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Improving spectral resolution of SERS using moving Ag nanopillar substrate

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The detection of complex molecular species using surface-enhanced Raman scattering (SERS) spectroscopy can induce dissociation of the molecules that reduces the reproducibility of the measurement. The issue can be addressed by moving the SERS substrate during measurements in the perpendicular axes to the laser exploiting the unique uniformity of the substrate.

The problem with conventional surface enhanced Raman spectroscopy (SERS) methods is that a nearly diffraction-limited laser focal spot and a high laser power are required to obtain a high spectral resolution. However, the increased power density at the substrate leads to heating and other effects which can damage the analyte molecule.

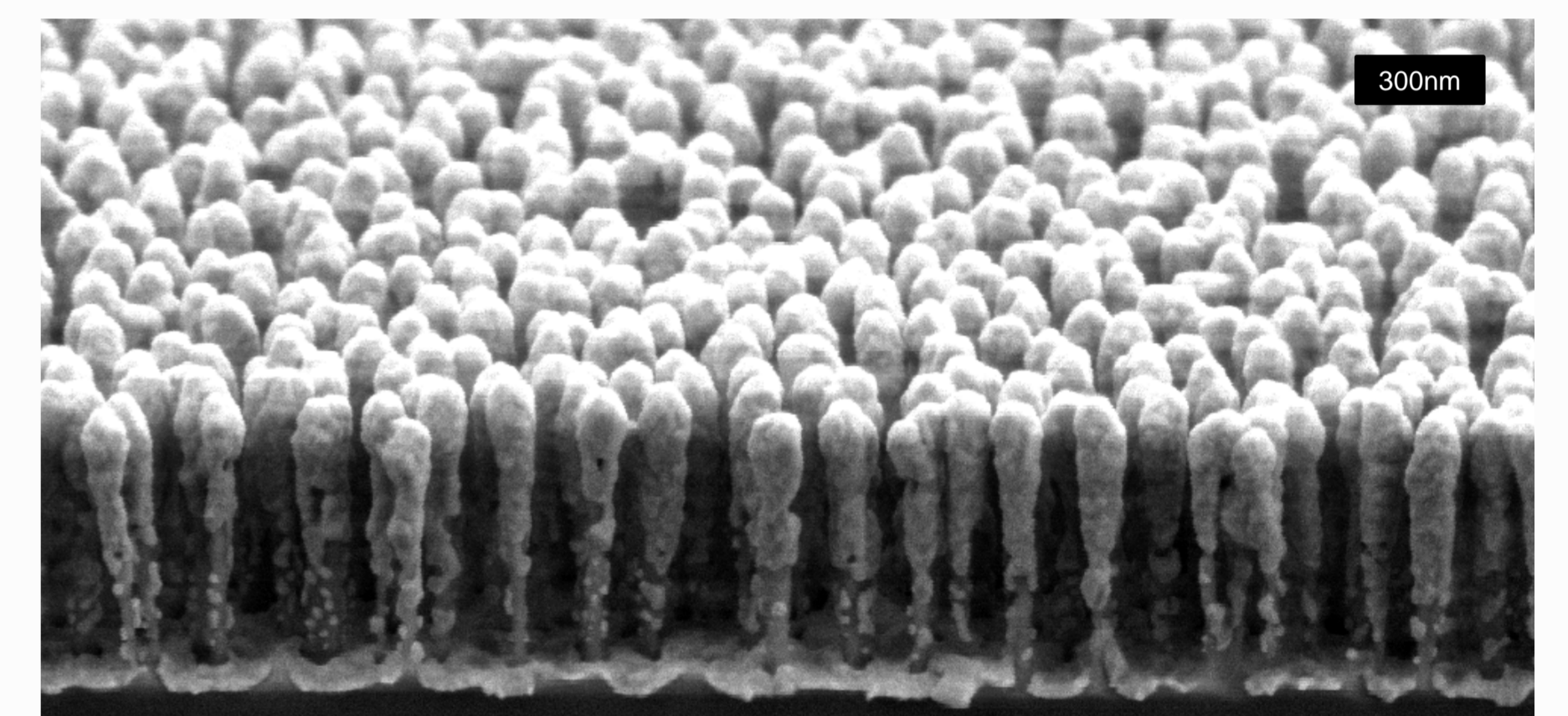
The usual solution either to increase the size of the laser spot or reduce the laser power, both resulting in lower spectral resolution.

The SERS substrate consists of silver coated silicon nanopillars. These are fabricated by a simple two-step cleanroom fabrication process; **1.** an optimized reactive ion etching forms the nanopillars and **2.** a metal layer is evaporated on top of the pillars creating nanoparticles on sticks. This configuration means that the particles are exceptionally stable and easy to work with.

