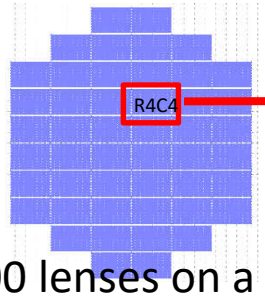
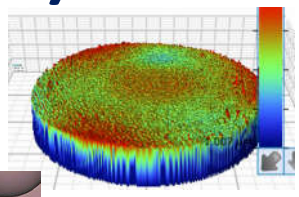
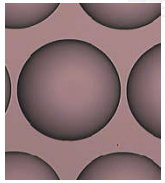
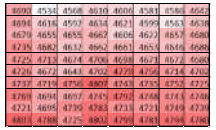
Microlens Array (IMT, 2013-present)



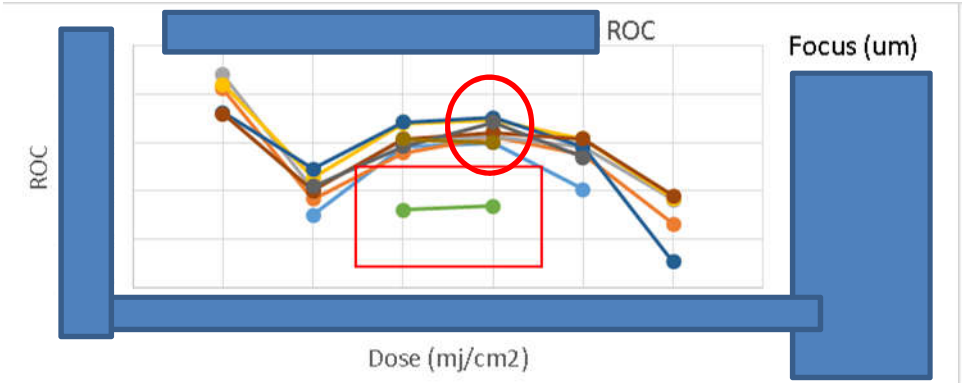
Large Data (3D profiles, uniformity)

