Micro-Raman Spectroscopy Measurement of Stress in Silicon

Sergej Shashkov, SOL instruments Ltd.,
Nezavisimosti ave.58-10, Minsk, Belarus

Mechanical stress can have direct or indirect effects on the functioning and reliability of a chip and can cause different failure modes, such as:

- changes in electron or hole mobility
- dislocations near isolation structures
- cracks in chips,
- creep in metals,
- stress migration, etc.

Stress can also be used in a positive way, for example to increase the carrier mobility.

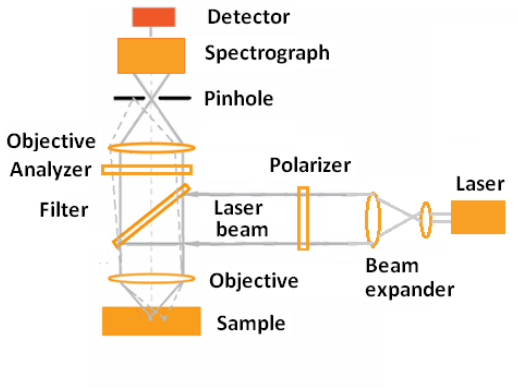
Local Strain Metrologies

method	sensitivity ε : strain	Spatial resolution	feature
Raman scattering	0.05 cm^{-1} ($\varepsilon \sim$ 0.005%)	~130 nm	Non-destructive Non-contact
CBED (Convergent beam electron diffraction)	$\Delta d/d=$ 0.02%	~20 nm	High precision
NBD (Nano-beam electron diffraction)	$\Delta d/d =$ 0.1%	~ 10 nm	High spatial resolution