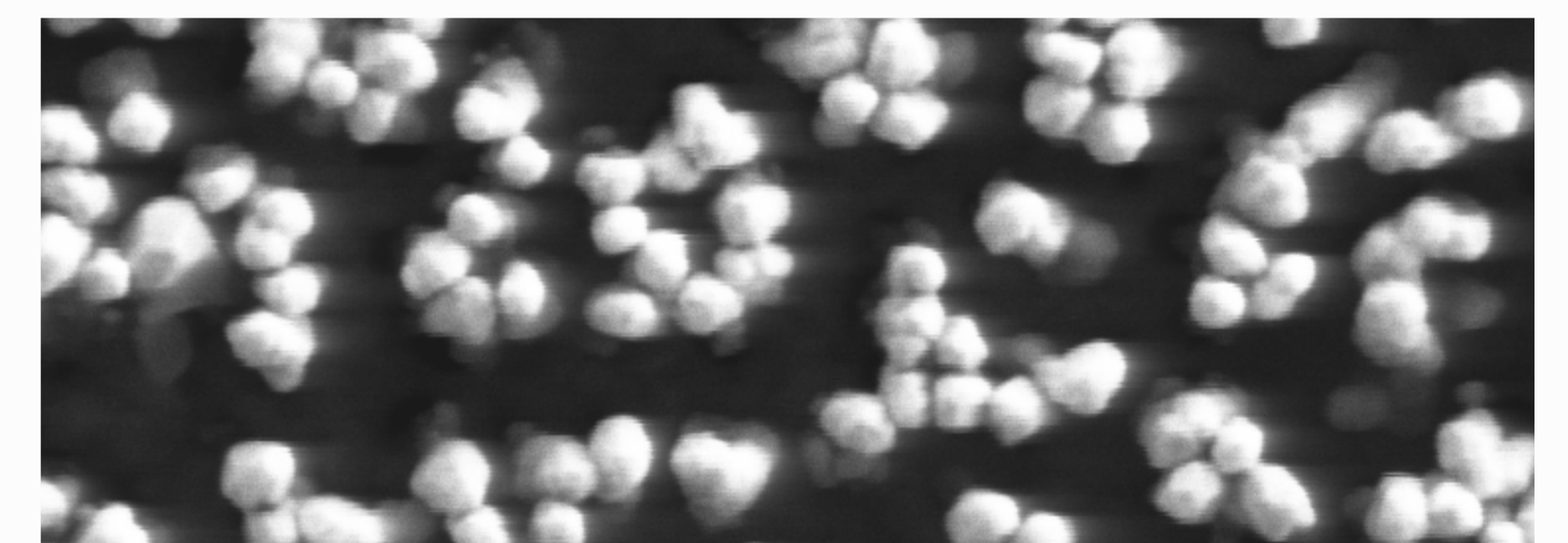
Hotspot formation happens when the solvent evaporates from the substrate generating surface forces which pulls the pillars towards each other forming small clusters.

When moving the substrate while measuring SERS, either a change in molecule orientation or alteration of the molecule-pillar configuration, allows to record more vibrations and therefore a more complete spectrum. This is only possible because of the very high uniformity and stability of the SERS substrate.

