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CuO Nanograss as a Substrate for Surface Enhanced Raman Spectroscopy

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Surface-enhanced Raman spectroscopy (SERS) is a sensitive approach to detect and to identify a variety of molecules. To enhance the Raman signal, optimization of the gap between nanostructures is quite important. One-dimensional materials such as nanowires, nanotubes, and nanograsses have great potential to be used in SERS due to their unique sizes and shape dependent characteristics. In this study we investigate a simple way to fabricate SERS substrates based on randomly grown copper oxide (CuO) nanowires. CuO nanograss is fabricated on pre-cleaned Cu foils. Cu oxidized in an ammonium ambient solution of 2.5 M NaOH and 0.1 M $(NH_4)_2S_2O_8$ at 4°C for 10, 30, and 60 minutes. Then, $Cu(OH)_2$ nanostructures are formed and dried at 180°C for 2 h. With the drying process, the $Cu(OH)_2$ nanostructure is transformed to CuO nanograss by dehydration reaction. CuO nanograss are grown randomly on Cu foil with the average length of 10 μm and the average diameter of a 100 nm. CuO nanograsses are covered by Ag with various thicknesses from 10 to 30 nm using a thermal evaporator. Then, we immerse uncoated and Ag coated CuO nanowire samples of various oxidation times in a 0.001M methanol-based 4-mercapto-pyridine (4-Mpy) in order to evaluate SERS enhancement. Raman shift and SERS enhancement are measured using a Raman spectrometer (Horiba, LabRAM ARAMIS Spectrometer) with the laser wavelength of 532 nm. Raman scattering is believed to be enhanced by the interaction between CuO nanograss and Ag island film. The gaps between Ag covered CuO nanograsses are diverse from <10 nm at the bottom to $\sim$200 nm at the top of nanograsses. SERS signal are improved where the gaps are minimized to near 10s of nanometers. There are many spots that provide sufficiently narrow gap between the structures on randomly grown CuO nanograss surface. Then we may find optimal enhancement of Raman signal using the mapping data of average results. Fabrication of CuO nanograss based on a solution method is relatively simple and fast so this result can potentially provide a path toward cost effective fabrication of SERS substrate for sensing applications.

Acknowledgements

This research was supported by the MSIP (Ministry of Science, ICT and Future Planning), Korea, under the "IT Consilience Creative Program" (NIPA-2013-H0203-13-1002) supervised by the NIPA (National IT Industry Promotion Agency).

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Keywords: SERS, Raman spectroscopy, CuO nanowire, 4-Mpy