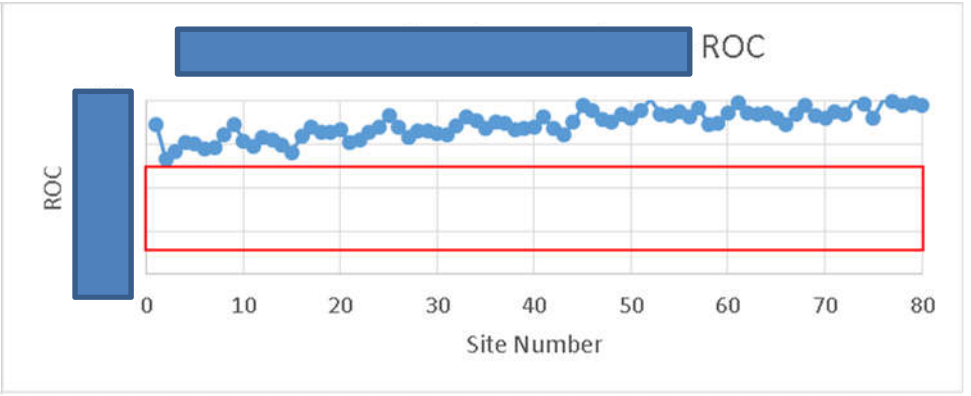


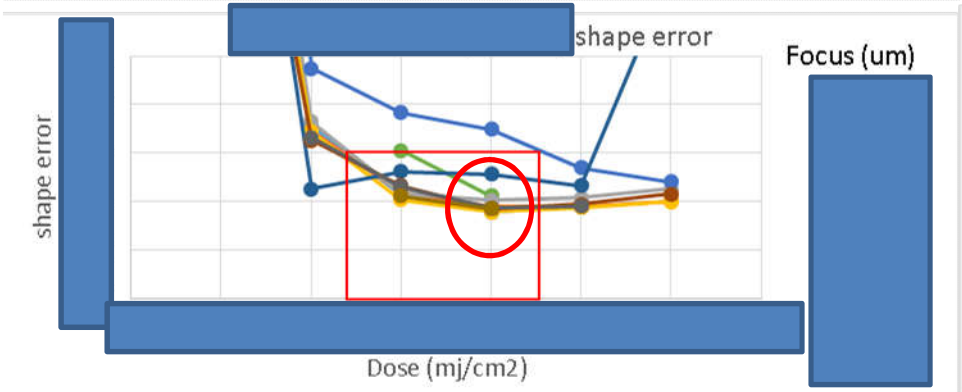


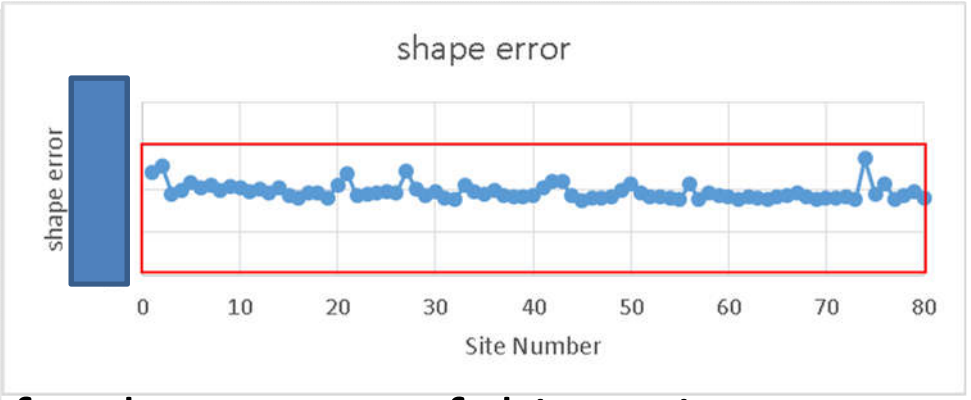


20,000 lenses on a wafer



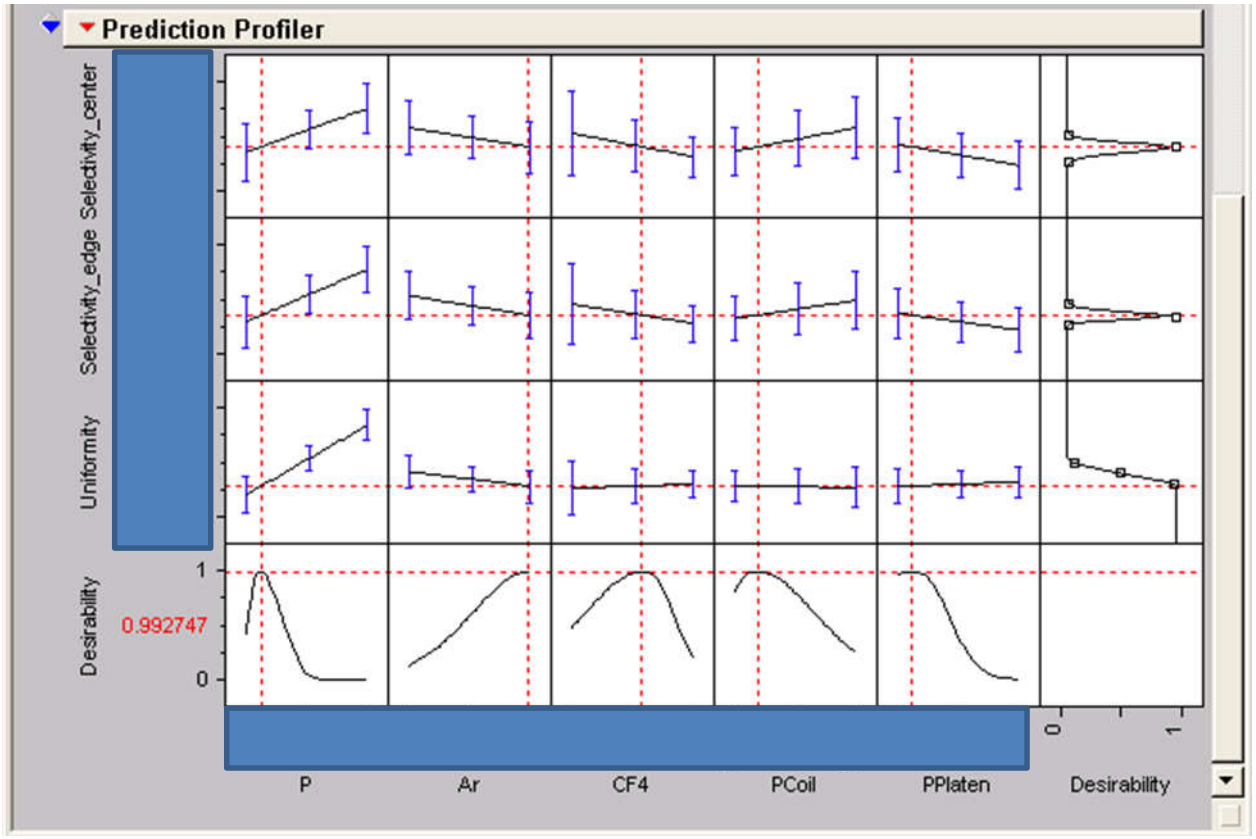






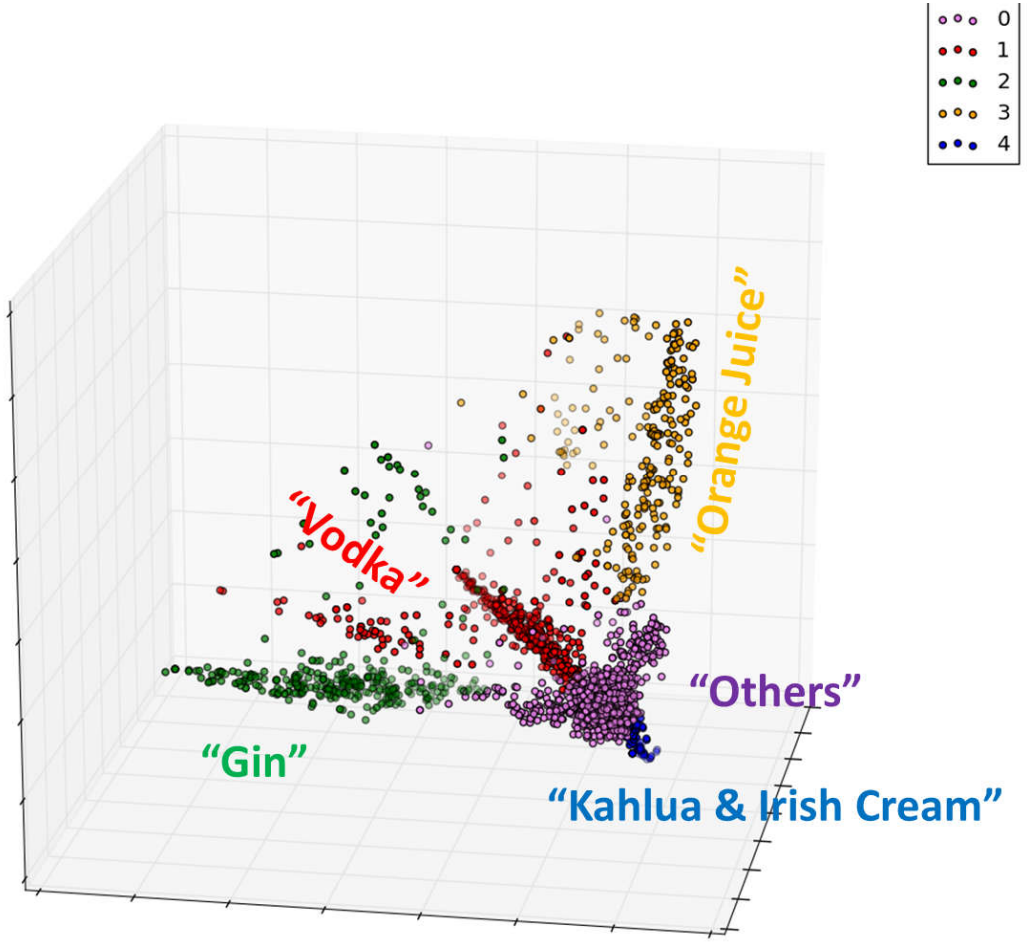
- Processed data essential for the success of this project.
- Transitioning to a volume production phase

