

# Developing Gold Nanoparticle-Embedded Dielectric Thin Films

research on noble metal nanoparticles has always remained interesting because of their optical and electronic properties. Gold nanoparticles (AuNPs), in particular, have been intensively studied for their fascinating localized surface plasmon resonance (LSPR) peak in the visible region of electromagnetic spectrum. The tunable nature of LSPR of AuNPs leads to a large number of applications of AuNPs in the fields of plasmonics and bioscience.

The LSPR peaks of AuNPs can be tuned from the visible to the near-infrared region by controlling the shape, size, and structure of the particles. Another way of changing the optical properties is to change the surrounding of AuNPs as the LSPR peak is also very sensitive to the dielectric properties of the surrounding medium. The later method becomes an easy and superior one when the nanoparticles are embedded in a dielectric matrix. If the surrounding matrix is a transparent one, at least in the region of the spectrum where LSPR occurs, it becomes an added advantage for many photonic and plasmonic applications.

In order to explore and control the effects of shape, size, structure and dielectric media on LSPR properties, several preparation methods are used to form hybrid structures of nanoparticles and dielectric interfaces. In the present work, different ways of tuning LSPR positions of metal-dielectric nanocomposite thin films have been demonstrated with AuNPs embedded indium oxide (Au:IO) thin films as a case study. Au:IO thin films have been prepared by a sequence-specific sandwich method. The films were characterized by glancing angle x-ray diffraction (GXR), optical absorption, high-

resolution transmission electron microscopy (HRTEM) and Rutherford backscattering spectrometry (RBS). The advantages of the sandwich method have been shown by comparing the optical properties of Au:IO thin films so formed with that of Au:IO films formed by the most commonly used co-sputtering method.

### **Importance of the work**

The work in the publication titled "Tailoring plasmonic properties of metal nanoparticles embedded dielectric thin films: The sandwich method of preparation" by Ranjit Laha et al. reports the experimental ways of tuning plasmonic positions (following a derived working formula) of AuNP embedded metal oxide thin films. The novelty lies in followings

- A specific sequence of the sandwich method has been suggested that enables the many independent ways of tuning the plasmonic positions. The different steps involved such as thermal evaporation, sputtering and intermediate annealing are common techniques used in industry as well as research & development laboratories. Therefore, it is not very difficult to adopt the method.
- Controlled agglomeration-cum-self assembling process has been used as an advantage in tuning the plasmonic properties against the common belief that "agglomeration of small particles into big ones is a disadvantage in many nanoparticles research problems".
- The shape of the embedded AuNPs has been characterized to be oblates by a combination of HRTEM and RBS studies. Normally, characterizing shape of buried particles is a difficult proposition.
- An empirical working formula has been derived for tailoring the plasmonic position of any pair of the metal-dielectric nanocomposite. Thus, by knowing the shape and volume fraction of the embedded nanoparticles,

plasmonic position can be worked out.

- To the best of our belief, the work will have impact among the researchers working on nurturing the nanoscale properties in photonic and plasmonic applications.

This study, [Tailoring plasmonic properties of metal nanoparticle-embedded dielectric thin films: the sandwich method of preparation](#) was recently published in the *Journal of Nanoparticle Research*.

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## Nano aluminium offers fuel cells on demand – just add water



The accidental discovery of a novel aluminium alloy that reacts with water in a highly unusual way may be the first step to reviving the [struggling hydrogen economy](#). It could offer a convenient and portable source of hydrogen for fuel cells and other applications, potentially transforming the energy market and providing an alternative to batteries and liquid fuels.

“The important aspect of the approach is that it lets you make very compact systems,” says [Anthony Kucernak](#), who studies fuel cells at Imperial College London and wasn’t involved with the research. “That would be very useful for systems which need to be very light or operate for long periods on hydrogen, where the use of hydrogen stored in a cylinder is prohibitive.”

The discovery came in January, when researchers at the US Army Research Laboratory at Aberdeen Proving Ground, Maryland, were working on a new, high-strength alloy, says physicist Anit Giri. When they poured water on it during routine testing, it started bubbling as it gave off hydrogen.

