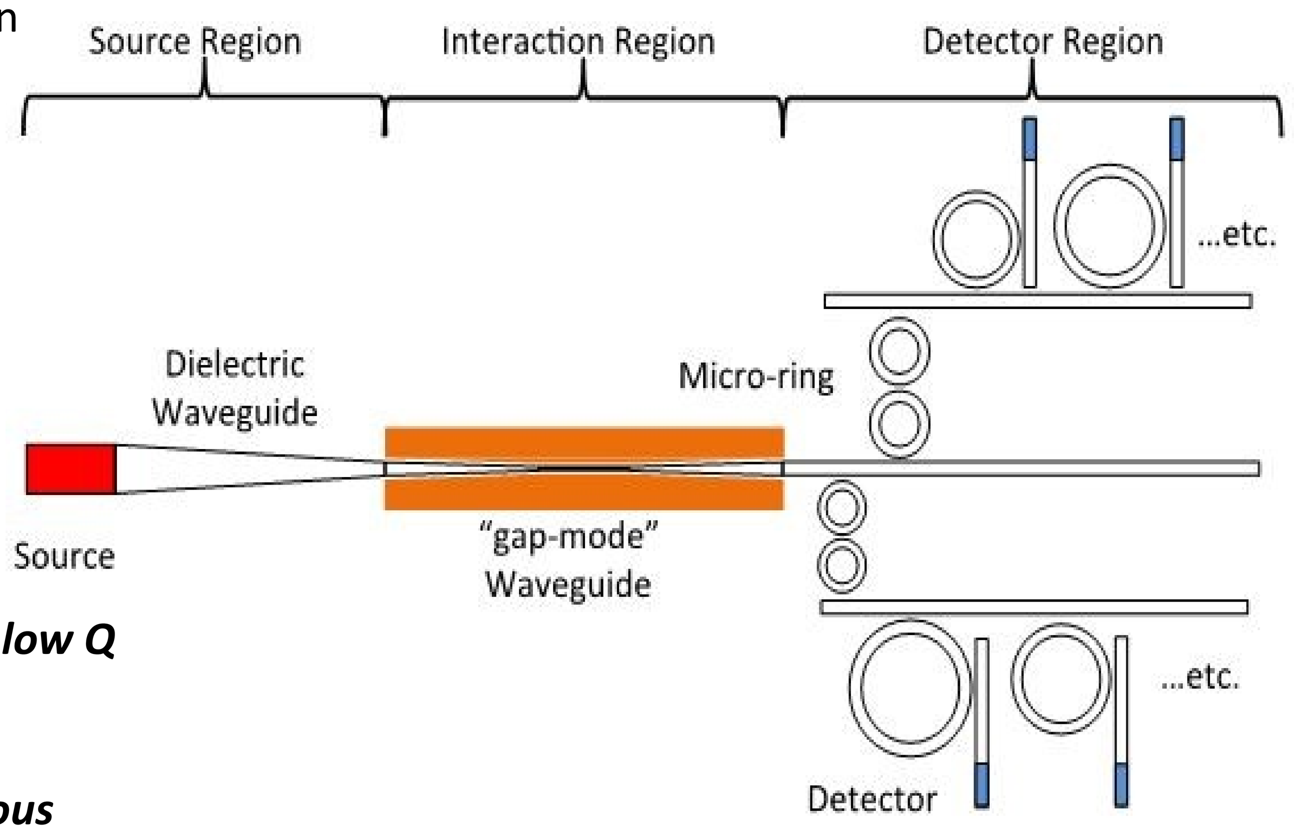
# Planar integrated plasmonic MID-IR spectrometer

Farnood K. Rezaie*[,1], Christopher Fredricksen[2], Walter Buchwald[3] , Justin Cleary[4], Andrew Davis[5] , Imen Rezadad[1], Evan Smith[1], Janardan Nath[1] and Robert E. Peale[1]
[1]University of Central Florida ,[2]LRC Engineering Inc., [3]University of Massachusetts Boston,
[4]Sensors Directorate of Air Force Research Laboratory, [5]Solid State Scientific Corp.
farnood_rezaie@knights.ucf.edu