T. Kanayama, 2007 Int Conf Frontiers of Characterization and Metrology for Nanoelectronics, March 29, 2007

SOL instruments

Confotec family



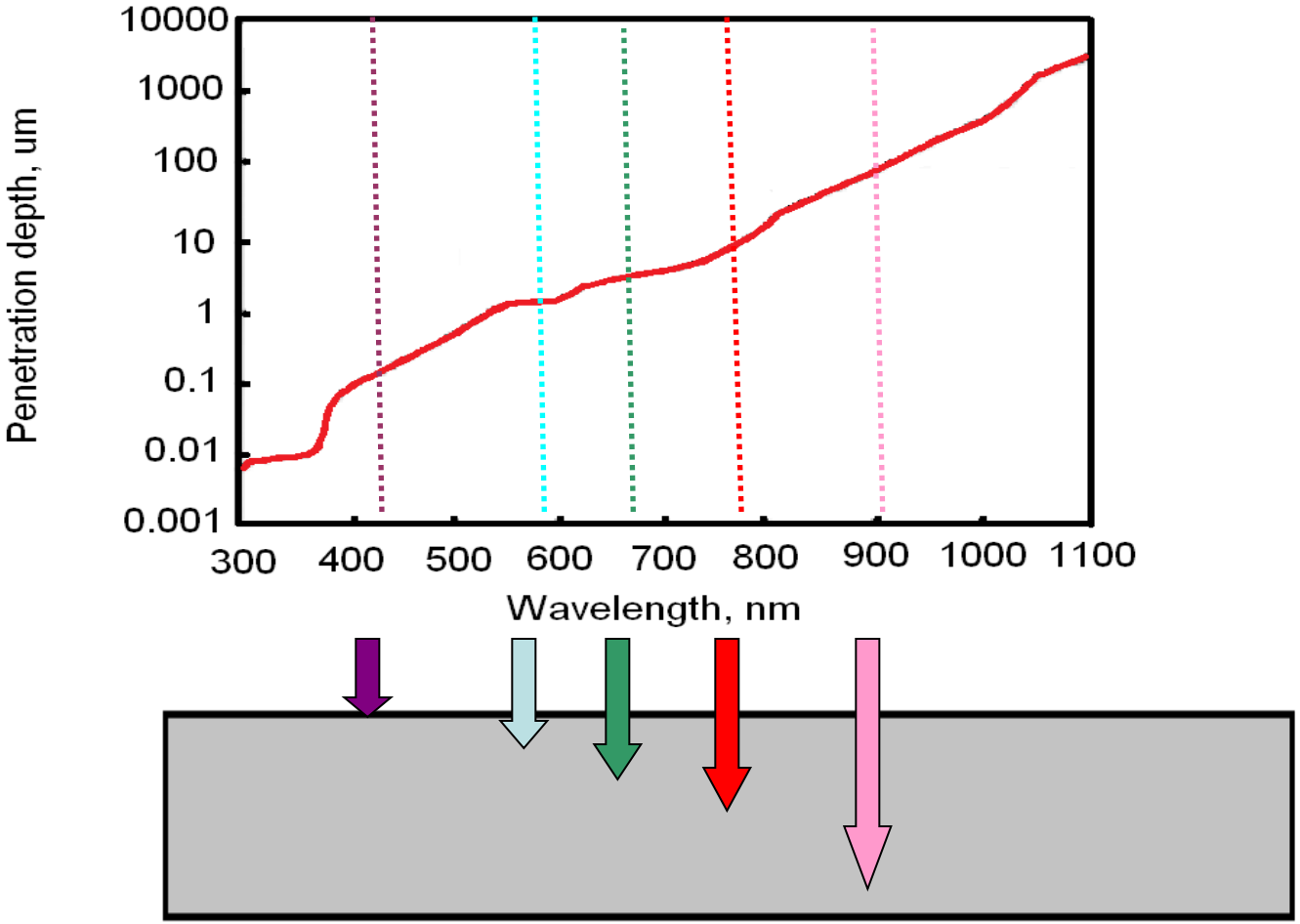
Confotec® MR350

Confotec® MR520

Confotec® NR500

Confotec® CARS

Penetration Depth

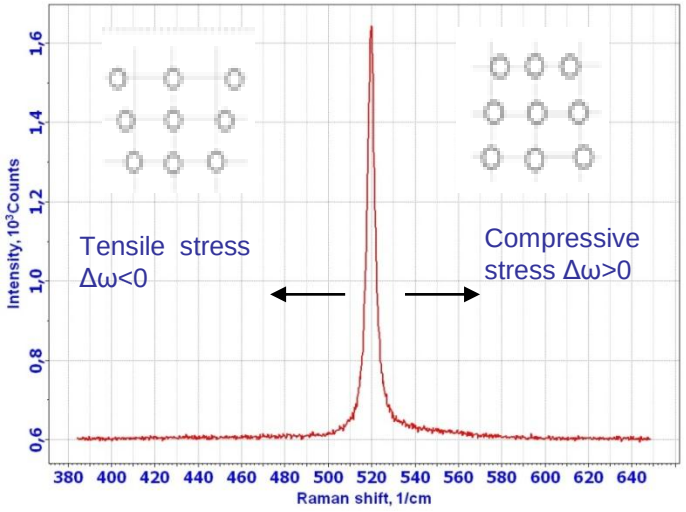


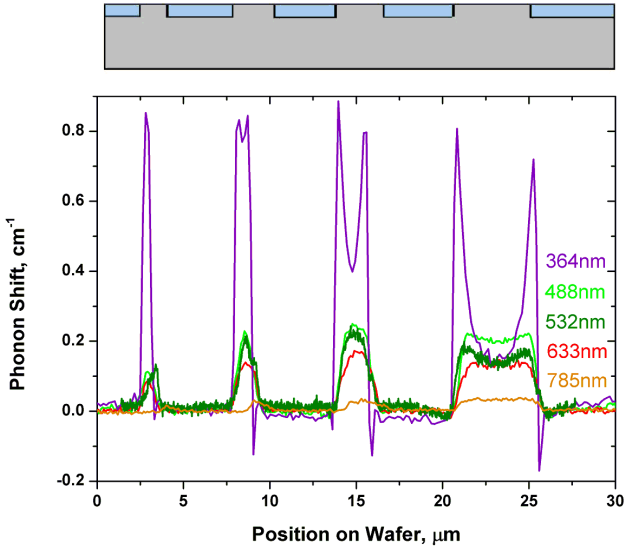
E.D. Palik, “Handbook of Optical Constants of Solids”, Academic Press,Sant Diego, 1998.

The next equation can be applied to the Si stress monitoring:

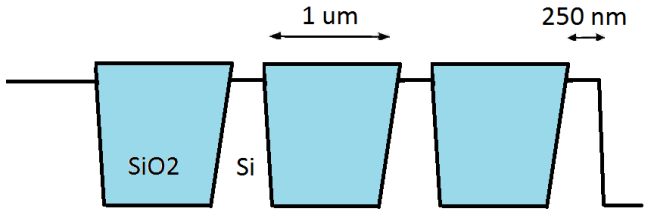
$\sigma(MPa) = -435 \cdot (\omega - \omega 0)\ (cm^{-1})$,

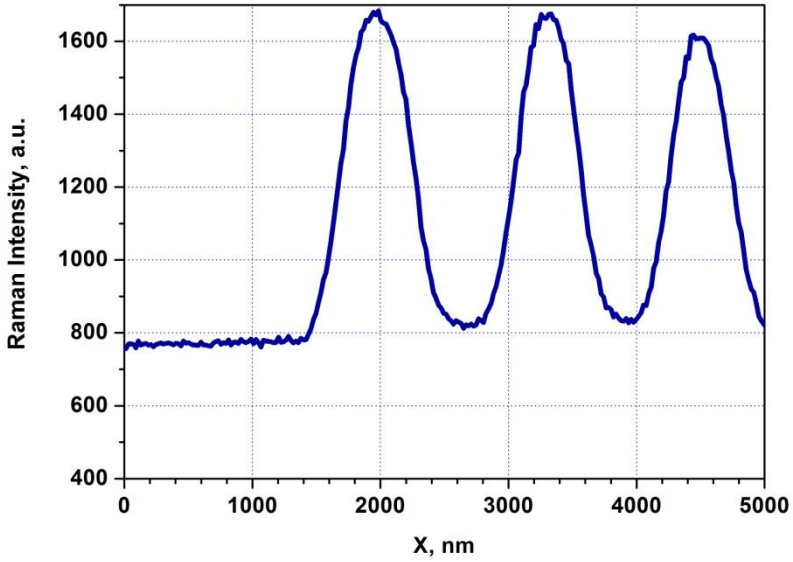
where σ is the stress value, $\omega 0 = 520.5\ cm^{-1}$ is the peak position of the stress-free state, ω is the Si peak position at the stressed state.

