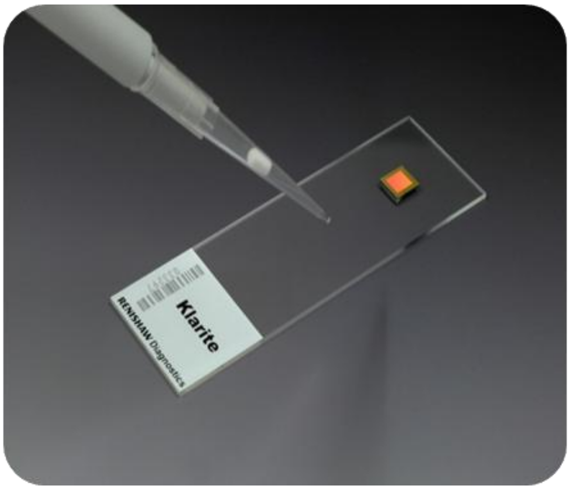
A comparison of Klarite® SERS Substrates with a rival

Overview

Customer applications which make use of surface enhanced Raman scattering (SERS) require robust, reproducible and sensitive substrates to truly deliver the acknowledged advantages of this exciting technique. This application note shows a comparison between Klarite, the market leading solid state SERS substrate, and a recently released competitor product. By comparing surface morphology, background cleanliness and sensitivity, we show the clear advantages of a Klarite-based SERS solution. The nano-engineered architecture and tightly controlled surface structure results in significantly higher enhancement factors and excellent batch-to-batch reproducibility, while the clean background spectrum facilitates meaningful spectral interpretation for accurate results.



Product description

To the naked eye, gold coated silicon materials can look extremely similar. However, a closer inspection of Klarite and a recently released competitor product reveals strikingly different surface morphologies when viewed under the scanning electron microscope (SEM). The competitor product consists of polydisperse gold aggregates on a silicon surface, with particle sizes varying from approximately 40-100 nm. In contrast, Klarite substrates consist of uniform 1.5 µm diameter etched pyramids with roughened gold (feature size ~20 nm) deposited onto the internal pyramid walls using a controlled, reproducible method. The uniformity of the surface features, which have a significant impact on measurement reproducibility, is evident from the SEM images in figure 1.

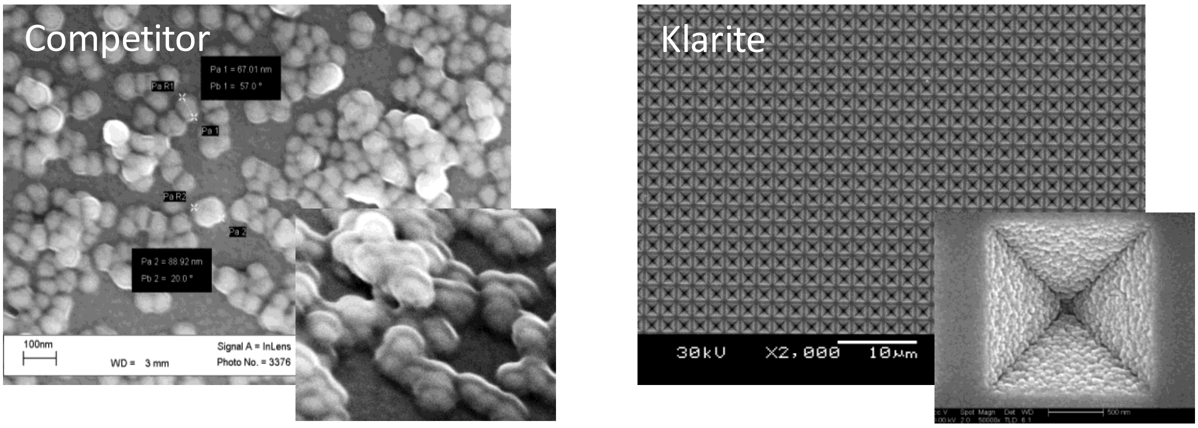


Figure 1 – SEM micrographs showing the surface structure of the two silicon-based substrates. Note that scale bars used are different (LHS - 100 nm, RHS - 10µm) in order to properly compare features of interest.

The uncontrolled deposition of gold nanoparticles onto a flat surface (gold coated or not) will result in a random orientation of aggregates with poorly defined structure. In contrast, the nano-engineered Klarite surface is a highly regular and well characterised system carefully designed to control surface plasmonics and deliver the optimum enhancement factor for a wide variety of experimental conditions.

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Background spectra

For most solid state substrates, a high 'blank' background is generally indicative of a higher enhancement factor. Background spectra were recorded of unmodified, clean substrates using a Raman microscope at 785 nm laser wavelength, 100% power, and 20x microscope objective. The spectra shown below are averages calculated from 3x3 point maps, with each point collected using a 5 second acquisition time.

