ISMSE-14

→ APPLICATION OF SURFACE ENHANCED RAMAN SPECTROSCOPY FOR CONTAMINATION ANALYSES IN SPACE ENVIRONMENT TESTING AND MONITORING OF ENVIRONMENT

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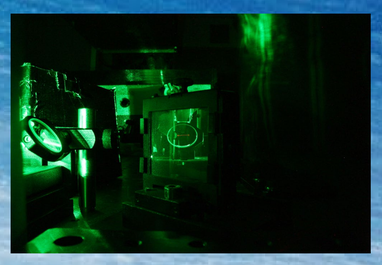

Recently, the surface-enhanced Raman scattering (SERS) provided an alternative method for environmental analysis mainly due to its substantial electromagnetic enhancement induced by local surface plasmon resonance (LSPR). SERS-active analyte must generally have an inherent affinity toward the noble metal surface where the electromagnetic field is localized. The enhancement factors (EF) of the SERS are dependent on the substrate. There are two important mechanisms underlying SERS: the electromagnetic field enhancement, where LSP of metallic nanostructure increase the Raman signal intensity and the chemical enhancement mechanism, where the charge transfer mechanism between the adsorbed molecule (1-3) and metal plays a critical role in enhancing and modifying the modes of molecular vibrations (4-5).

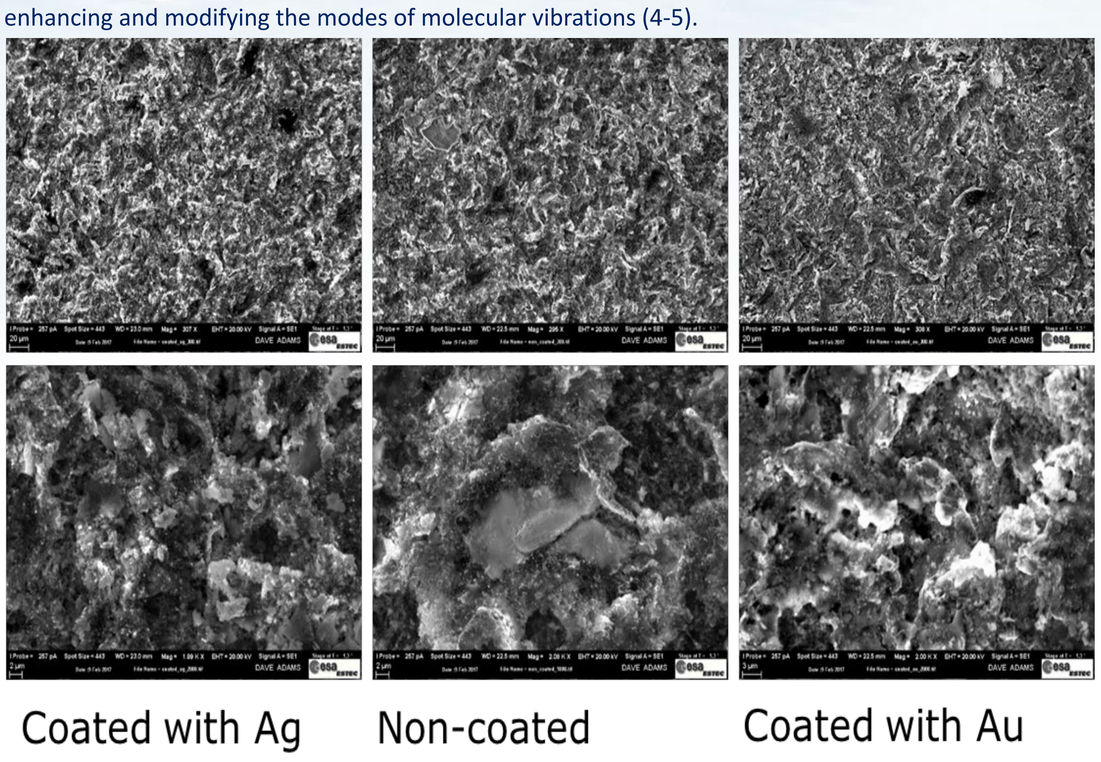

Figure 1. The characterization of NV14 and NV14 coated with gold or silver layer by SEM

The importance of the development of highly sensitive analyses techniques for detecting organic molecules in the gas phase has increased in the last years for space applications. This includes among others: 1) monitoring environment in clean rooms during assembly of space hardware and investigation of space returned samples; 2) analyses of the environment on the ISS, delivery space vehicles; 3) cleanliness assessment of hardware for planetary exploration; 4) contamination control of optical instruments for earth observation satellites. In addition, there is also a strong need for such techniques for monitoring of ground based space environmental tests with hardware and materials.

The Surface-Enhanced Raman Spectroscopy (SERS) provides a highly sensitive method for environmental analyses mainly due to its substantial electromagnetic enhancement induced by local surface plasmon resonance. To succeed in SERS measurements, an analyte must be SERS active, and generally have an inherent affinity toward the noble metal surface where the electromagnetic field is localized.

However, the non-polar nature of some hydrocarbons prevents this approach to polar metal surfaces thus preventing the SERS application for the detection of hydrocarbons at ambient conditions. In this work, a series of experiments were conducted in the Materials' Physics and Chemistry Section (TEC-QEE) of ESA with several candidates of SERS substrates with an objective to enhance the affinity of the SERS substrate to organic contamination in gas phases.

