

L.4: Low-cost automated systems for SERS measurements with analysis and uniform Au nanoparticle films preparation

Surface enhanced Raman scattering (SERS) is being explored for trace detection of various organic molecules. Integrating this technique with machine learning and deep learning methods for more reliable and robust prediction of compounds is one of the current research interests in this field. For this, acquiring and analysis of large number of SERS spectra are inevitable. In this regard, an automated system for acquiring desired number of spectra, subsequent data pre-processing and automatic analysis will be highly useful, and currently no such system is available.

In view of this, a fully automated low-cost system has been indigenously developed. The system comprises of a portable Raman spectrometer integrated with in-house developed programmable XYZ translation stage using ultra-low cost CNC shield for sample measurement and raspberry Pi based computer system for in-situ microscopic video monitoring of sample measurements (Figure L.4.1). The key features of the system are: programmable measurements of either multiple samples or mapping of single sample, online video monitoring of measurements, audio alarms at different stages, automated data pre-processing (background correction and statistical analysis) and machine learning based compound prediction, without human intervention. Within five hours, the system can acquire thousand spectra (~10 s integration time), subsequent pre-process (background correction) and auto-naming the files with details of laser power and integration time, etc.

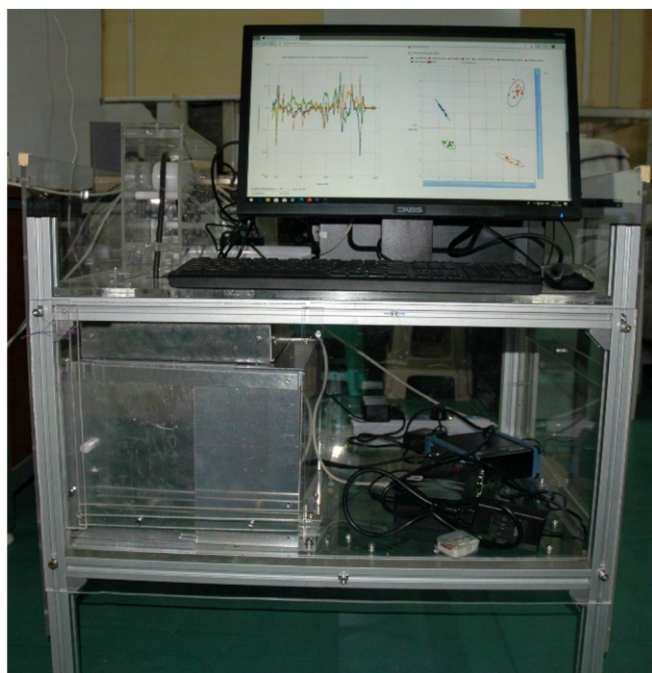


Fig. L.4.1: Photograph of the developed automated SERS measurement system.

This system is highly useful for reliable and time saving measurements for both R&D and industrial users. It will be beneficial for industrial users requiring rapid analysis of large number of samples on regular basis for various applications like raw material verification, process monitoring, quality control of products, etc.

Further, Au or Ag nanoparticle films of different morphologies find various applications mainly SERS substrates, photovoltaics, solar light absorber coating, catalysis, etc. To produce large area uniform Au nanoparticle films from colloids, an automated cost effective system has been designed and developed in-house. This system (Figure L.4.2) is first of its kind, which utilizes low-cost electronic controllers for four axes linear motion, raspberry-Pi based computer system integrated with in-house developed application software with visual recognition based process automation for preparing these nanoparticle films. The system has unique features of contact-less real time liquid level monitoring with bilingual audio alarms and process guidance. This automated control of substrate translation and programmable solvents injection/extraction assures reliability of this process. Using this system, uniform, large area gold nanoparticle films of different patterns from in-house synthesized colloids of various shape particles have been produced with high repeatability.

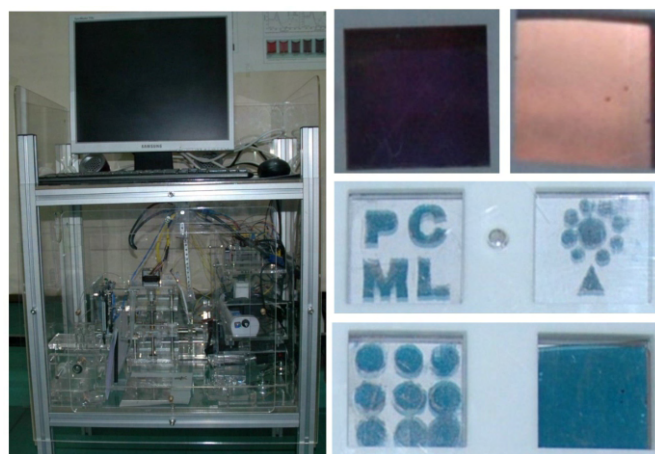


Fig. L.4.2: The developed system (left) and prepared Au nanoparticle films of different patterns (right).

The developed automated SERS measurement system is novel for obtaining quick results in deep learning related research studies. The second low-cost system that produces Au nanoparticle films with significantly low cost as compared to international market, can be upgraded to develop an automated unit for synthesis of Au and Ag nanoparticle colloids of various shapes.

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