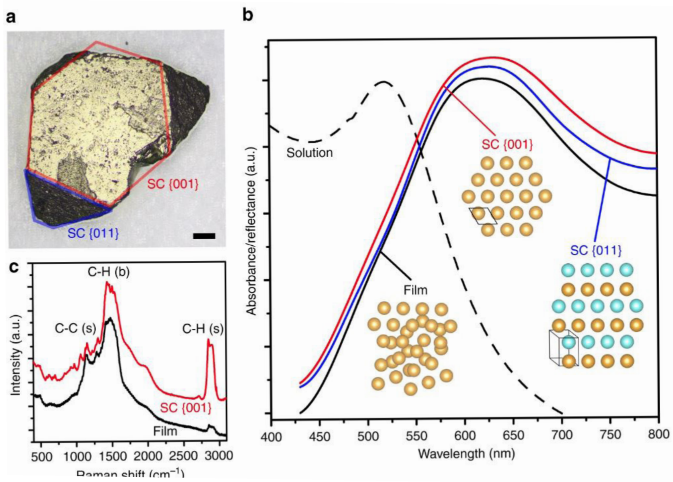
GOLD NANOPARTICLE SUPERCRYSTAL CHEMICAL SENSORS

Patent Pending
SD# 14801
Technology Readiness Level: 3-4
Concept demonstrated analytically or experimentally

Self-assembling gold nanoparticle supercrystals with superior chemical detection sensitivity, sub-millimeter size, and tunable structural features for optics, electronics, and sensor platforms

Metallic nanoparticles such as gold and silver can self-assemble and crystallize into highly ordered arrays known as supercrystals. Highly ordered single supercrystals have great potential in areas such has optics, electronics, and sensor platforms; however, obtaining high-quality supercrystals for production scale usage and device integration has been a limitation in their wide-scale adoption.

Sandia researchers have synthesized gold nanoparticles into large supercrystals with chemical detection sensitivity nine times higher than existing nanoparticle technologies. This development has potential for useful applications in the chemical detection of drugs or explosives as well as integrations in optics and electronic devices.



Large gold supercrystal of sub-millimeter size and optical characteristics. a) Photograph of a gold SC measured 490 μm. Scale bar is 50 μm. The blue and red frame outline SC {011} and SC {001} surface, respectively. b) Optical reflectance spectra (normalized) collected from two different facets (blue and red) of the SC and a drop-cast film (black solid line) and absorption from the NP solution (black dashed line). c) Anti-Stokes Raman spectra of dodecanethiol ligand collected from the surface of SC (red) and film (black).

Sandia's synthesis method displays important advantages over existing approaches using single nanoparticle or thin film substrates. Overall, it offers more systematic control of nanoparticle morphology and structure, which allows precise tunability of the shape, size, composition, and other functional properties. Control over the structure of these supercrystals is achieved through a binary solvent diffusion method that allows for a seeding and growth process. The material's enhanced sensing features derive from giant electromagnetic field enhancements between the self-assembled gold nanoparticles, which result from localized surface plasmon resonance of nanoparticles within the supercrystals.

Together, these breakthroughs enable the large-scale production of high-quality supercrystal materials for reduced cost. Though made of gold, these materials use very small quantities- 12 mg per supercrystal. The ability to adjust the chemical and physical nature of nanomaterials at different crystallization stages provides a powerful degree of tunability to achieve desirable functions and properties in manufacturing for a variety of applications -- including those requiring novel shapes.

TECHNICAL BENEFITS

- Enhanced sensing capability- 9X higher sensitivity for chemical detection than nanoparticles in solution or thin film nanoparticle substrates
- Enables large scale fabrication with reproducible properties at reduced cost
- Tunable function, properties, and novel shapes
- Higher functional efficiency- reduces amount of material needed
- Inexpensive- utilizes 12 mg per supercrystal

INDUSTRIES & APPLICATIONS

- Chemical sensors
- Charge and energy transport
- Nanoelectronics
- Optoelectronics
- Photovoltaics (PV)
- Surface catalysis

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