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 (GXRD), optical absorption, highresolution 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*.