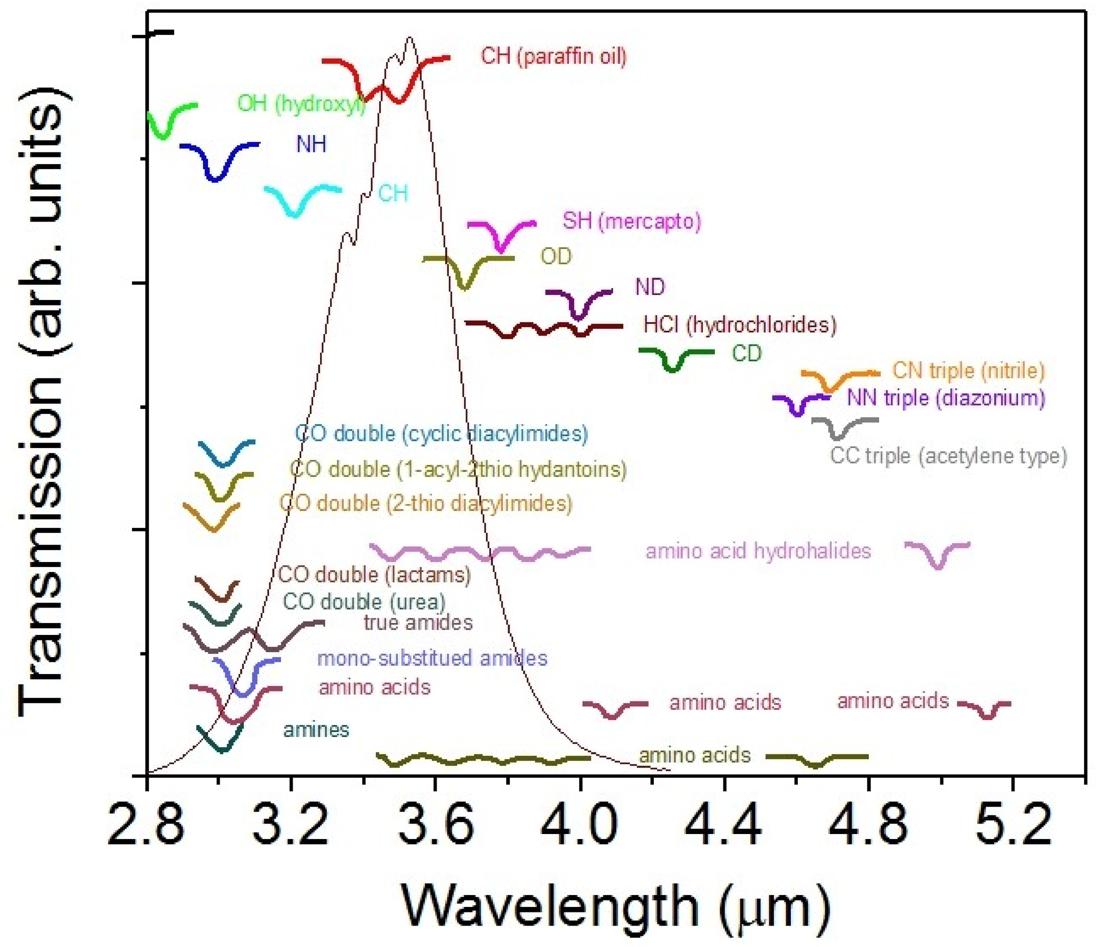
**A compact spectrometer featuring a plasmonic molecular interaction region has been conceived, designed, modeled, and partially fabricated. The on-chip mid Infrared spectrometer consists of different components:**

1. IR LED source
2. Silicon photonic waveguide on insulator
3. Photon-to-plasmon transformer
4. Plasmon-analyte interaction region
5. Plasmon-to-photon transformer
6. Dispersing elements
7. Photodetectors