That doesn’t normally happen to aluminium. Usually, when exposed to water, it quickly oxidises, forming a protective barrier that puts a stop to any further reaction. But this alloy just kept reacting. The team had stumbled across the solution to a decades-old problem.

Hydrogen has long been touted as a clean, green fuel, but it is difficult to store and move around because of its bulk. “The problem with hydrogen is always transportation and pressurisation,” says Giri.

## Slow reaction

If aluminium could be made to effectively react with water, it would mean hydrogen on demand. Unlike hydrogen, aluminium and water are easy to carry – and both are stable. But [previous attempts to drive the reaction](#) required high temperatures or

catalysts, and were slow: obtaining the hydrogen took hours and was around 50 per cent efficient.

The new alloy, which the team is in the process of patenting, is made of a dense powder of micron-scale grains of aluminum and one or more other metals arranged in a particular nanostructure. Adding water to the mix produces aluminium oxide or hydroxide and hydrogen – lots of it. “Ours does it to nearly 100 per cent efficiency in less than 3 minutes,” says team leader Scott Grendahl. Moreover, the new material offers at least an order of magnitude more energy than lithium batteries of the same weight. And unlike batteries, it can remain stable and ready for use indefinitely.



The army team has used the material to power a small, radio-controlled tank. Grendahl doesn't see any practical issues with scaling up production to produce hundreds of tonnes of the stuff as it can be made from scrap aluminium, which is relatively cheap. The new material could power everything from laptops to buses and [cars](#).

“In principle, the process should work,” says [Robert Steinberger-Wilckens](#), who directs a fuel cell programme at the University of Birmingham, UK.

But he cautions that a repeat experiment is needed to show that the reaction works the way it should. “There’s a lot of stuff that works in the laboratory but not in the field.”

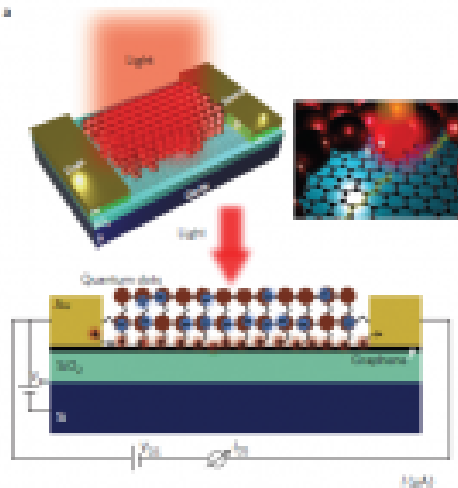
If it does pan out, the powder could also be used as the raw material for 3D printing. The researchers have put forward proposals – now being considered by the army – for small air or ground robots that use their own structure as fuel. These self-cannibalising machines would be useful for one-way intelligence-gathering missions, burning themselves up at the end to leave no trace.

more

information: <https://www.newscientist.com/article/2142693-nano-aluminium-offers-fuel-cells-on-demand-just-add-water/>

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**Hybrid graphene–quantum dot phototransistors with ultrahigh gain**



Graphene is an attractive material for optoelectronics<sup>1</sup> and photodetection applications<sup>2–6</sup> because it offers a broad spectral bandwidth and fast response times. However, weak light absorption and the absence of a gain mechanism that can generate multiple charge carriers from one incident photon have limited the responsivity of graphene-based photodetectors to  $\sim 10^{22}$  A/W<sup>21</sup>. Here, this group demonstrate a gain of  $\sim 10^8$  electrons per photon and a responsivity of  $\sim 10^7$  A/W<sup>21</sup> in a hybrid photodetector that consists of monolayer or bilayer graphene covered with a thin film of colloidal quantum dots. Strong and tunable light absorption in the quantum-dot layer creates electric charges that are transferred to the graphene, where they recirculate many times due to the high charge mobility of graphene and long trapped-charge lifetimes in the quantumdot layer. The device, with a specific detectivity of  $7.3 \times 10^{13}$  Jones, benefits from gate-tunable sensitivity and speed, spectral selectivity from the short-wavelength infrared to the visible, and compatibility with current circuit technologies.

more information: Gerasimos Konstantatos *et al.* *nature nanotechnology*, DOI: 10.1038/NNANO.2012.60.

