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# Nanoscale Raman mapping for near-field laser heating

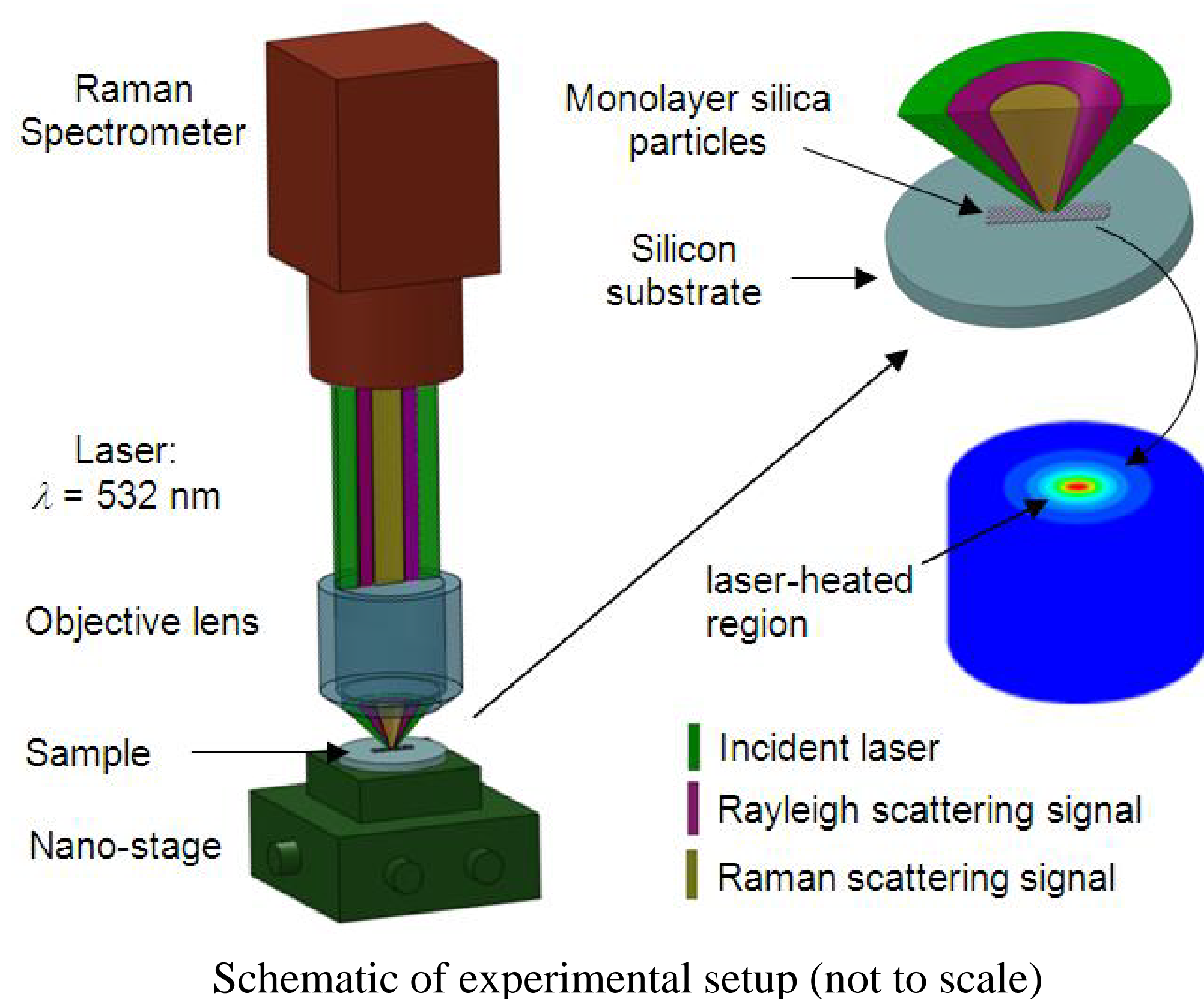
## Abstract

A systematic study of nanoscale mapping of particle-induced thermal and stress fields is reported. Raman spectroscopy is employed to investigate the temperature and stress rise in silicon. Nanoscale mapping results based on Raman intensity variation, wavenumber shift, and linewidth broadening all give consistent conjugated thermal, stress, and near-field focusing effects at a 20 nm resolution. Nanoscale mapping of near-field effects of particles from 1210 down to 160 nm demonstrates the strong capacity of such technique. The temperature and stress rise in the nanoscale heating region is evaluated for particle of 1210 nm diameter at different energy levels. The experimental results indicate that the temperature and stress rise inside the substrate increases almost linearly with the energy fluence.