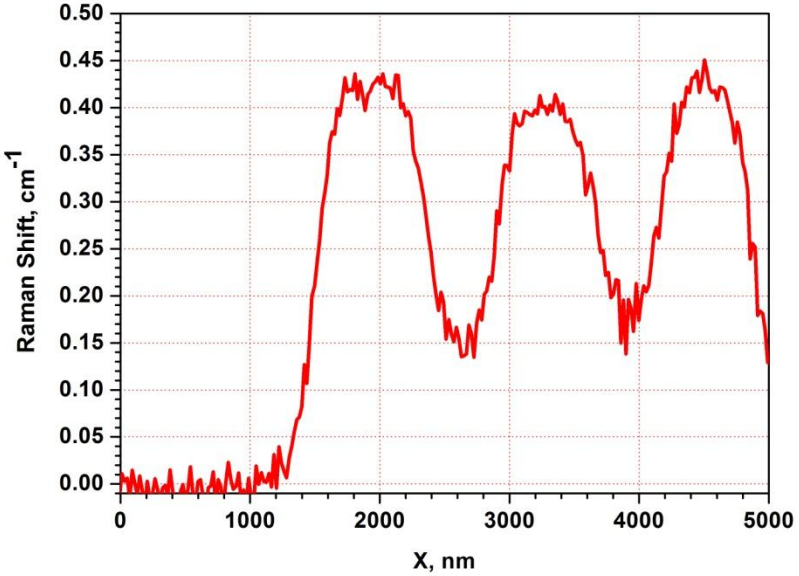




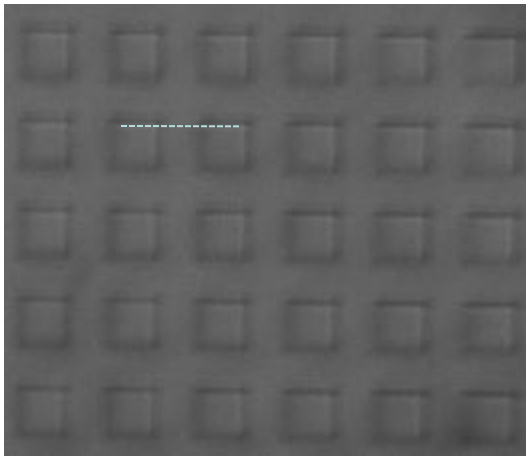
The sample consists 1, 1.5, 2 and 4 μm wide Si stripes separated by 4 μm shallow trenches.