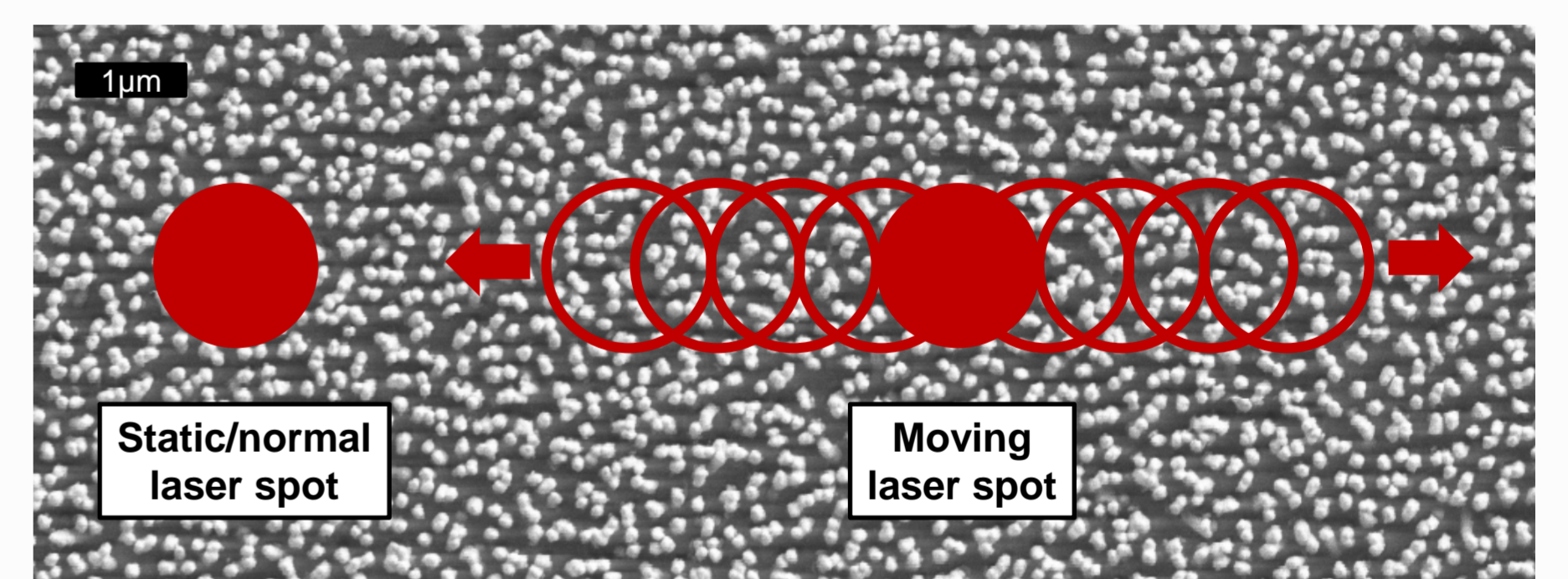
In conclusion the spectral resolution is improved by moving of the SERS substrate in the perpendicular axes to the laser, exploiting the uniformity of the substrate. Thus, this measurement method has the potential of recording previously hidden vibrations.



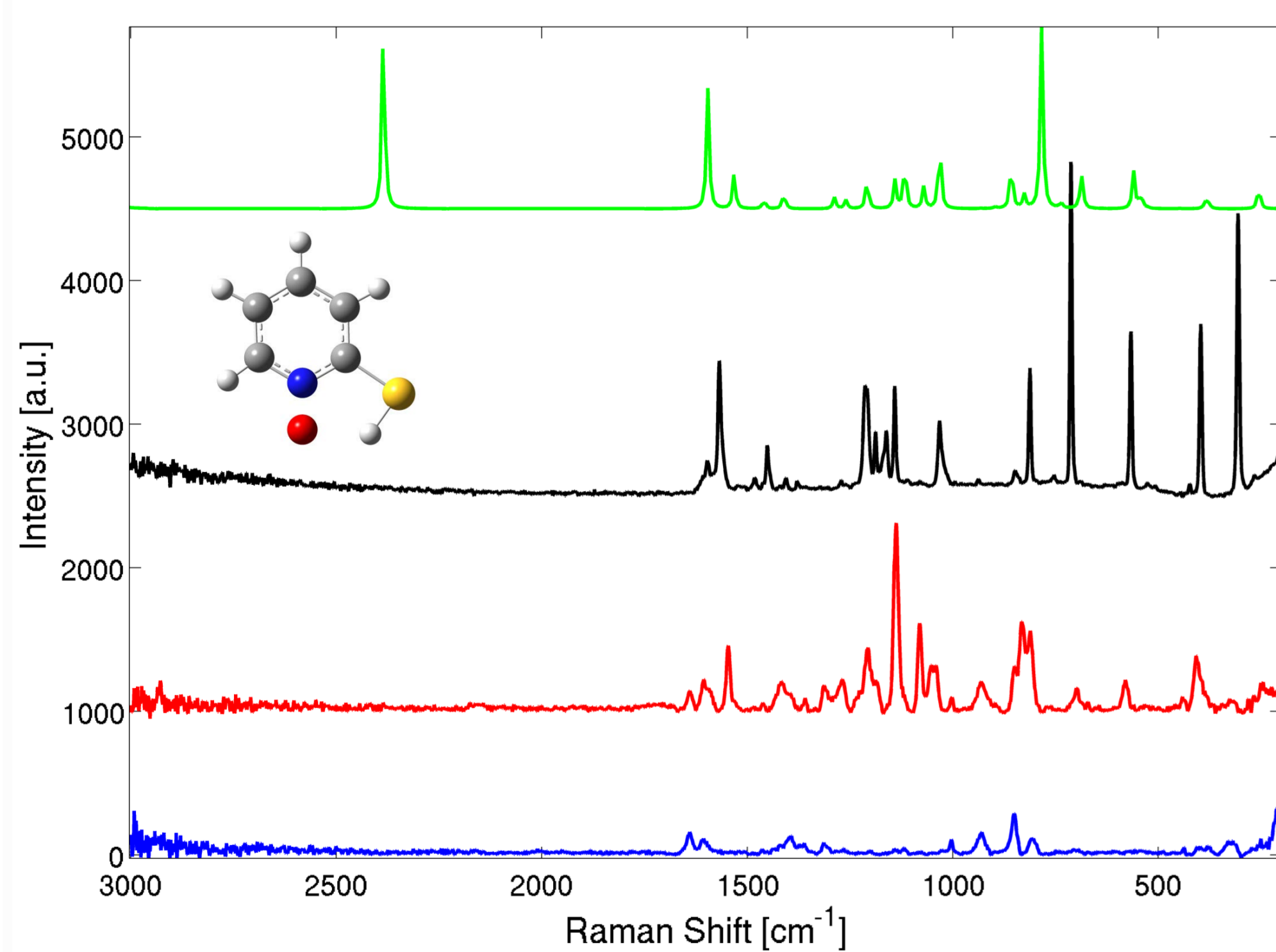
Silver coated silicon nanopillars for surface enhanced Raman spectroscopy. This substrate are made in wafer scale and still gives a very uniform SERS signal.