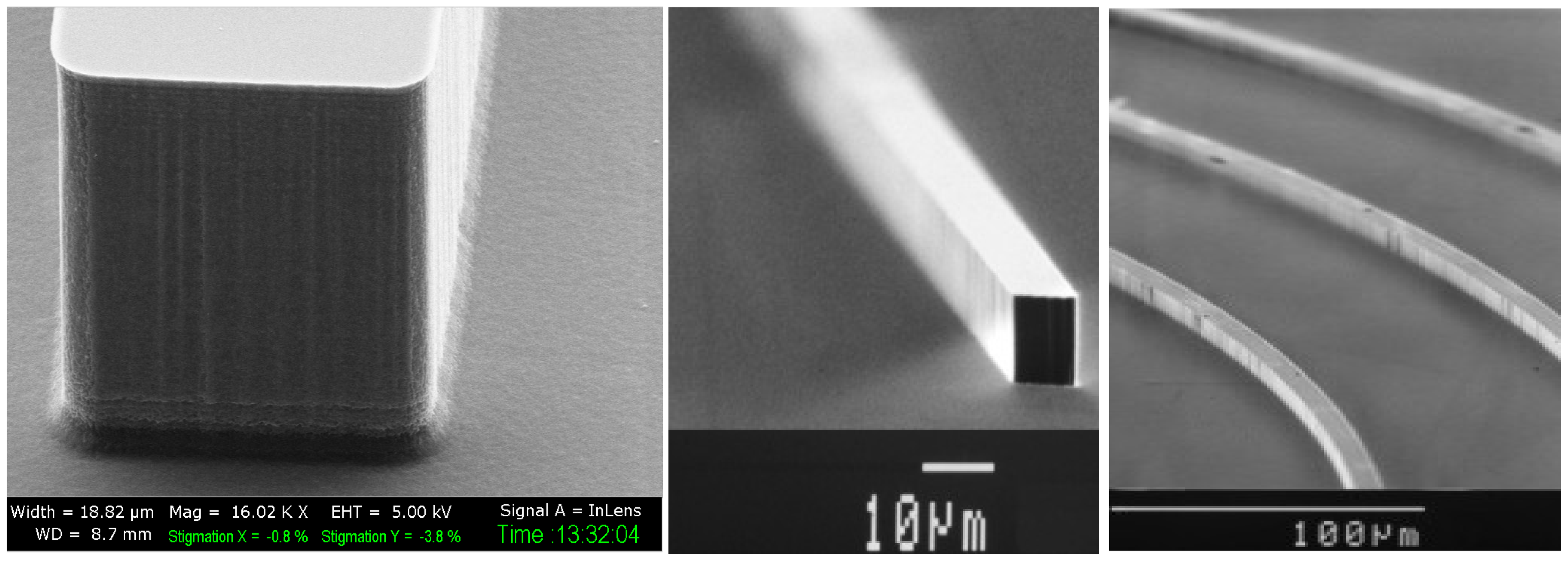

*NOTE: Cascade ring resonators feature **low Q and high FRS** rings followed by **high Q and low FSR** rings to obtain high resolution information with **unambiguous** wavelength identification*

1. **Light emitting diodes (LED)** at ~3.4 micron wavelengths have been chosen as a source due to occurrence of important characteristics molecular vibrations in this range, namely the bond stretching modes: C-H, O-H, N-H as well as CO double bond, $NH_2$ and CN.

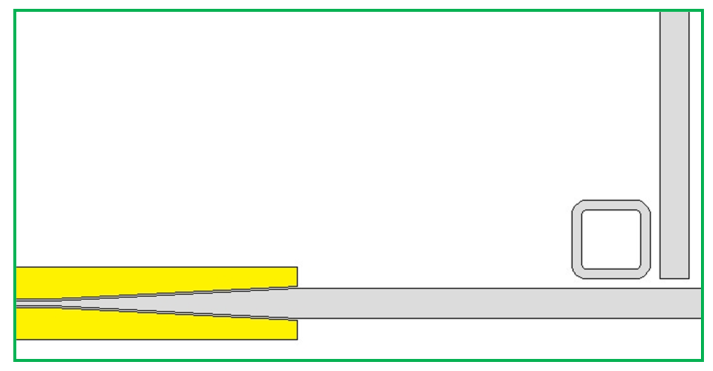



Above graph represents spectra of molecules in the range of 3.4 μm LED, superimposed on the measured spectrum of IR LED.

