Chemical Imaging at the Nanoscale: PTIR based novel Infrared Nano-spectroscopy

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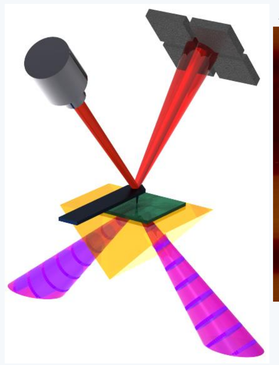
Motivation

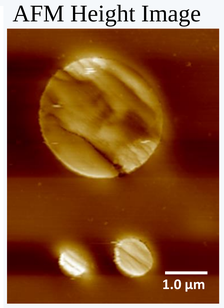
- Nanomaterials possesses special properties due to their nanoscale sizes.
- For optimization of nanomaterials we need to understand their ***structure-property*** relationship.
- High resolution imaging techniques e.g. AFM, SEM etc. provides information on *structure*.
- Chemical composition (*property*) of nanomaterials are usually obtained over a large scale area (e.g. FTIR), providing an average information.
- Thus, the present spectroscopic methods fail to correlate between structure and property of nanomaterials.

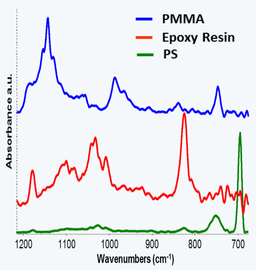
Photo-Thermal Induced Resonance (PTIR)

- PTIR combines high lateral resolution of AFM and the rich chemical specificity of infrared spectroscopy.

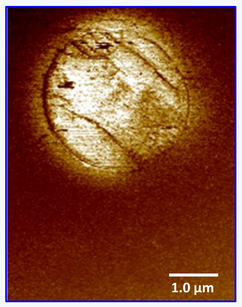


AFM Height Image

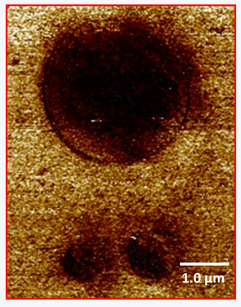




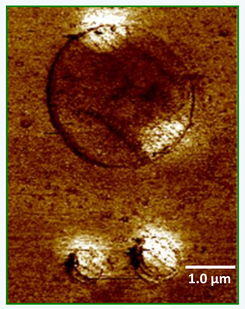
Chemical Image at 1142 cm^{-1}



Chemical Image at 825 cm^{-1}

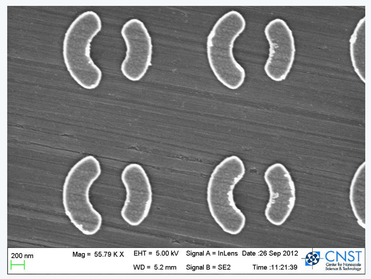


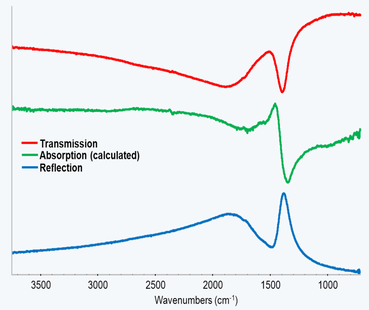
Chemical Image at 3030 cm^{-1}



Asymmetric Split Ring Resonators (A-SRRs)

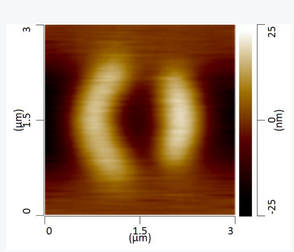
- Plasmonic nano-structures of two arcs that shares the same center of curvature but has different arc lengths.
- Produces both Bright and Dark optical modes.
- Utilized for optical Bio-sensing.