JMP (IMT, 2013-present)



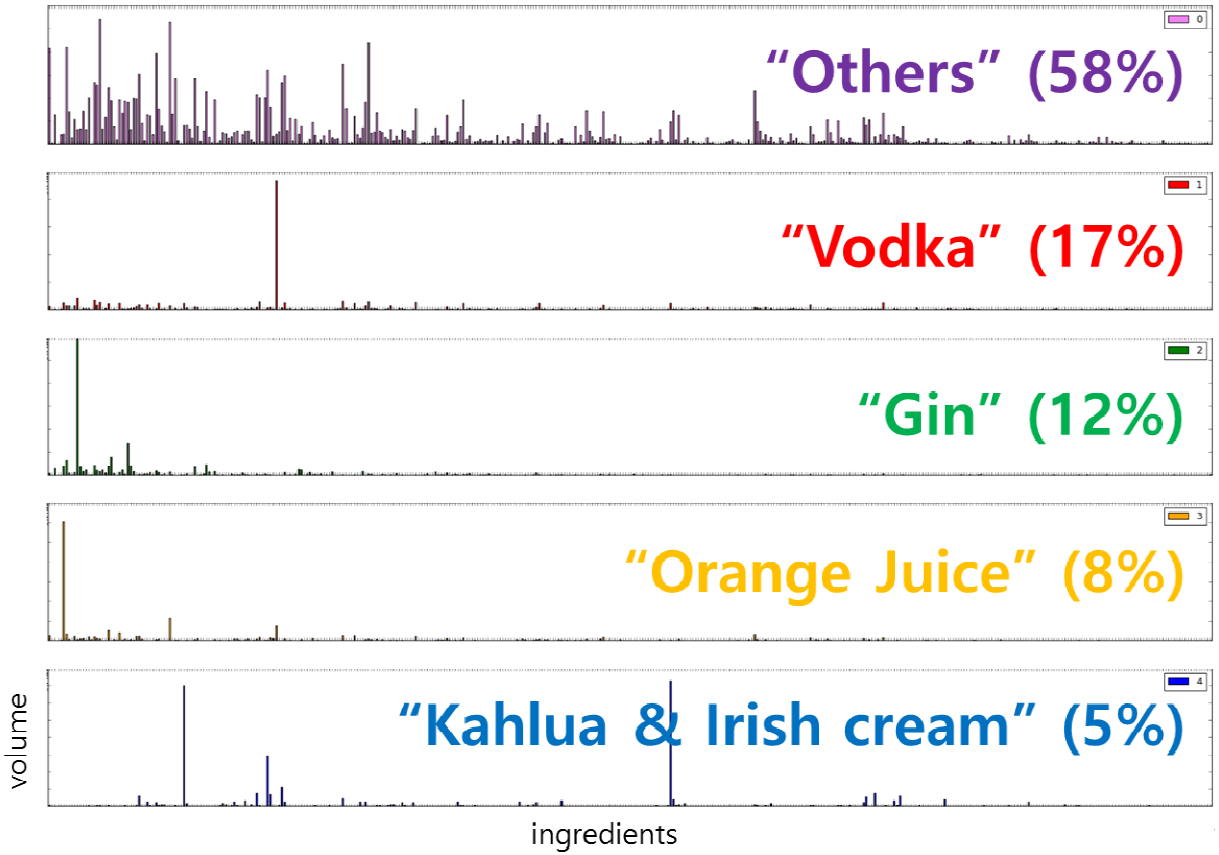
- SAS JMP used for optimizing process

Python programming as a hobby (2016)



- 3081 cocktail recipes were downloaded from http://www.TheCocktailDB.com using their API.
- Each cocktail was embedded in a 471-dimensional vector space using ingredient information.
- Principal Component Analysis (PCA) was used in order to visualize 3081 cocktails in a 3D space.
- Spectral Cluster algorithm was used to separate the groups
- Generated profiles of each market segment.

Python programming as a hobby (2016)