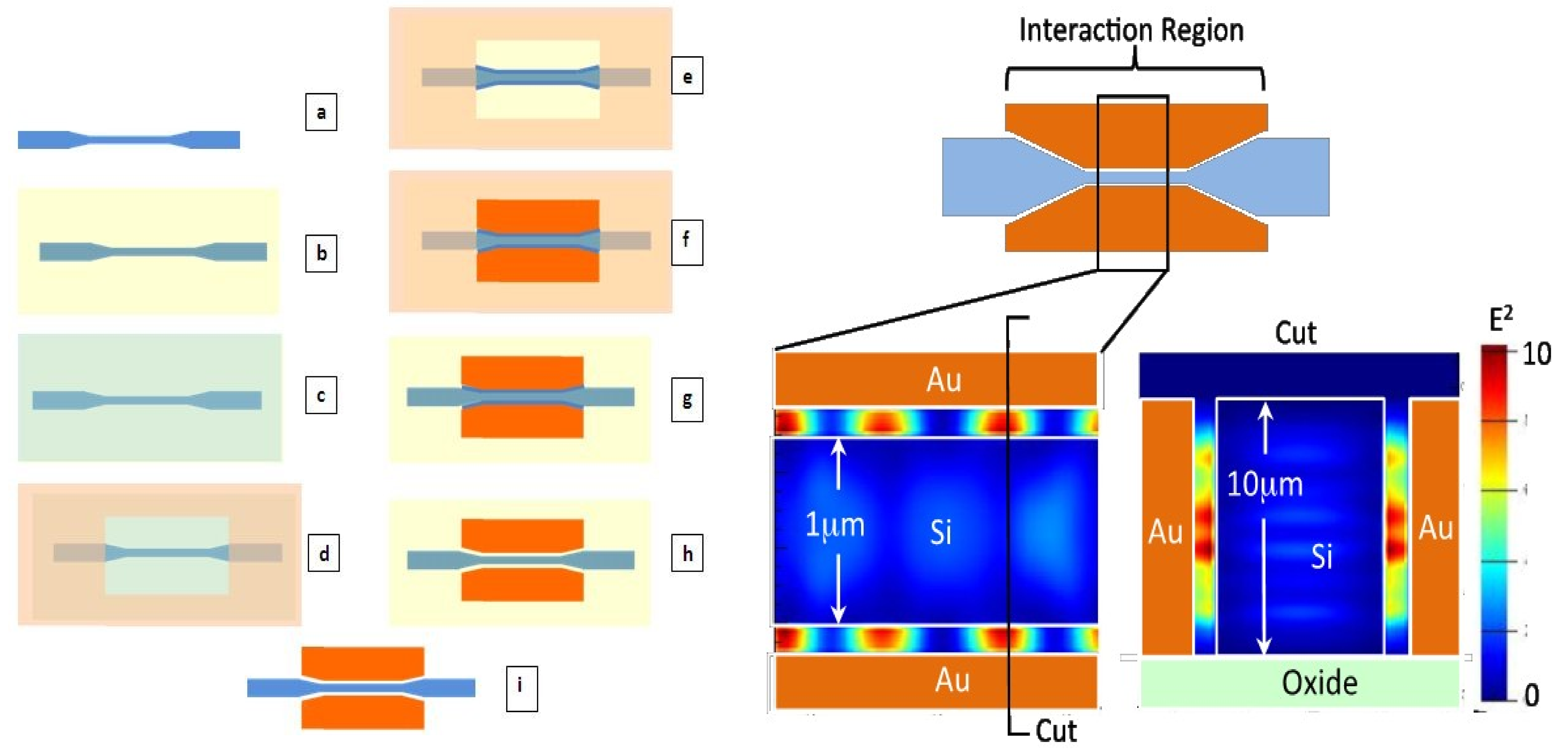
2. **Silicon photonic waveguides** have been fabricated by reactive ion etching (RIE) with Fluorine chemistry using photolithographically defined metal masks. As it is shown, vertical sidewalls and smooth etched surfaces were achieved. Si waveguides shown below are on insulator layer, have 10x10 $\mu m^2$ cross section and they are 1000 μm apart.