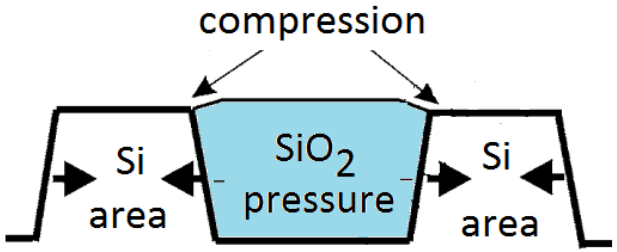


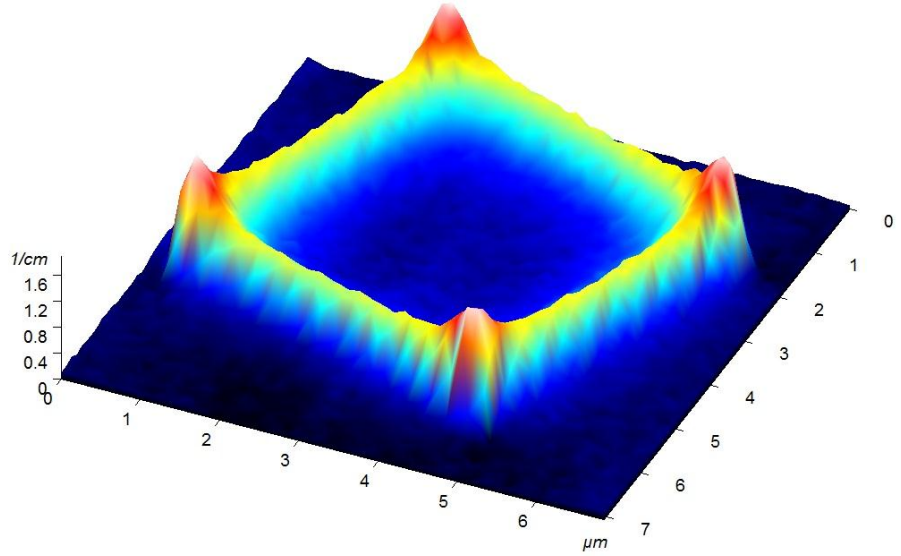


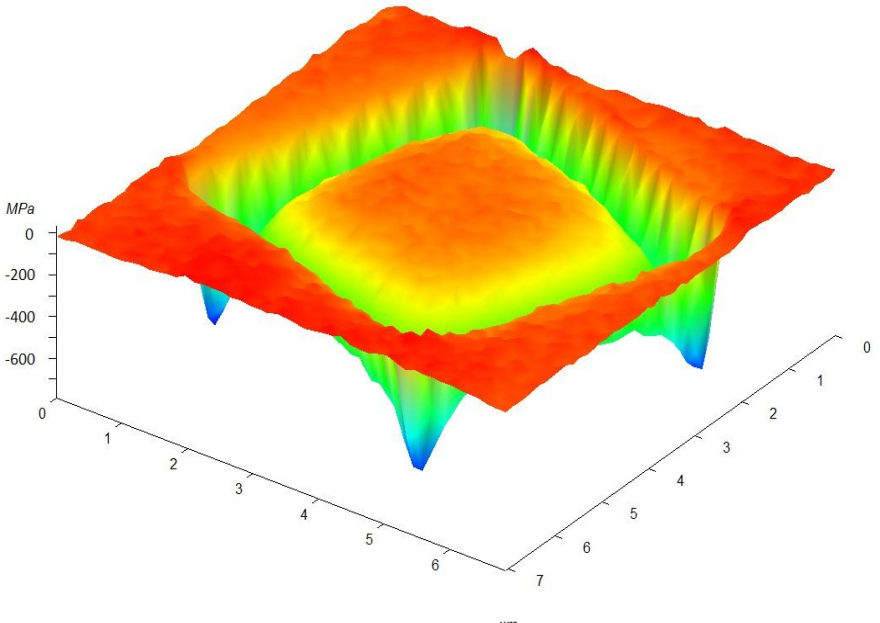
1sec/point; 532nm laser; ~2 mW laser power, 20nm scanning step