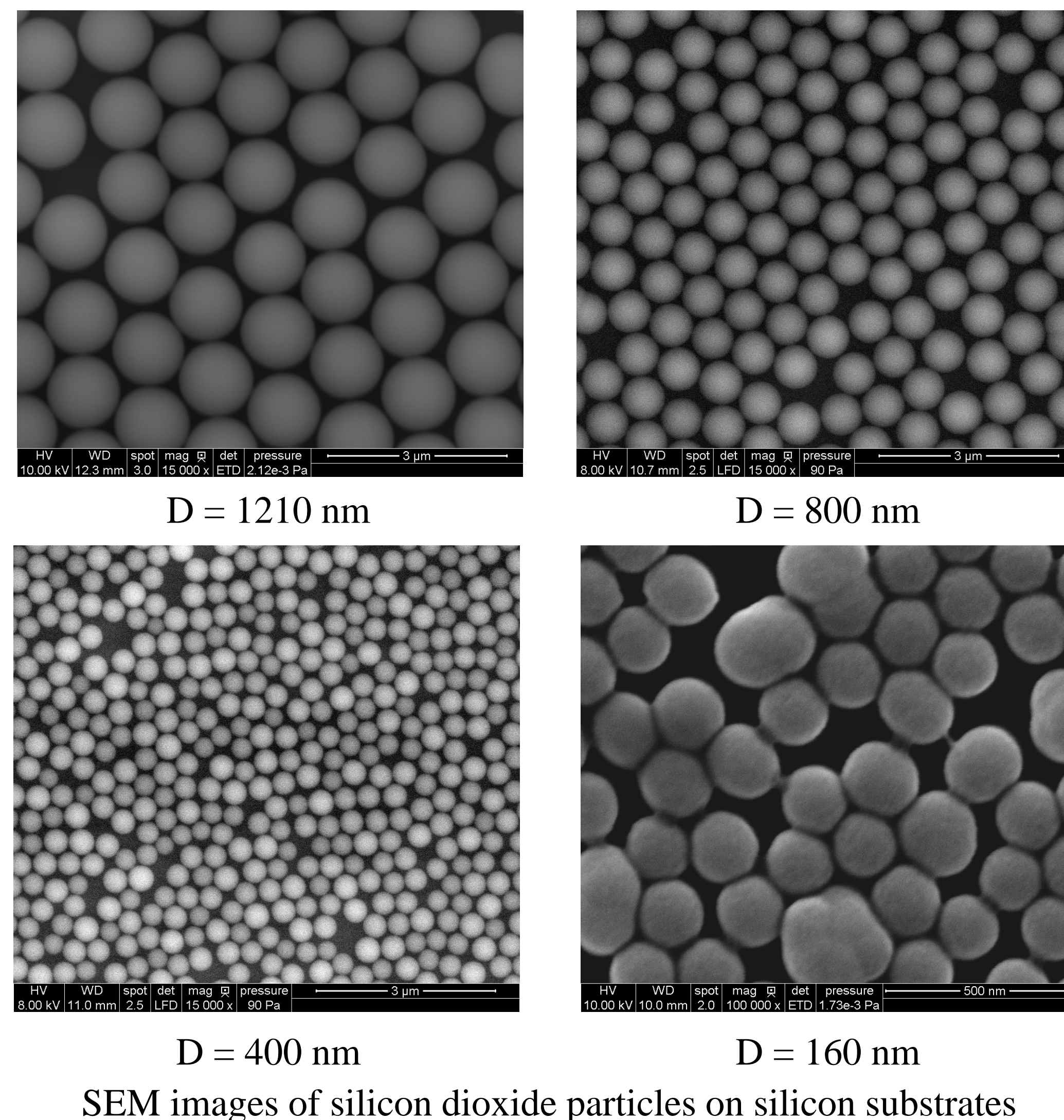
## Introduction

- ❖ Micro/nanoscale particles can act as spherical lenses and heat the substrates under laser irradiation. Near-field laser heating induced by micro/nanoparticles has been widely used in laser-assisted nanopatterning and nanolithography.
- ❖ Knowledge of the temperature and stress in the nanoscale near-field heating region is critical for process control and optimization.
- ❖ Little experiment about thermal and stress mapping and probing inside a substrate under particle-focused heating has been reported.