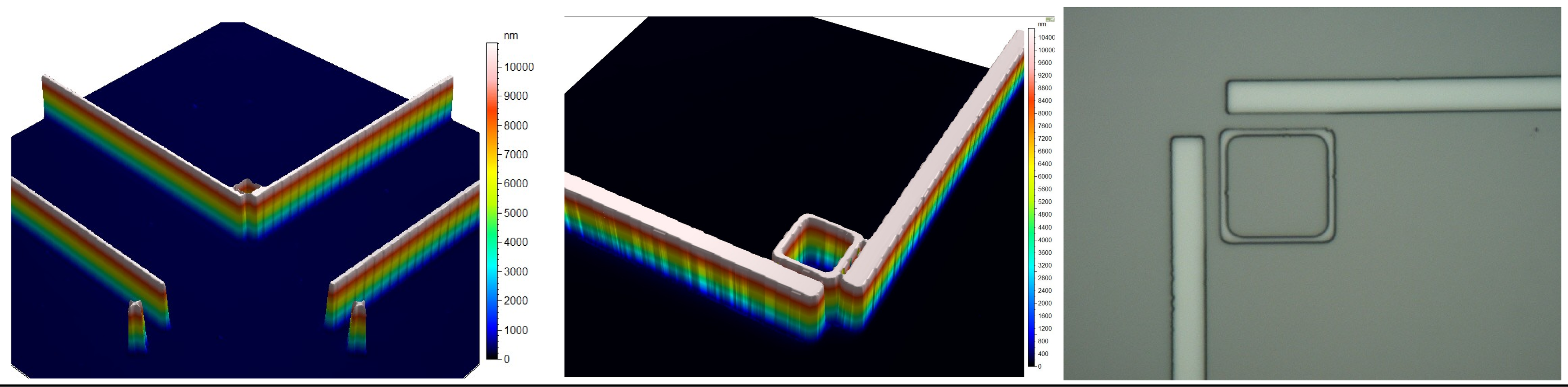

**3,5. Photon/Plasmon transformers** are tapers that reduce waveguide to below cutoff while bringing metal surface in close proximity to guide side walls.



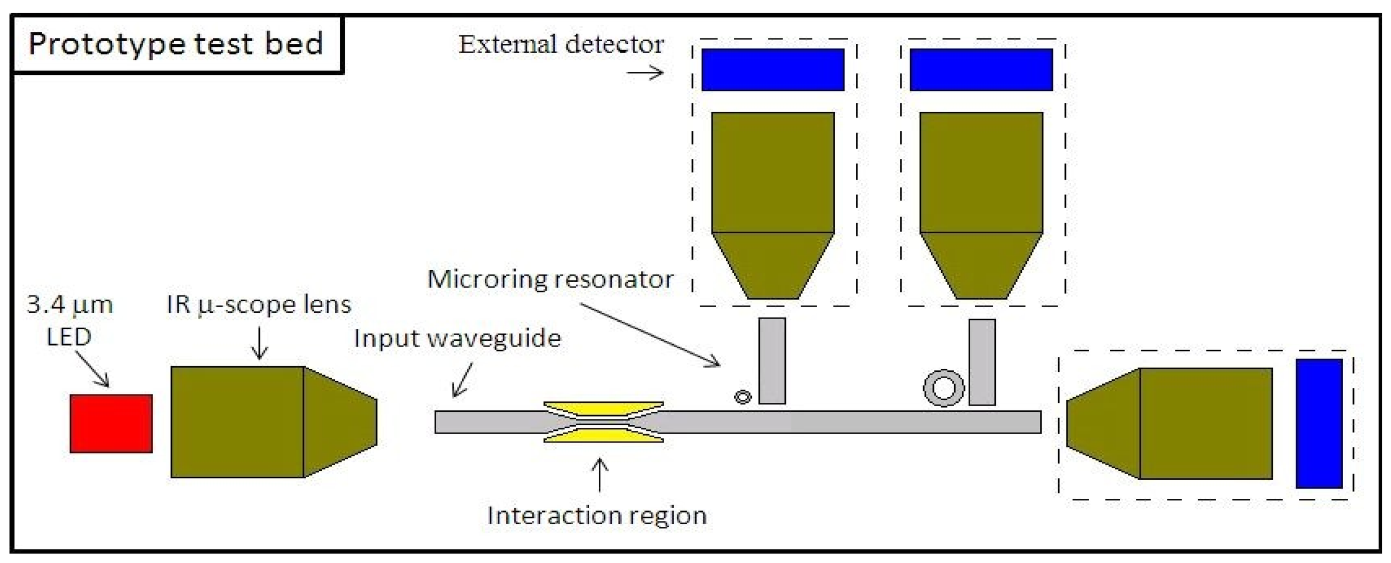
**4.The plasmon-analyte interaction region** is a vertical slot between a sub-cut-off silicon waveguide and a metal surface. Figure below summarizes our process for patterning interaction region. Electrodynamic simulations informs us about the mode inside the waveguide.




**6. Dispersing elements** are series of micro-ring resonators that have been fabricated by photolithography. The corners have radius of 3 μm and are the 3 μm wide . Resonance FWHM of 3 nm would be accomplished by using of two series of ring resonators .



**IR transmission of Si waveguides will be tested in an optical setup:** Light from the 3.4 micron LED is coupled in from the left using a microscope objective. A second microscope objective is used to couple the light out to an external detector. The objective/detector combination can be positioned at the exit of each of the waveguides, measuring the output after each ring resonator and the bus separately




**Acknowledgement:**

Air Force Office of Scientific Research

Harvard University Center for Nanoscale Systems

Solid State Scientific Corporation

LRC Engineering Inc.