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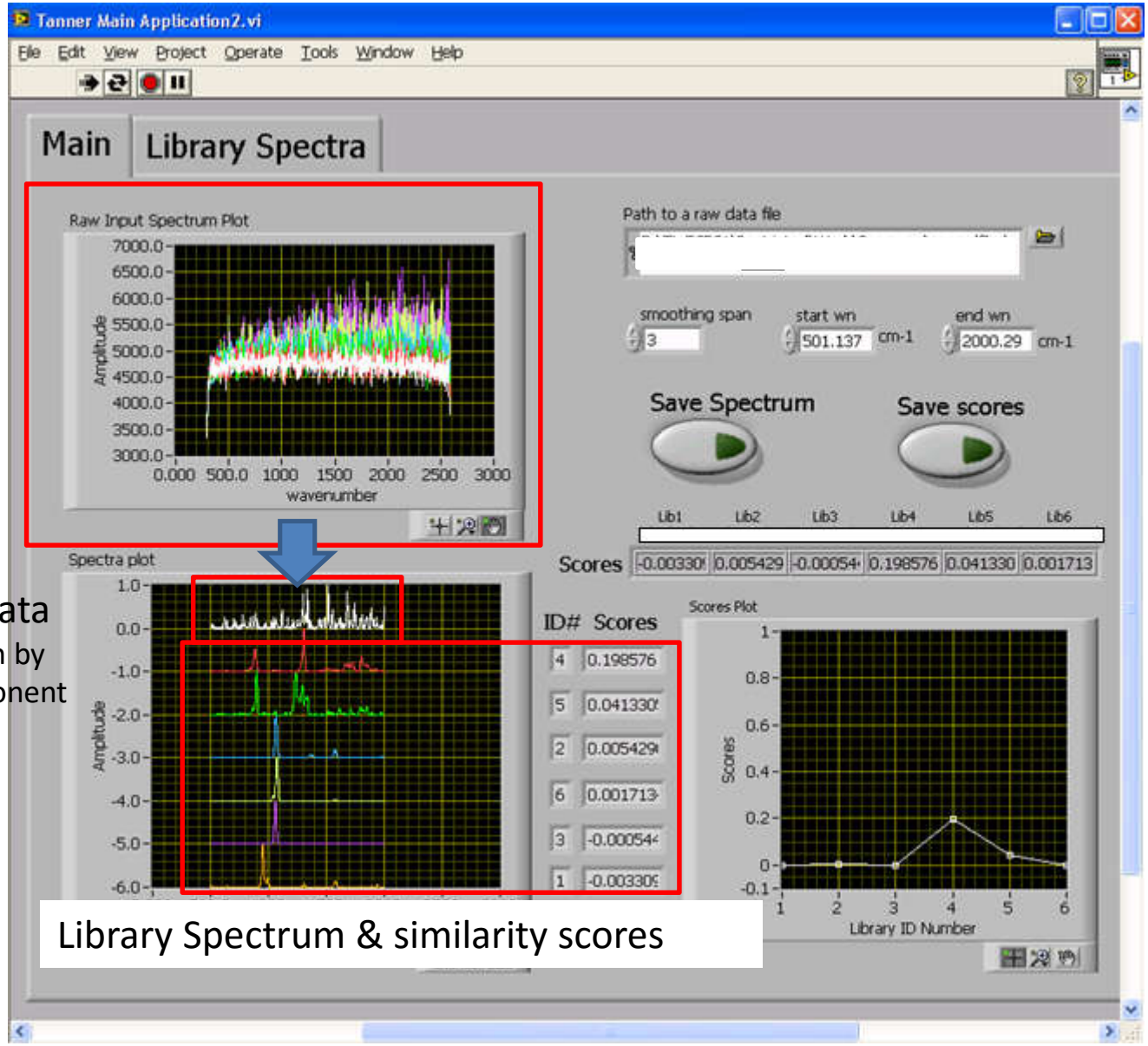
- Spectral Cluster algorithm was used to separate the groups
- Generated profiles of each market segment.

Chemical Detection (Tanner Research, 2009-2013)

Raw Data

Processed Data
(noise reduction by Principal Component Analysis)

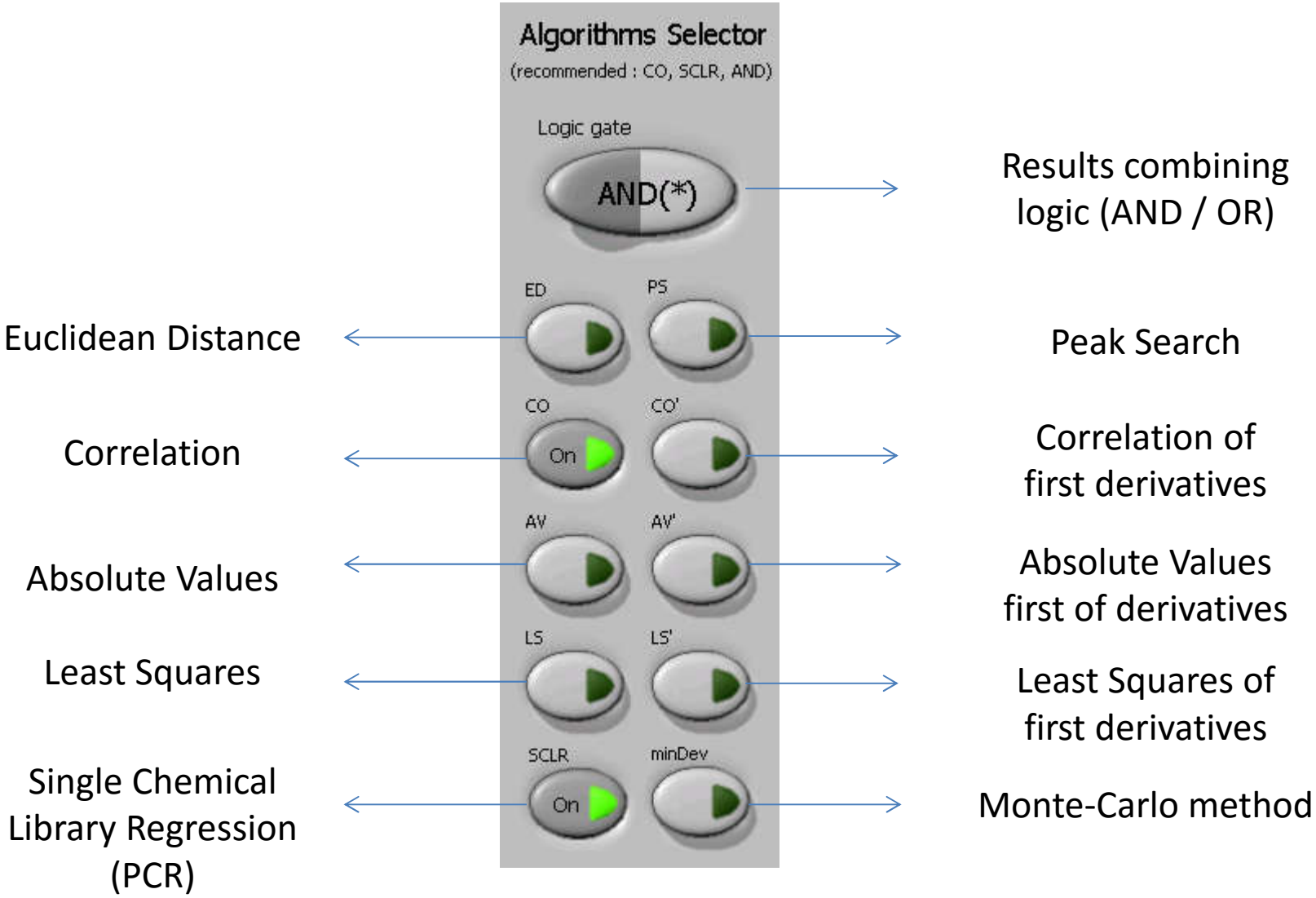


Chemical Detection (Tanner Research, 2009-2013)