During the investigation SERS substrates were prepared by different methods on various materials: silicon, quartz crystals, ceramic coating NV14, Zeolite. The effectiveness of different methods of chemical synthesis and physical coating of silver and gold structures on silicon surfaces was also demonstrated. The prepared SERS samples were then probed as witness plates for the monitoring of the lab environment and test conditions in vacuum facilities.

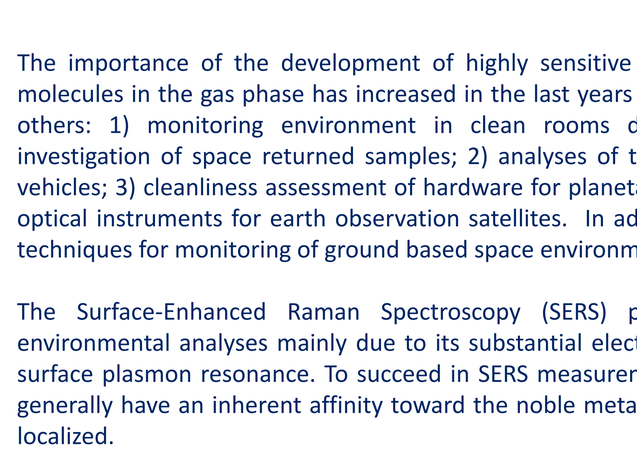

Figure 2. Optical pictures of of SERS substrates based on ceramic coating NV14 after 10 days of lab environment testing

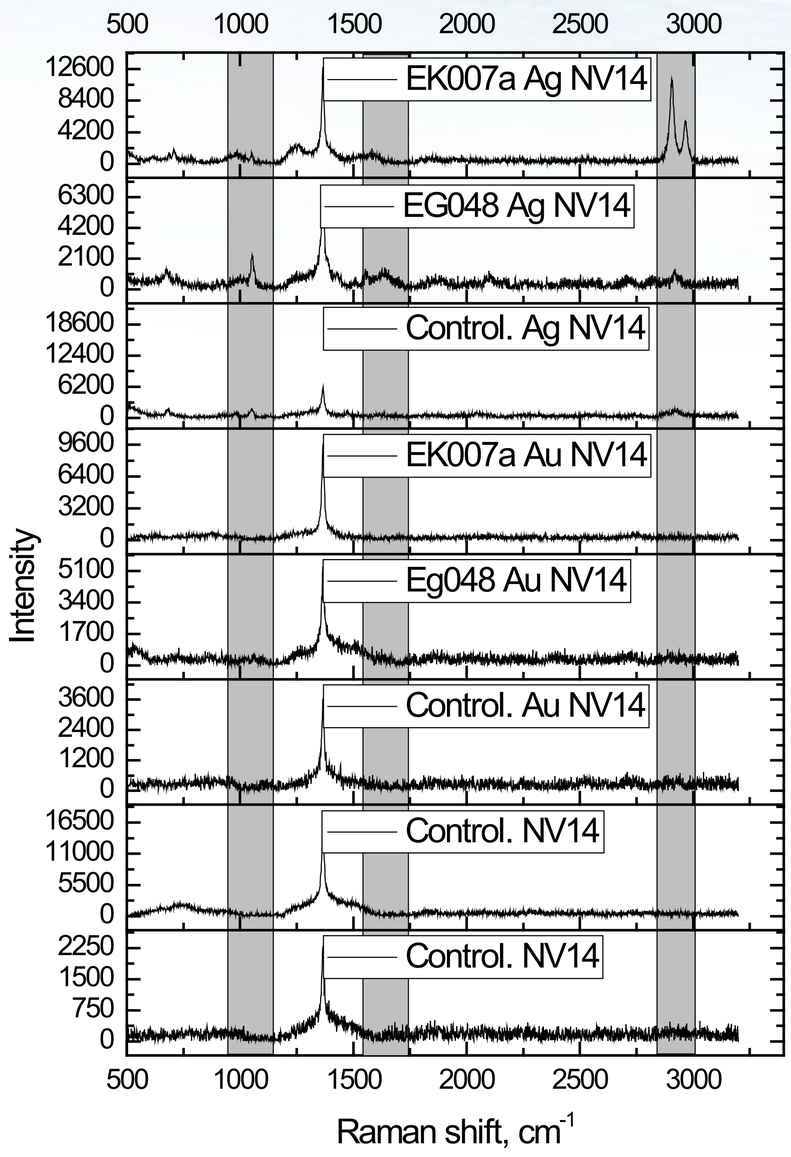

Figure 3. Results of investigation of SERS substrates based on ceramic coating NV14 in different laboratories

Figure 3 presents a set of Raman spectroscopy data with the SERS substrates based on ceramic coating NV14 with silver and gold nanoparticles. The enhancement of peaks corresponding to hydrocarbons is clearly observed in EK007a laboratory (top spectrum) compared to the other spectra.

CONCLUSIONS

Results of the investigation showed that one of the promising material for the preparation of SERS substrates is porous ceramic coating NV14. Substrates based on this material were tried as witness plates for the monitoring of the environment in different laboratories on the presence of gas phase organic molecules.

Literature

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