctional coatings. The work received an "outstanding poster" award at the spring meeting of the Materials Research Society. His poster was judged "superior in technical content, appearance, graphic excellence, and presentation quality."

Partnerships formed

Sandia National Laboratories partnered with Lockheed Martin Corporation to develop SAMOC technology and identify significant applications for canopies and missile sensor windows. Researchers from the University of New Mexico also participated.

Patents filed or awarded

This patented technology was published in *Science* magazine and was featured in technical journals including *Journal of the American Chemical Society*, *Chemistry—A European Journal*, and *Chemical Communications*. The SAMOC technology has been awarded three patents in 2012 and 2013, Self-Assembly of Water-Soluble Nanocrystals, Patent No. 8,092,595 B1 (issued on Jan. 10, 2012); Method of making monodisperse nanoparticles, Patent No. U.S. 8,288,001 B (issued on Oct. 16, 2012); and Method of making nanoporous, hydrophobic coatings, U.S. 8,425,981 B1 (issued on April 23, 2013).

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