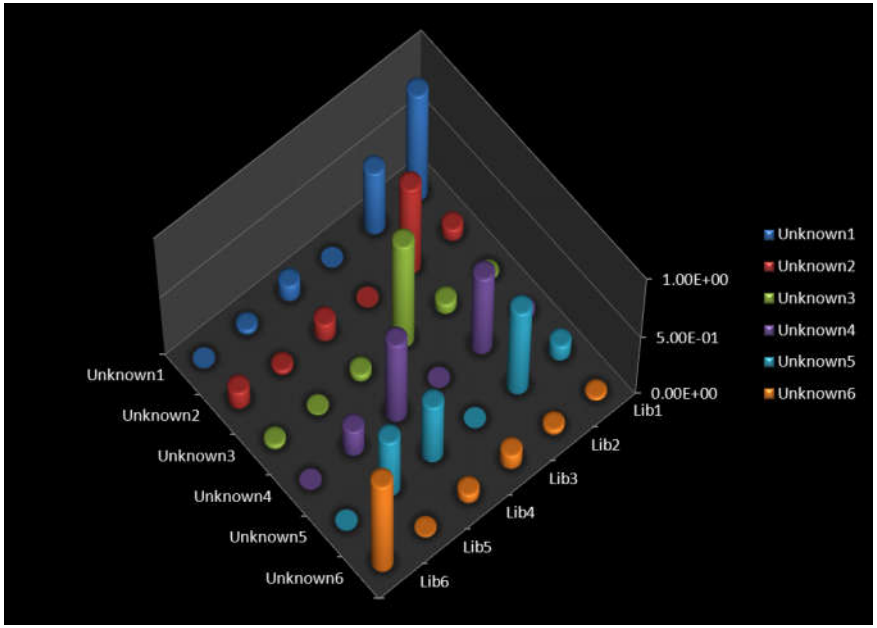
Name	Formula for Scores (worst=0, best=1)
Euclidean Distance (ED)	$S_k = \frac{L_k \cdot U}{\sqrt{L_k \cdot L_k}\sqrt{U \cdot U}}$ (=cosθ_k, where $\theta_k$is the angle between L_k and U)
Correlation (CO)	$S_k = \frac{L_k{}' \cdot U'}{\sqrt{L_k{}' \cdot L_k{}'}\sqrt{U' \cdot U'}}$, where $L_k{}' = L_k - \frac{\sum_{i=1}^{n} L_{ki}}{n}$ and $U' = U - \frac{\sum_{i=1}^{n} U_i}{n}$
Absolute Value (AV)	$S_k = 1 - \frac{\sum_{i=1}^{n} \lvert L_{ki} - U_i \rvert}{n}$
Least Squares (LS)	$S_k = 1 - \frac{\sum_{i=1}^{n} (L_{ki} - U_i)^2}{n}$
Single Chemical Library Regression (PCR)	$S = UL^t(LL^t)^{-1}$, assuming $U = SL$ holds true.

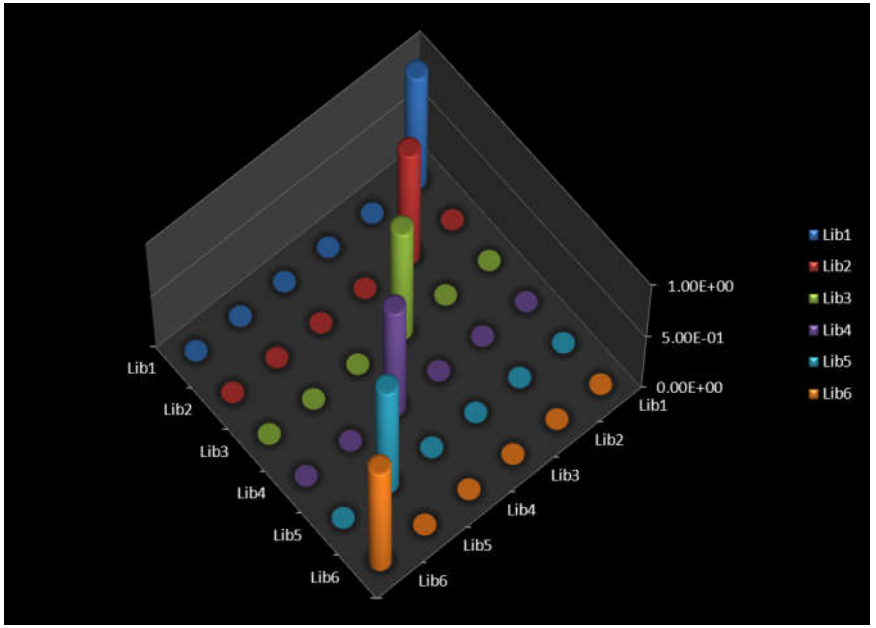
n: number of spectral data points (e.g., 1024)
U: unknown spectrum vector (e.g., 1x1024)
L: library spectra matrix (e.g., 6x1024)
S: score matrix (e.g., 1x6)
L_k: k-th library spectrum vector (e.g., 1x1024)
L_{ki} : i-th spectral component of k-th library spectrum vector
S_k: score of unknown vector against k-th library spectrum vector

Chemical Detection (Tanner Research, 2009-2013)



