Active-illumination parallel Raman/SERS imaging

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Raman spectroscopy can provide molecular information via inelastic light scattering without physical contact. Coupled with microscopic imaging, Raman imaging is a powerful technique for material analysis, for example, stress and temperature measurement in silicon and compositional analysis of polymer microparticles. However, due to the small Raman cross-section, the data acquisition time is significantly longer than other optical modalities. The traditional design of conventional charge coupled detector (CCD) readout electronics introduces additional latency, resulting in slow Raman imaging throughput.

Recently, we have developed a novel parallel Raman imaging scheme for simultaneously collecting Raman spectra from multiple points [1]. This scheme is realized by multiple-point laser active-illumination using a spatial light modulator (SLM) coupled with wide-field Raman image collection. We have demonstrated the performance of this scheme using uniform samples, fixed polymer microparticles (Fig. 1) and trapped polymer microparticles (Fig. 2) with mixed molecular composition within a ~ 100 x 100 μm^2 field of view This scheme enables the acquisition of Raman spectra from as many as 80 laser spots (equivalent to ~200 diffraction limited imaging pixels) simultaneously using a single illumination pattern and detector recording frame without scanning.

In this talk, we will discuss strategies for extending this technique to continuous image acquisition via multiple pre-designed illumination patterns, where streamlined pattern illumination and synchronized Raman data collection is key. We will also present results on snapshot image guided Raman/SERS acquisition, in which a snapshot brightfield image is first taken and analyzed to extract features of interest, and a series of illumination patterns are subsequently generated for Raman/SERS acquisition. As a result, the throughput of this scheme can be orders of magnitude faster than commercial systems.

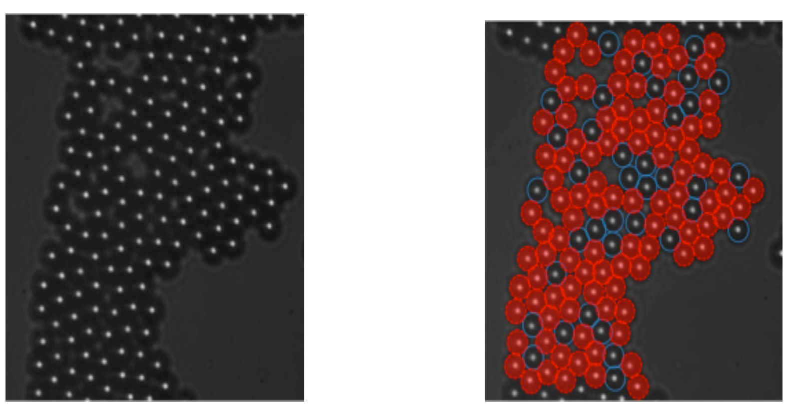

Fig. 1. Classification of two types of polymer beads: (left) brightfield image; (right) classification based on Raman spectra (PS: red, PMMA: blue).

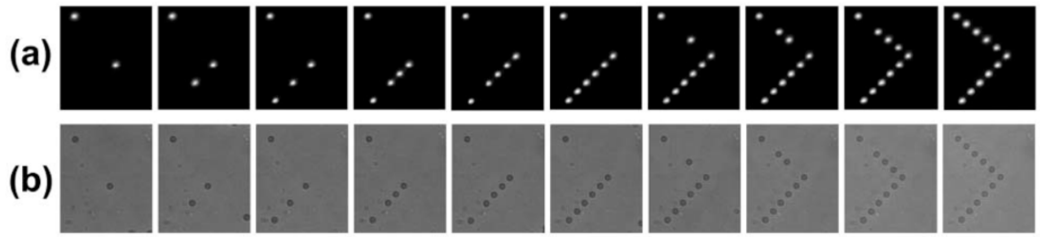

Fig. 2. Simultaneous trapping and Raman imaging of multiple beads: (a) Raman images using polystyrene Raman peak at 1001 cm^{-1}; (b) brightfield images.

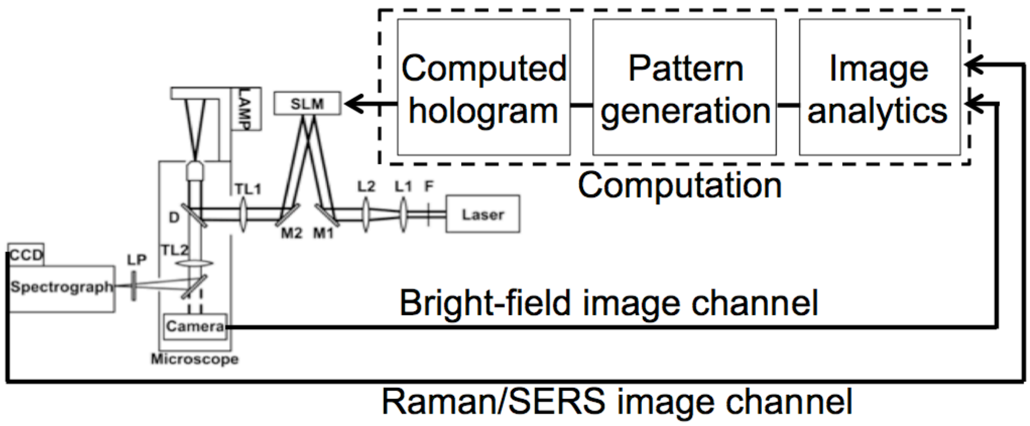

Fig. 3. Configuration of the active-illumination system with integrated computational core.

References:

[1] Ji Qi and Wei-Chuan Shih, "Parallel Raman microspectroscopy using programmable multi-point illumination," *Optics Letters* 37(8): 1289-1291, 2012.