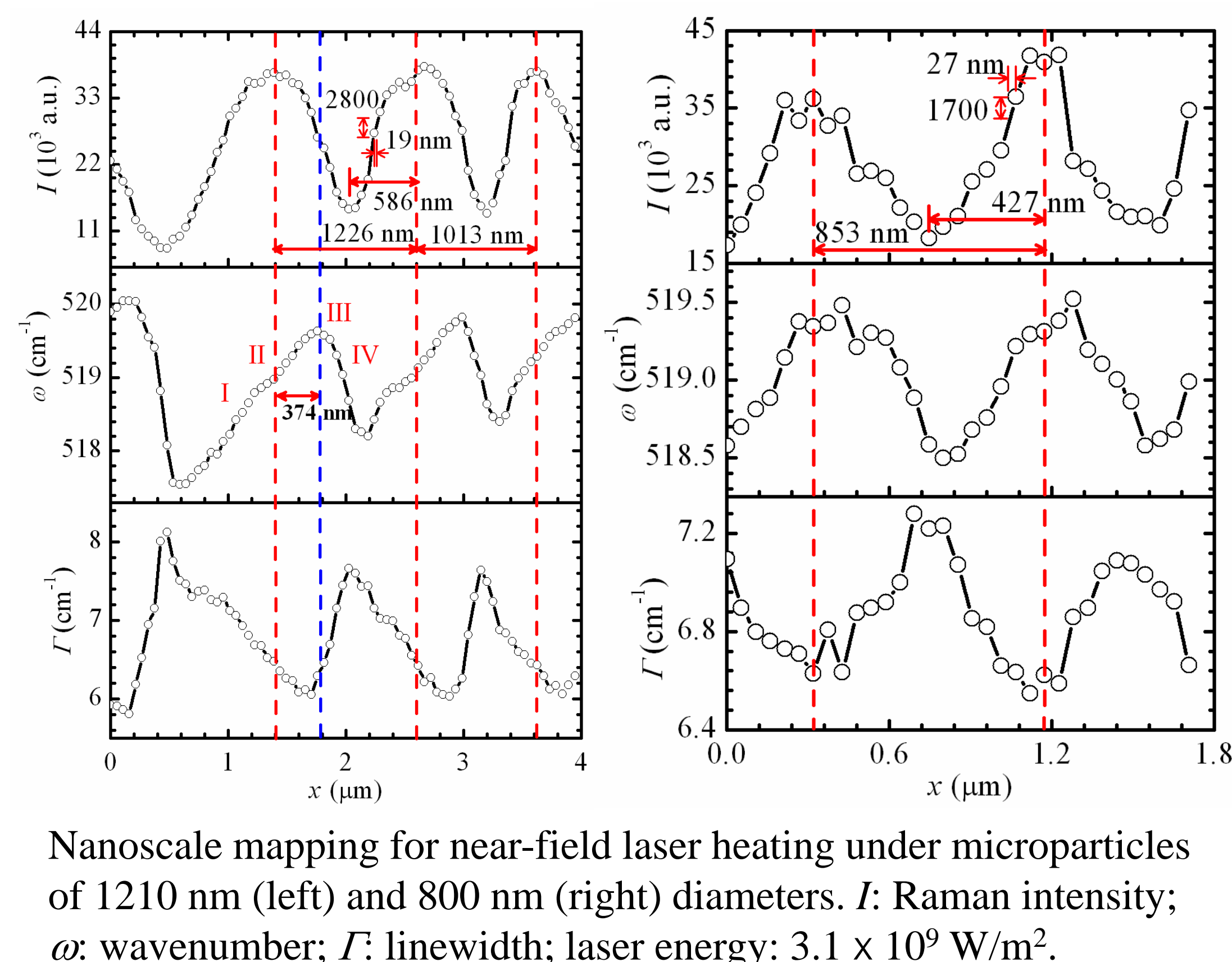
## Methods



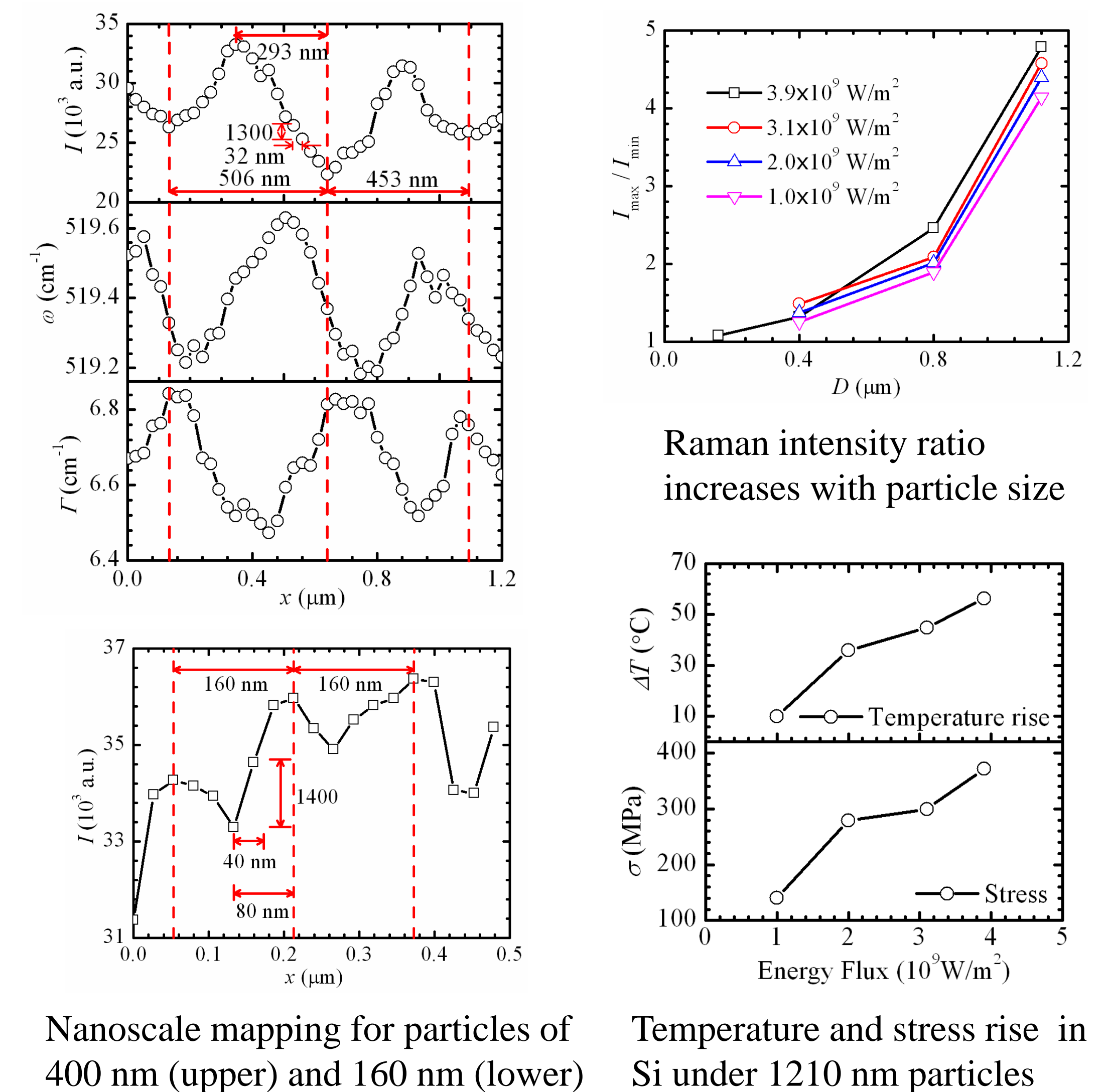
## Samples



## Mapping Results



## Mapping Results



## Conclusions

- ❖ Far-field nanoscale imaging of near-field focusing, thermal and stress fields in a silicon substrate beneath silica particles was conducted for the first time using Raman spectroscopy.
- ❖ Under 1210 nm silica particles, the temperature rise in the near-field focusing region in the silicon substrate reaches 56.1 °C under a laser fluence of  $3.9 \times 10^9 \text{ W/m}^2$ , and the local stress is 370 MPa.
- ❖ The temperature and stress rise inside the silicon substrate increases as the laser energy flux increases.

## References

- [1] Li, L.P., *et al.*, 2004, "Laser-assisted nanopatterning of aluminium using particle-induced near-field optical enhancement and nanoimprinting", *Nanotechnology*, 15 (11).
- [2] Tang, X. *et al.*, 2012, "Sub-wavelength temperature probing in near-field laser heating by particles", *Optics Express*, 20 (13).
- [3] Tang, X. *et al.*, 2013, "Nanoscale probing of thermal, stress, and optical fields under near-field laser heating", *PLoS One*, 2013, 8 (3).