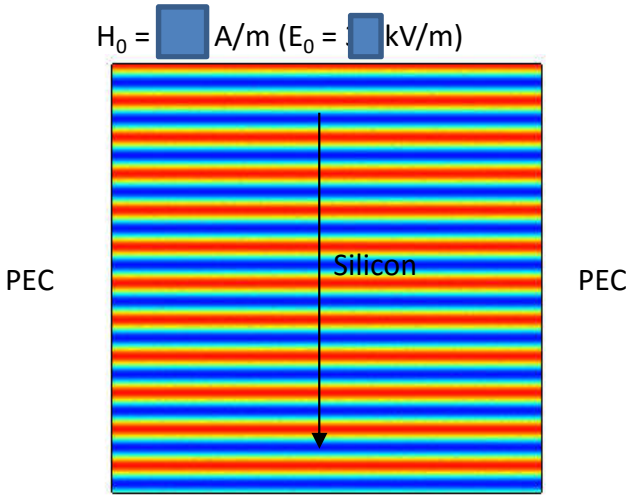
Chemical Detection Algorithms

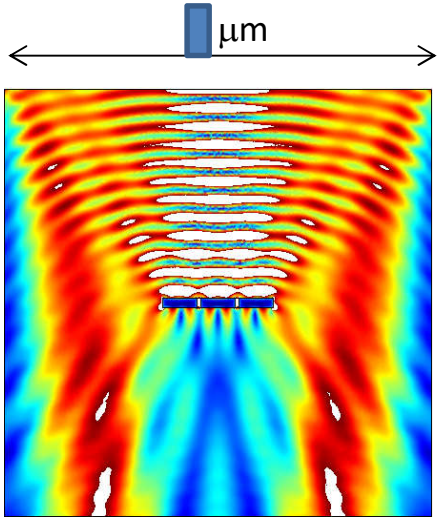


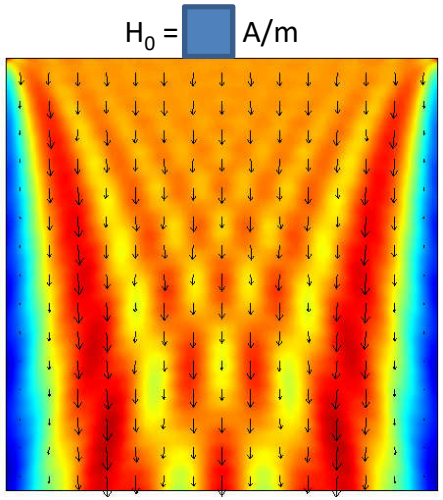


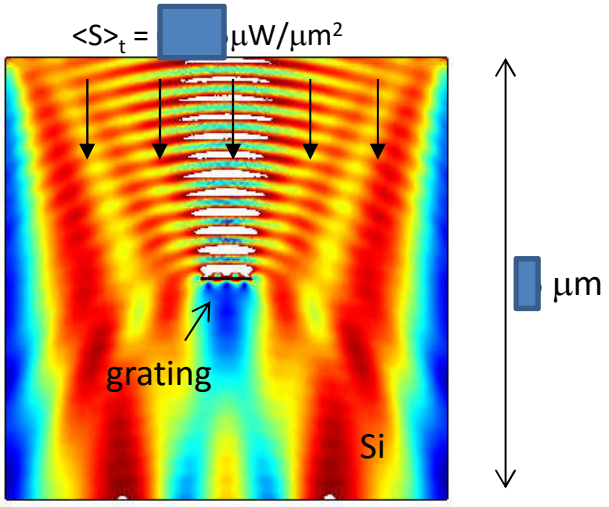
- This standoff-chemical detection system passed rigorous field tests (accuracy, recall) at customer's proving ground. Customer later asked us to deliver software only.

Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)