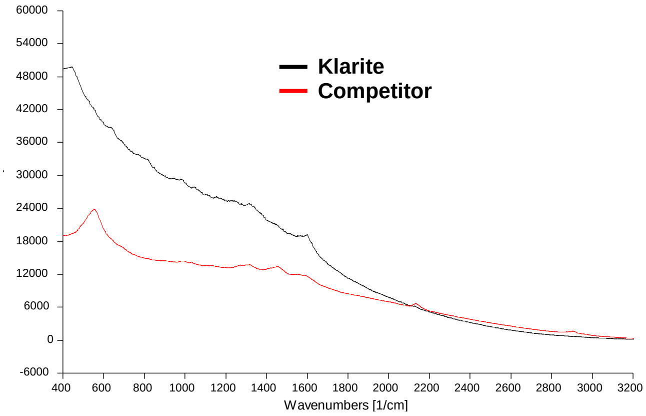

Figure 2 – Background spectra comparison

While the background spectra have similar profiles, the decreased intensity of the competitor substrate background indicates a significantly reduced enhancement factor. In addition, a prominent, broad peak is observed at 570 cm^{-1} which may prove obtrusive with some analytes.

Benzenethiol comparison

Self assembled monolayers (SAM) provide an excellent standardised test for substrate performance. A benzenethiol SAM was formed by immersing the substrates in a 5 mM benzenethiol solution for one hour before rinsing and drying. The same instrument parameters as above were used, but 10x10 point maps were taken across the whole substrate surface (4x4 mm in both cases) and averages calculated.

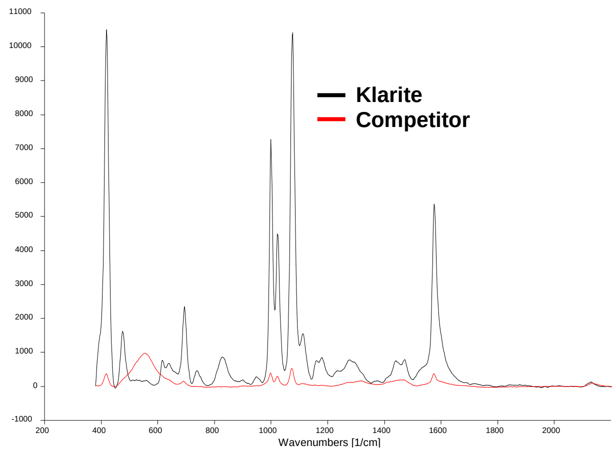

Figure 3 – Benzenethiol spectra comparison

The benzenethiol spectra shown in figure 3 have been background subtracted for ease of inspection but are otherwise unprocessed and accurately reflect the absolute intensities of the collected spectra. Comparing the two clearly illustrates a 10^2 increase in enhancement factor using Klarite. In addition, upon closer inspection of the competitor spectra, the peaks clearly observed in the background spectrum (including the broad peak at 570 cm^{-1}) have 'carried through' to the analyte spectrum and obscure several wavenumber regions.

Ibuprofen spectra

To provide information on how the lack of sensitivity of the competitor substrate could affect real-world applications, the spectra from a range of concentrations of ibuprofen solution were collected. 5 µl droplets were deposited on each substrate and allowed to dry in air before inspection. Figure 4 compares the spectra from solutions at a concentration of 10^{-3} M, collected in the same way as the benzenethiol measurements.

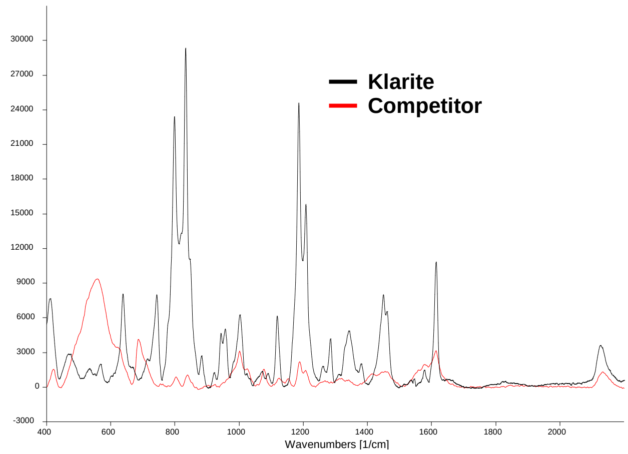

Figure 4 – Ibuprofen spectra comparison

Again, clear differences in enhancement factor are observed, and the addition of background peaks to the competitor substrate spectrum complicates analysis. The limit of detection for ibuprofen was found to be 10^{-3} M for the competitor substrate, and 10^{-6} M for Klarite (data available on request).

Conclusions

The difference in surface architecture of the two products is evident from SEM images - the competitor product consists of random gold aggregates on a Si surface, while Klarite is nano-engineered using a lithographic approach and controlled gold deposition. Spectra recorded from both show Klarite to have an enhancement factor at least two orders of magnitude higher than the competitor product, while the cleaner background allows clearer and more reliable spectral analysis. The improved sensitivity and accuracy of Klarite are essential for successful SERS applications.

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