A periodic STI (shallow trench isolation) structure

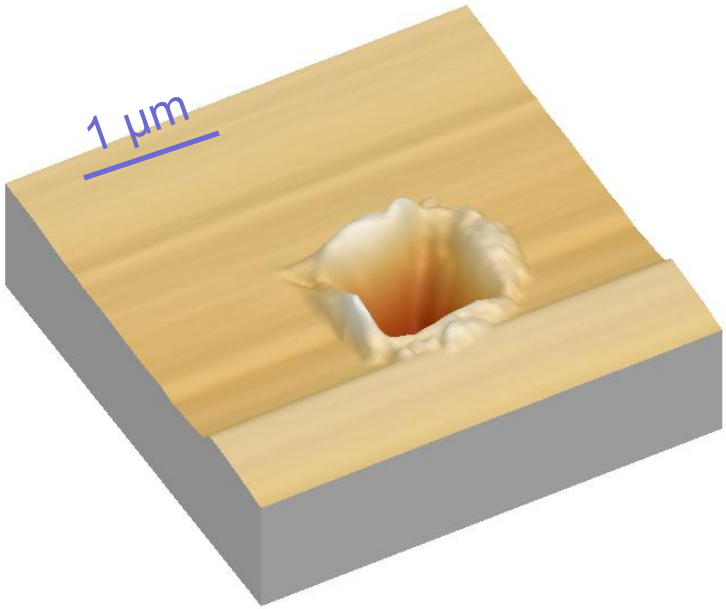




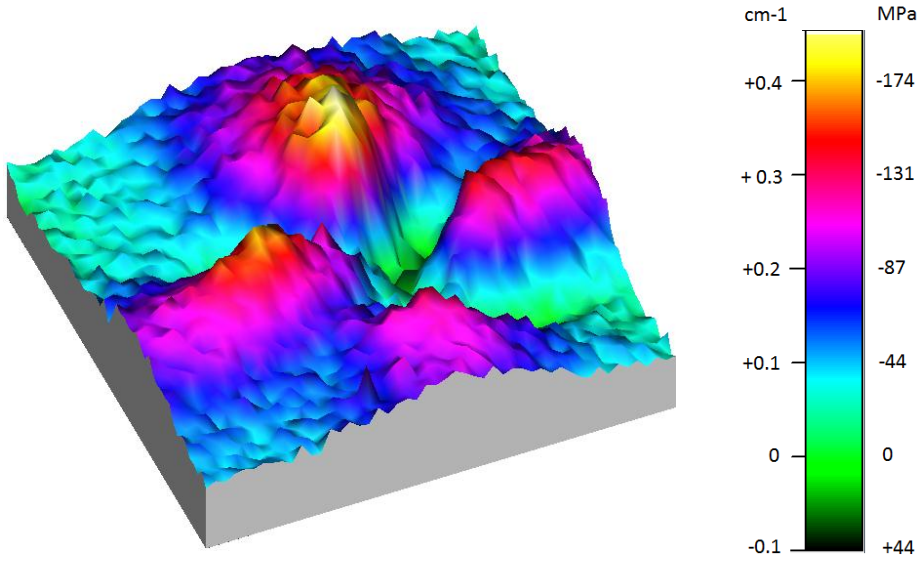


Defect Area on the Silicon Wafer

AFM

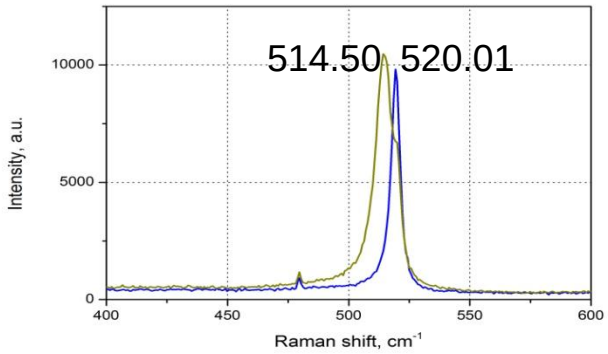


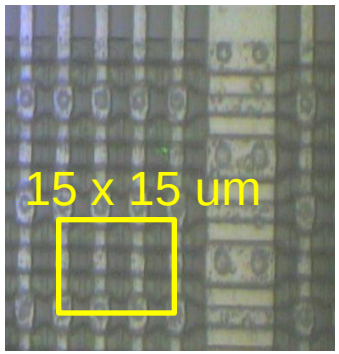
Stress Distribution

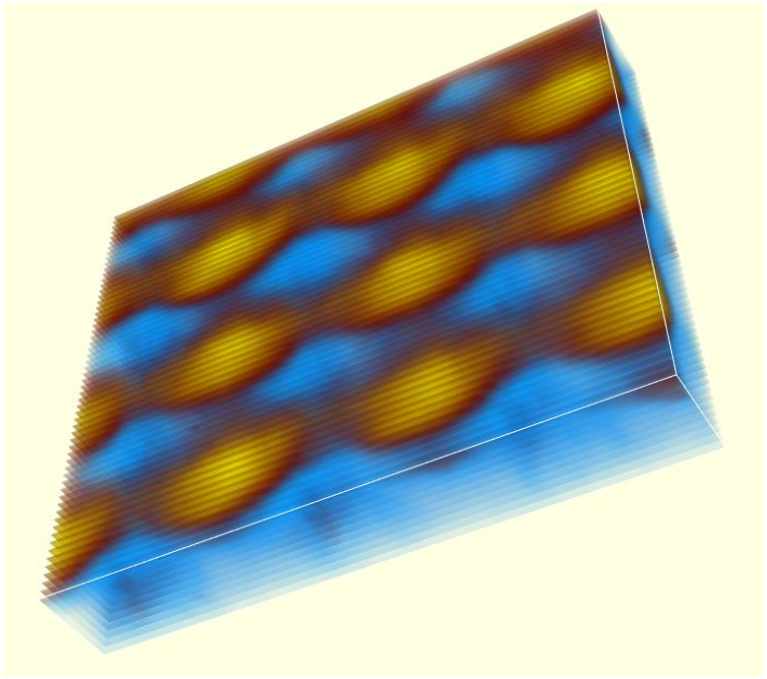


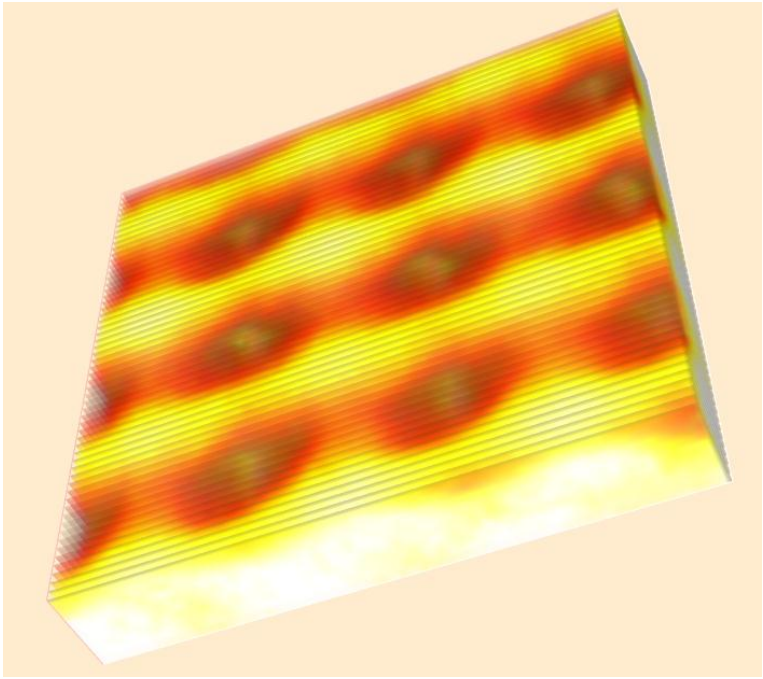
Variation of stress lies in the range between +43 MPa and -175 MPa.