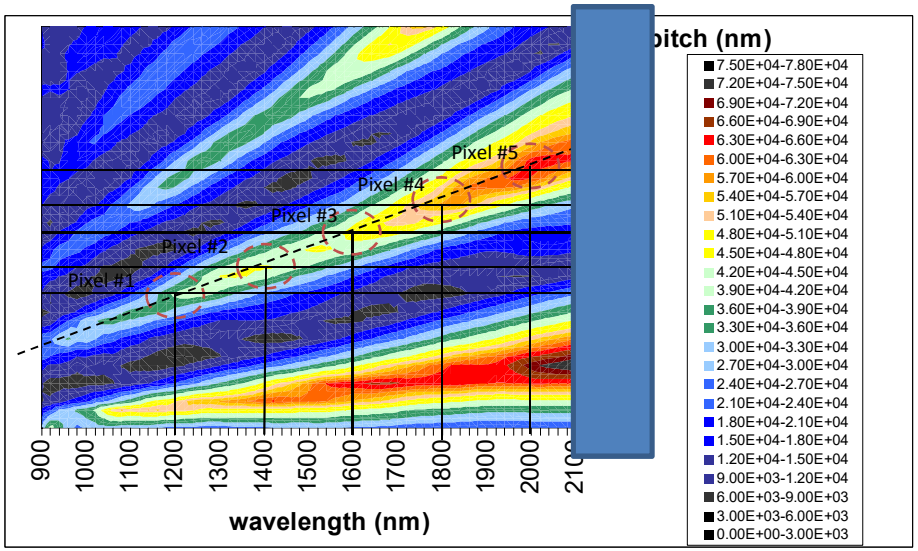




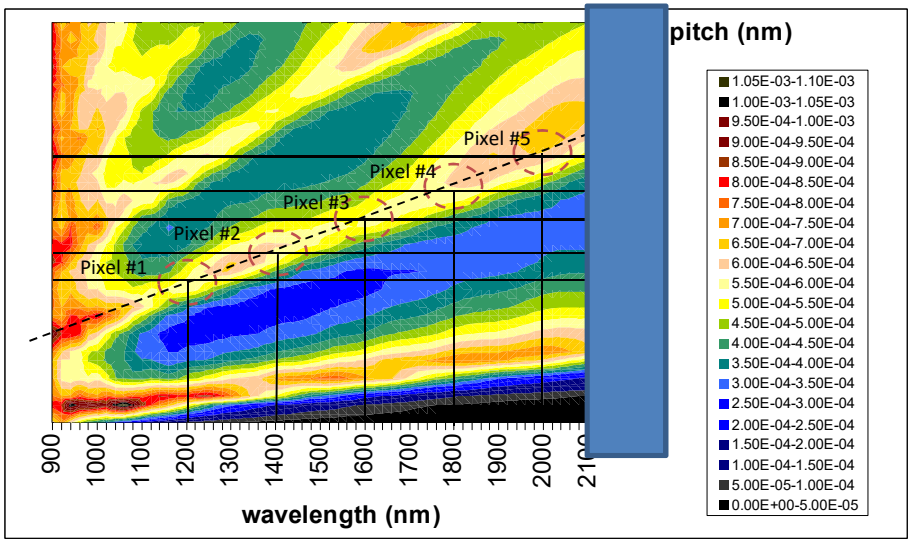
Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)

Strong E-fields and large ΔT when pitch = $(2n-1)/2*\lambda_{spp}$, n = 1,2,3, …
Weak E-fields and small ΔT when pitch = $n*\lambda_{spp}$, n = 1,2,3, …
Reference: D. Pacifici, *et al.*, PRB 77, 115411 (2008)

E-fields

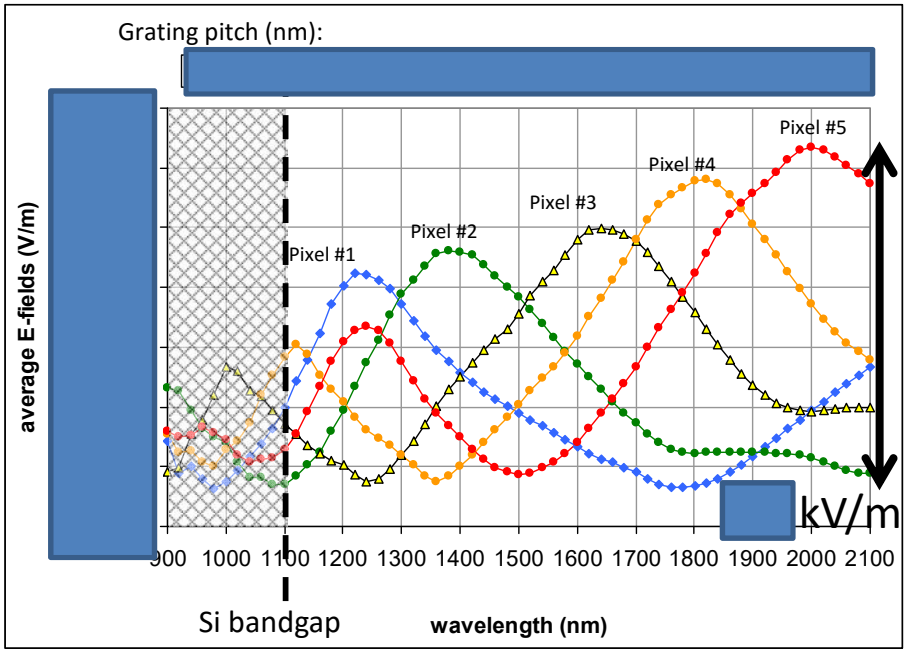


ΔT

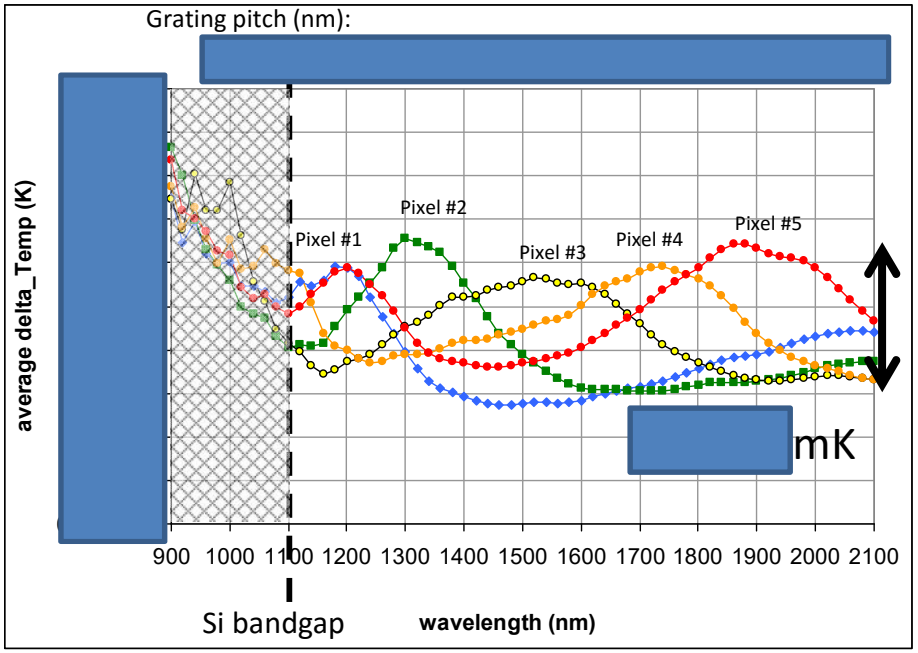


Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)

