Nano Cost Nano Patterned Template for Surface Enhanced Raman Scattering

H.- C. Hou, J. Kim, K. Kanakamedla, S. Basu, T. Daniels-Race, and M. Feldman*[a]
Division of Electrical and Computer Engineering
**LSU Center for Computation & Technology,*
Louisiana State University, Baton Rouge LA, 70803

Raman scattering is a well-known technique for detecting and identifying complex molecular samples. The weak Raman signals are enormously enhanced in the presence of a nano-patterned metallic surface next to the sample. Previous work[1] reported Raman enhancement with a patterned gold surface on a transparent substrate. The surface was part of a probe that obtained Raman signals from the surface or interior of a remote specimen, and could be used in a clinical environment. This paper reports a new technique to pattern the nanostructures required for Surface Enhanced Raman Scattering (SERS) without costly lithographic steps. It uses the nanostructures present in ordinary household aluminum foil,[2] at a cost of less than 0.005 cents for a 1 cm^2 sample.

Raman spectra were obtained with a Horiba LabRAM Raman spectrometer operating at 633 nm. Untreated aluminum foil produced a significant SERS signal in a 1 mM solution of Rhodamine 6G (Table I). The values shown are the average of 5 measurements in a 1 cm^2 specimen. Etching 0.7 μm from each side in a 30% solution of KOH further strengthened the signal, as did depositing 20 nm of gold. The combination of both etching the aluminum and depositing gold produced enhancements comparable to our best previous result.[1] The smooth and rough sides of the aluminum foil produced similar results. Not included in this data is one anomalous result of gold deposited on the rough, etched side of the foil: a maximum peak height 6 times larger than any other result.

Spectra were obtained using the smooth side of foil that was etched and coated with gold for solutions of Rhodamine 6G with concentrations from 1 nM to 1mM (Fig. 1). Figure 2 shows the resulting Raman signal strength as a function of the Rhodamine concentration. In another approach, the gold covered pattern was imprinted into UV curing epoxy on a transparent substrate. After an additional etch to remove the remaining aluminum, Raman spectra (Fig. 3) were obtained through the gold (Fig. 4) as required for clinical applications with remote probes.[1]

Results will be presented showing the naturally occurring nano-patterns on the aluminum and gold surfaces, along with methods to identify and improve those areas that produce particularly strong Raman signals.

This work was supported in part by the National Institutes of Health Grant # 1R03EB012519-01A1, the Louisiana Board of Regents LEQSF(2011-14)-RD-A-07, the AES Corporation, and Dr. Kristina Johnson of Enduring Hydro.

[1] J. Kim, et al, *J. Vac. Sci. Technol.*, **B-32**, 6 (2014).
[2] PRICE FIRST $_{TM}$, Wal-Mart Stores, Inc., Bentonville, AR 72716.

[a] E-mail: mfeldm1@lsu.edu

Material	Smooth side, no etch	Rough side, no etch	Smooth side, etched	Rough side, etched
Al	240	280	395	375
Al + Au	510	365	1600	1475

Table I. Typical enhanced Raman signal strengths for several metalic surfaces in contact with a 1 mM solution of Rhodamine 6G.

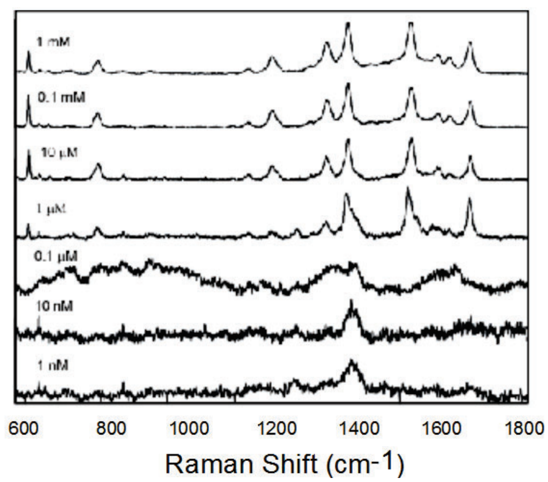

Fig. 1. Surface Enhanced Raman signals as a function of Rhodamine 6G concentration. For clarity the strongest samples were selected.

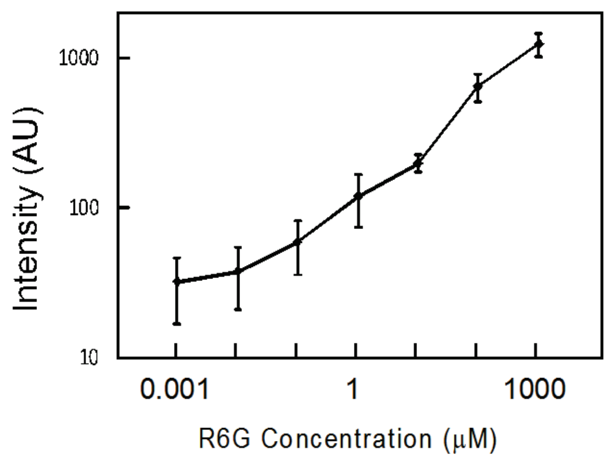

Fig. 2. Surface Enhanced Raman signals as function of Rhodamine 6G concentration. Each data point represents 5 samples.

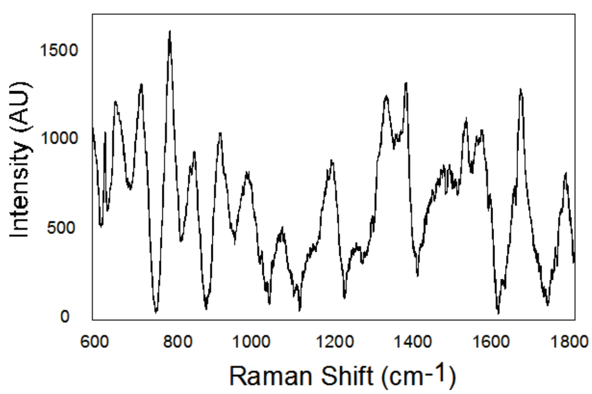

Fig. 3. Raman spectrum in transmission.

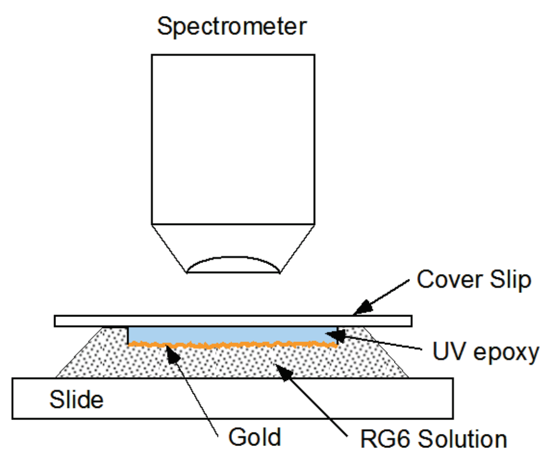

Fig. 4. Imprinted gold in epoxy after the aluminum template has been etched away.