EEPROM Investigation









cm^{-1}

521

519

517

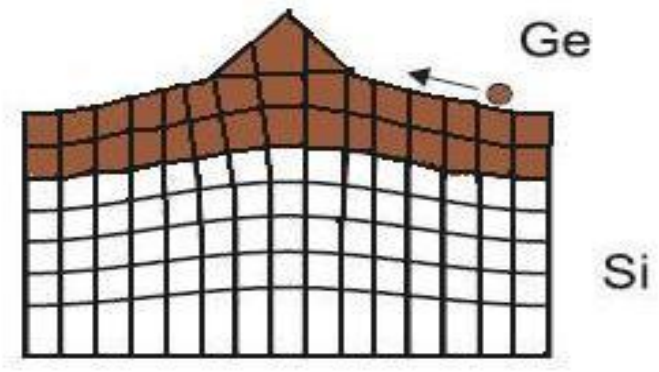
515

513

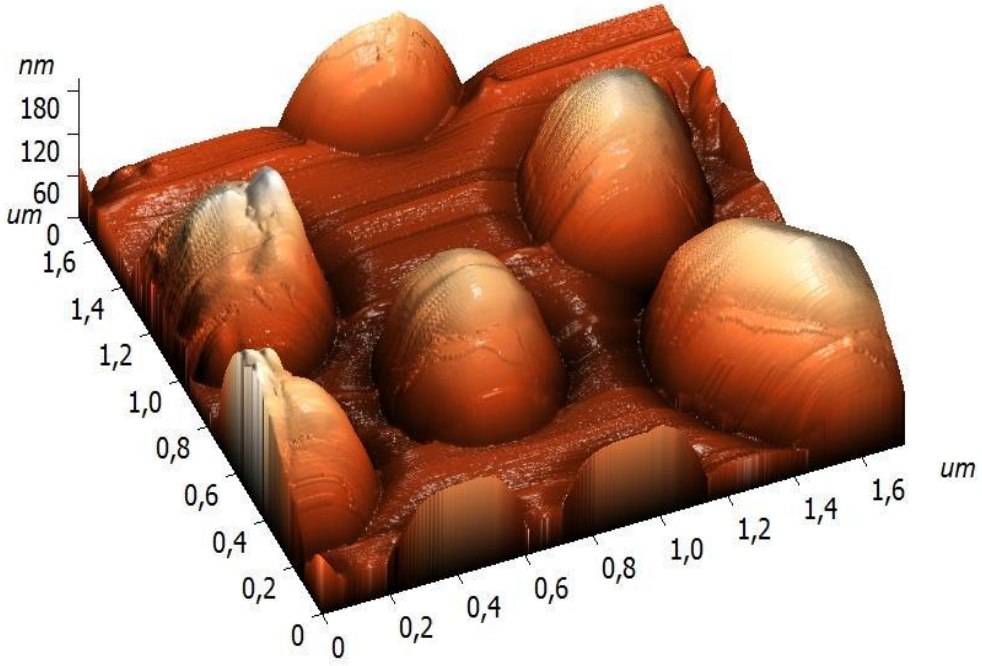
511

Ge QD on a Silicon Substrate

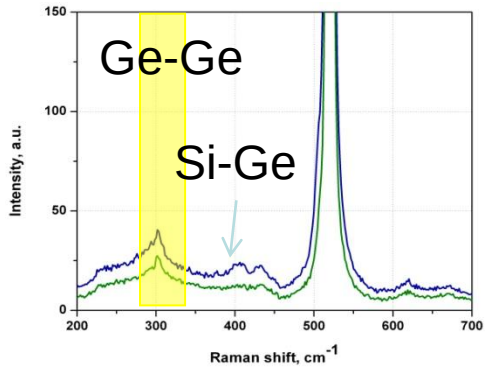
Growing of Ge dots on Si Substrate
(schematic diagram)