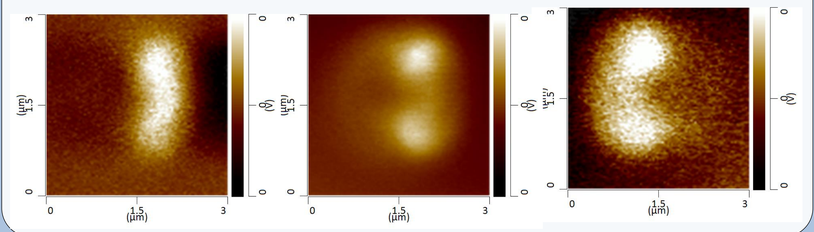




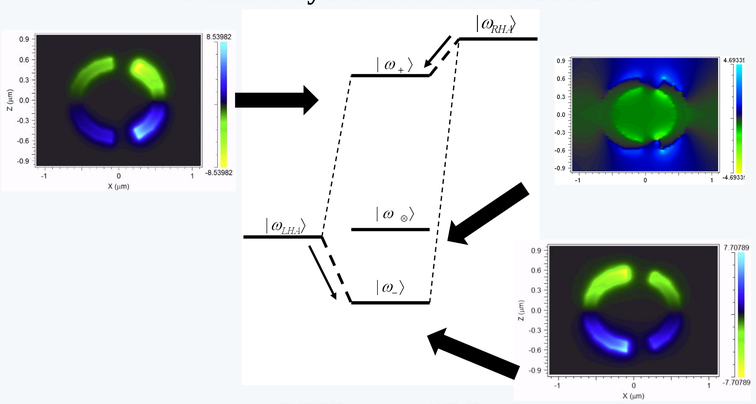
Bright and Dark Modes of A-SRRs

- Imaging at A-SRR's plasmon absorption wavelengths.



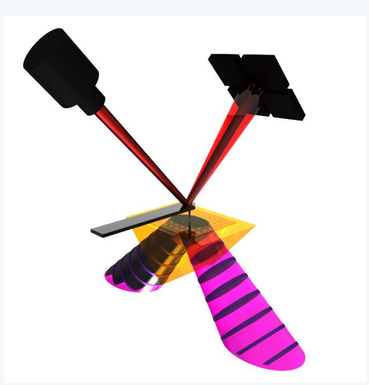


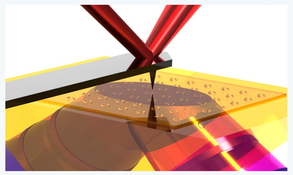
Resonance hybridization in A-SRRs

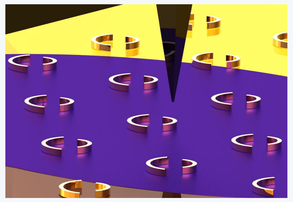


PTIR on A-SRRs

- Covering the A-SRRs with thin layer (~ 200 nm) of PMMA and Imaging.

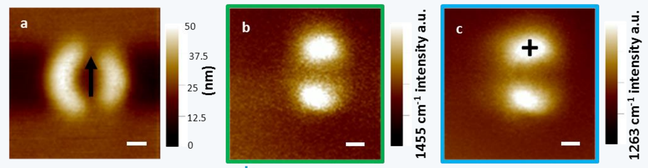


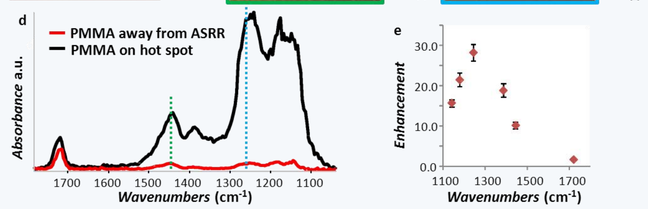




SEIRA Enhancement

- Imaging at PMMA absorption wavelengths.





Conclusion

- PTIR technique was used for the first time to study near field properties of plasmonic nanomaterials.
- PTIR enables the visualization of bright and dark plasmon modes.
- PTIR was used to obtain SEIRA spectra and IR chemical images with nanoscale resolution.
- PTIR allowed the identification of electromagnetic hot-spots and near field absorption enhancements maps.

References-

1. A.Dazzi et.al. 'Analysis of nano-chemical mapping performed by an AFM based (AFMIR) acusto-optic technique', *Ultramicroscopy,* 107, 1194 (2007).
2. B.Lahiri et al. 'Chemical imaging beyond the diffraction limit: Experimental validation of the PTIR technique', *Small*, DOI: 10.1002/smll.201200788.
3. B. Lahiri et al. 'Asymmetric split ring resonators for optical sensing of organic materials' *Optics Express*, 17, 1107 (2009).
4. B.Lahiri et. al. ' Nanoscale imaging of plasmonic hot-spots and dark modes with photo-thermal induced resonance technique' Nanoletters, 13,3218 (2013).