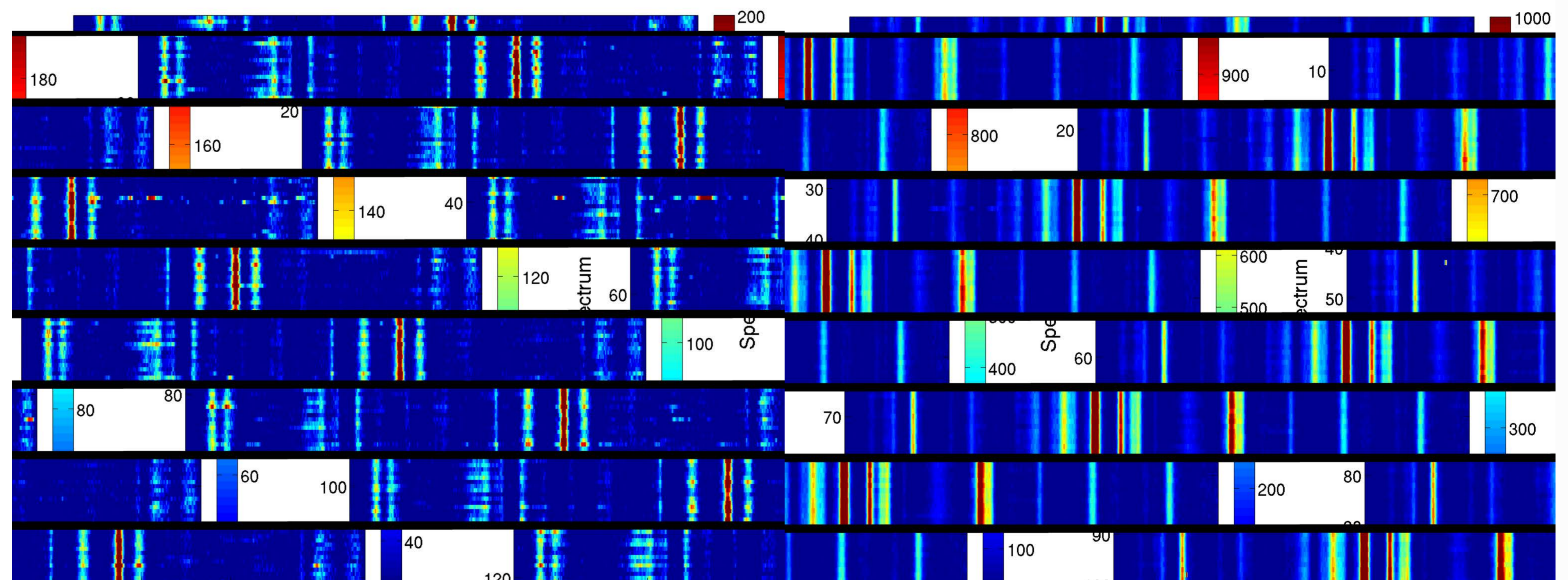
Top view of leaned silver coated silicon nanopillars. The pillars are wetted with the sample and when the solvent evaporates the surface tension pulls the pillars together forming clusters and potential hotspots.



Schematics of a normal laser spot in a static position and a moving laser spot.



Theoretical spectrum (green), Raman spectrum (black), static/normal spectrum (blue) and dynamic (red) spectrum of 2-mercaptopyridine N-oxide (inlet).



Map of 120 static measurements illustrating that only few peaks are visible by this measurement method

Map of 100 dynamic measurements illustrating that more peaks are visible by this measurement method and comparing with the theory, this method gives a more accurate spectra.