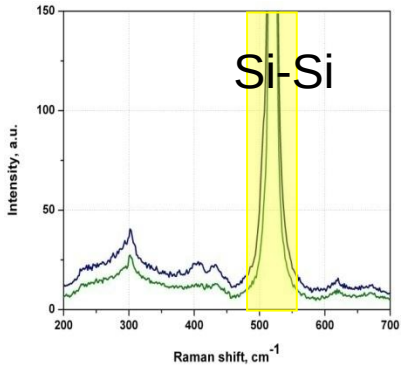


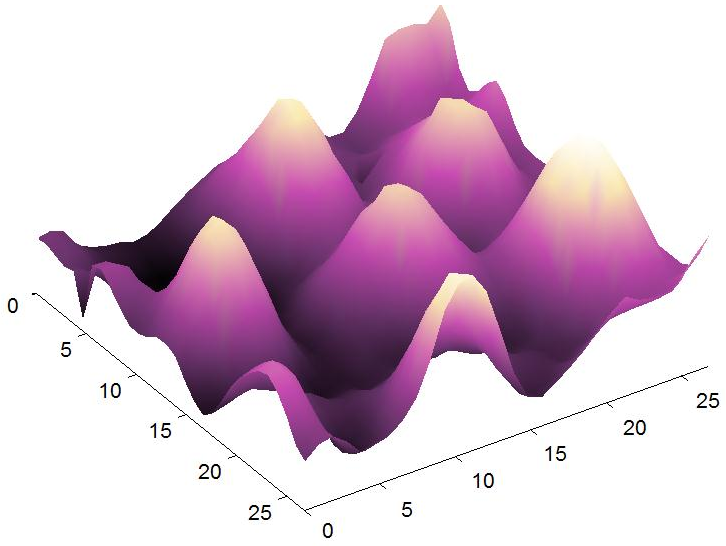
AFM Topography

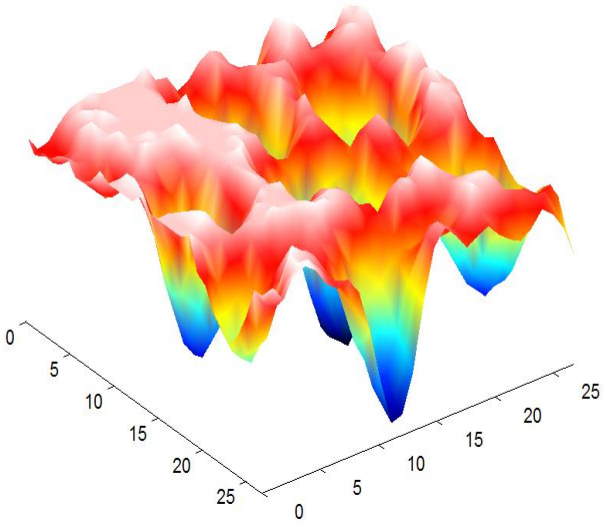


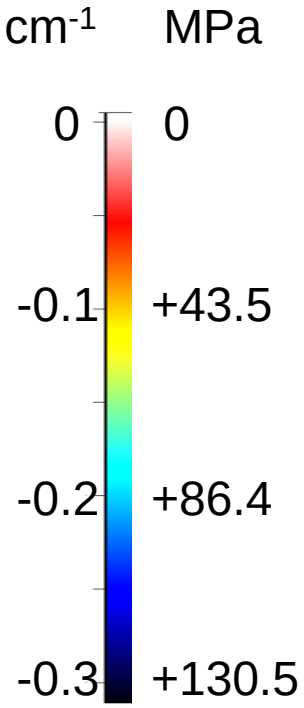
Raman Microscopy of Ge dots on Si



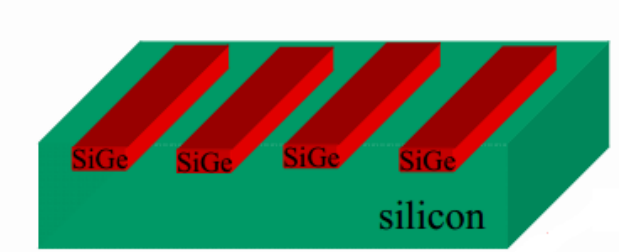


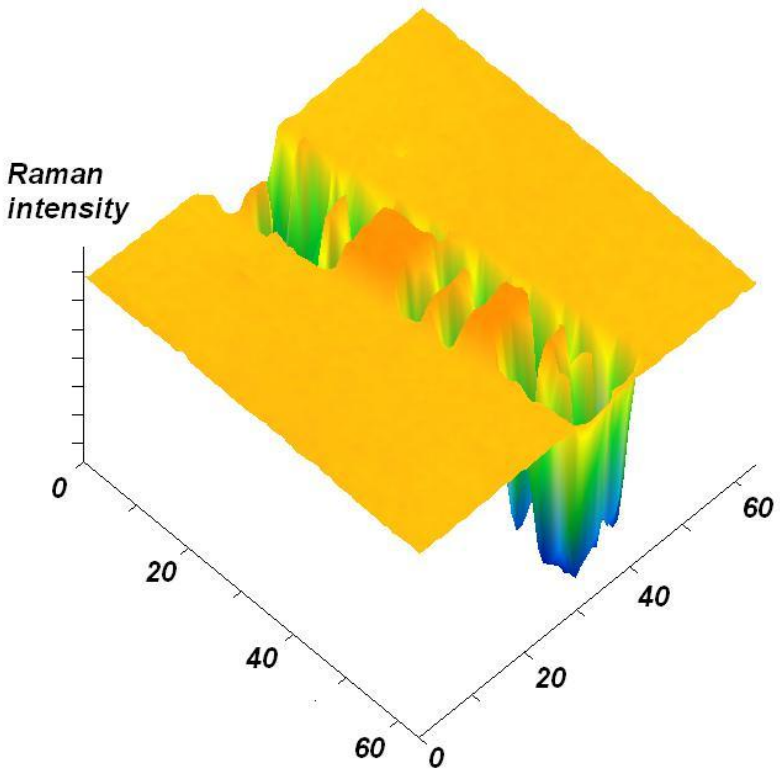


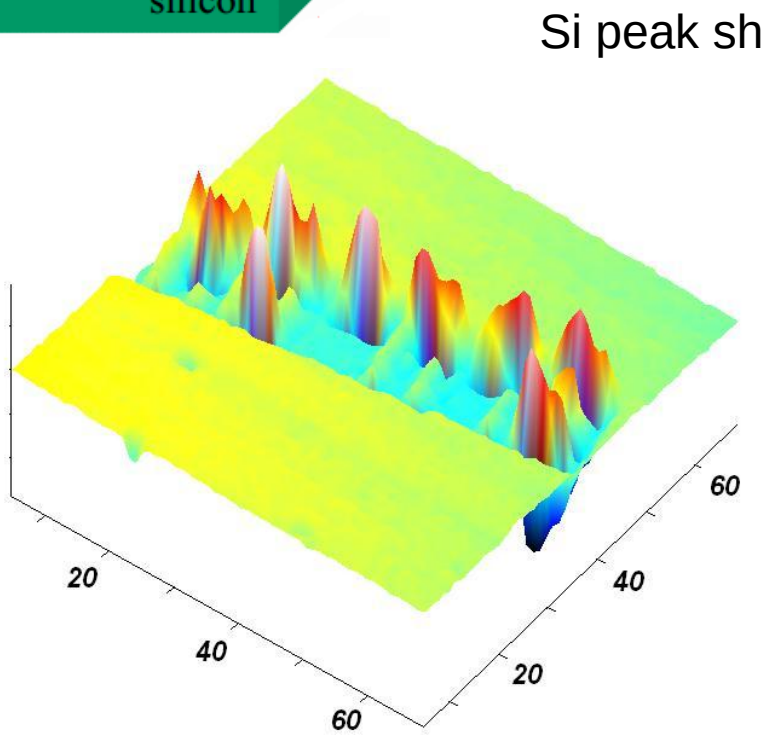




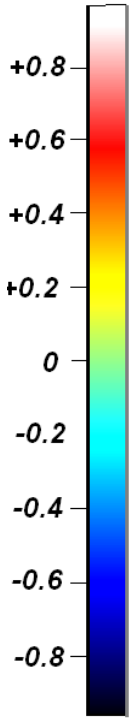
Strain Investigation in a SiGe Sample



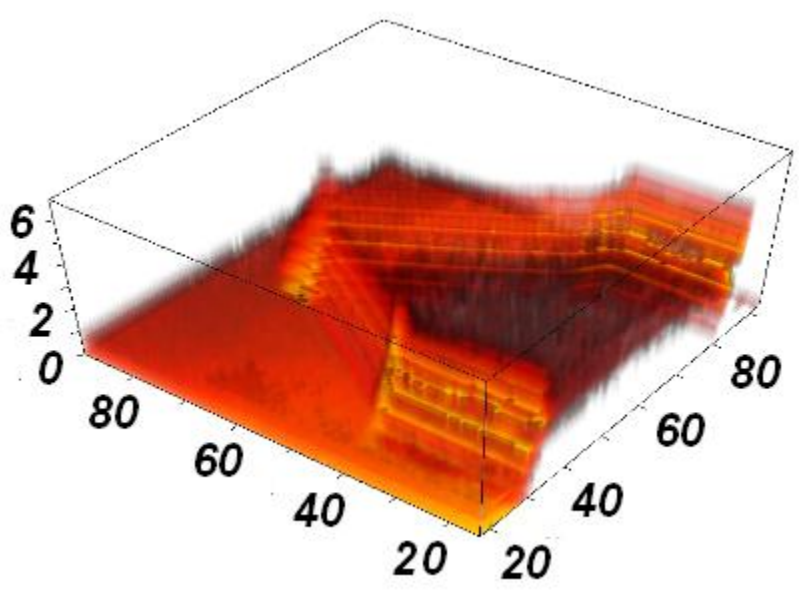


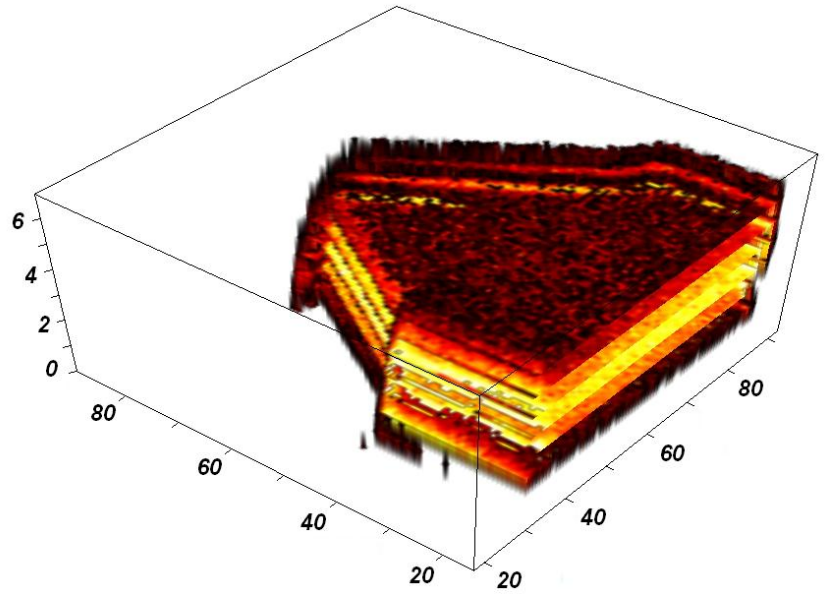


Si peak shift, cm^{-1}



AFM Cantilever: Raman Imaging





Thank you very much for your attention!