Average E-fields on the gaps

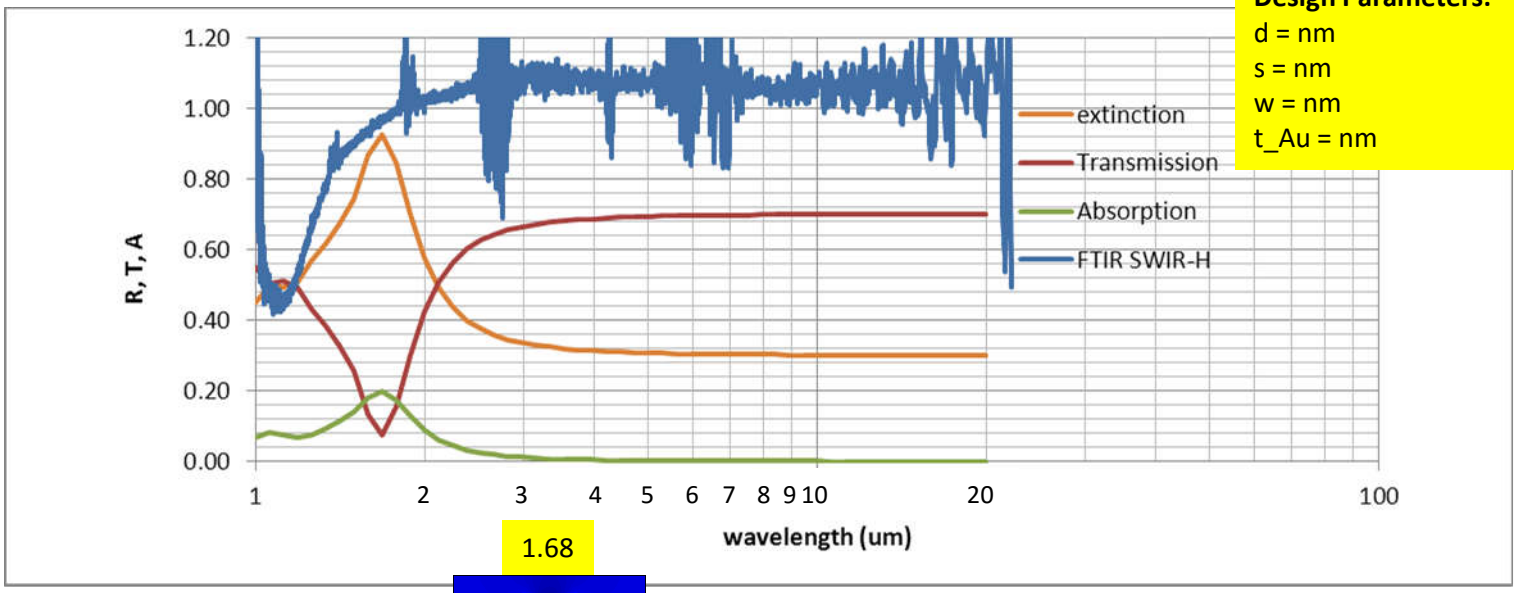


average ΔT (temperature change due to ohmic heating) on the gaps

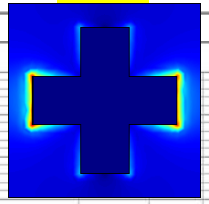


Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)

Design Parameters:
d = nm
s = nm
w = nm
t_Au = nm



1.68



Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)

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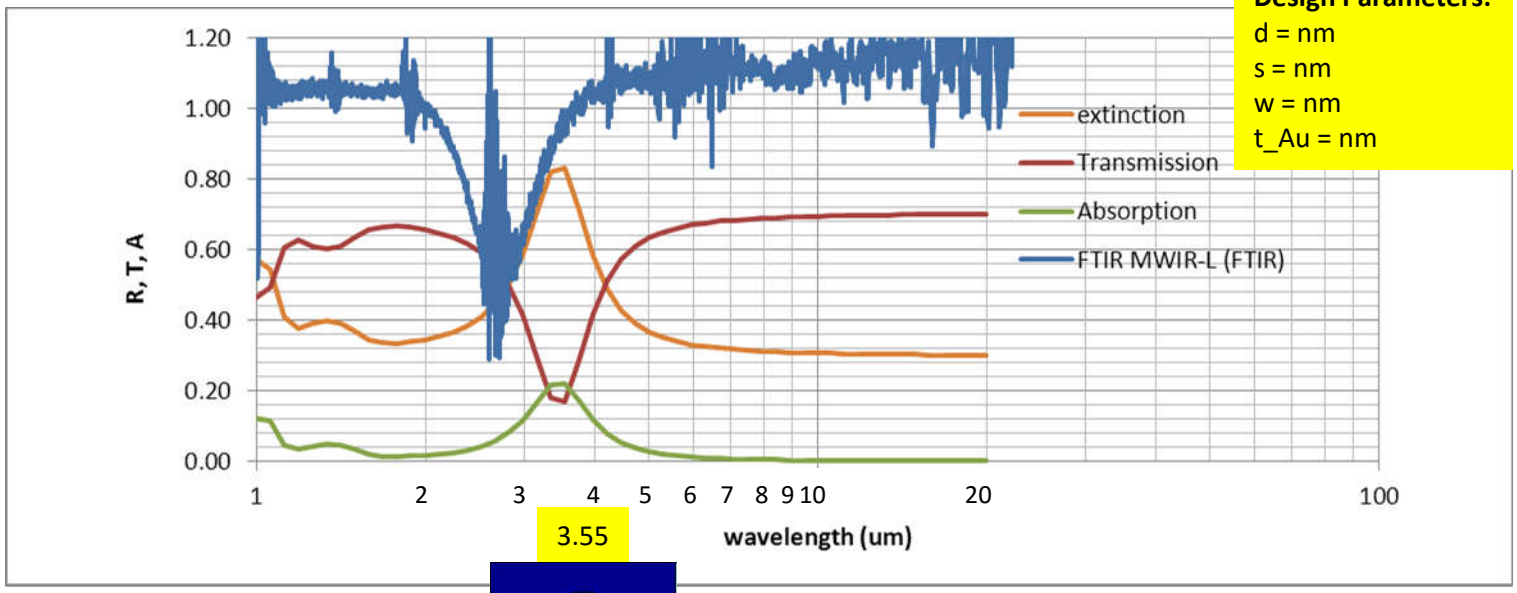
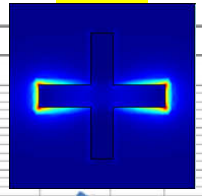


3.55



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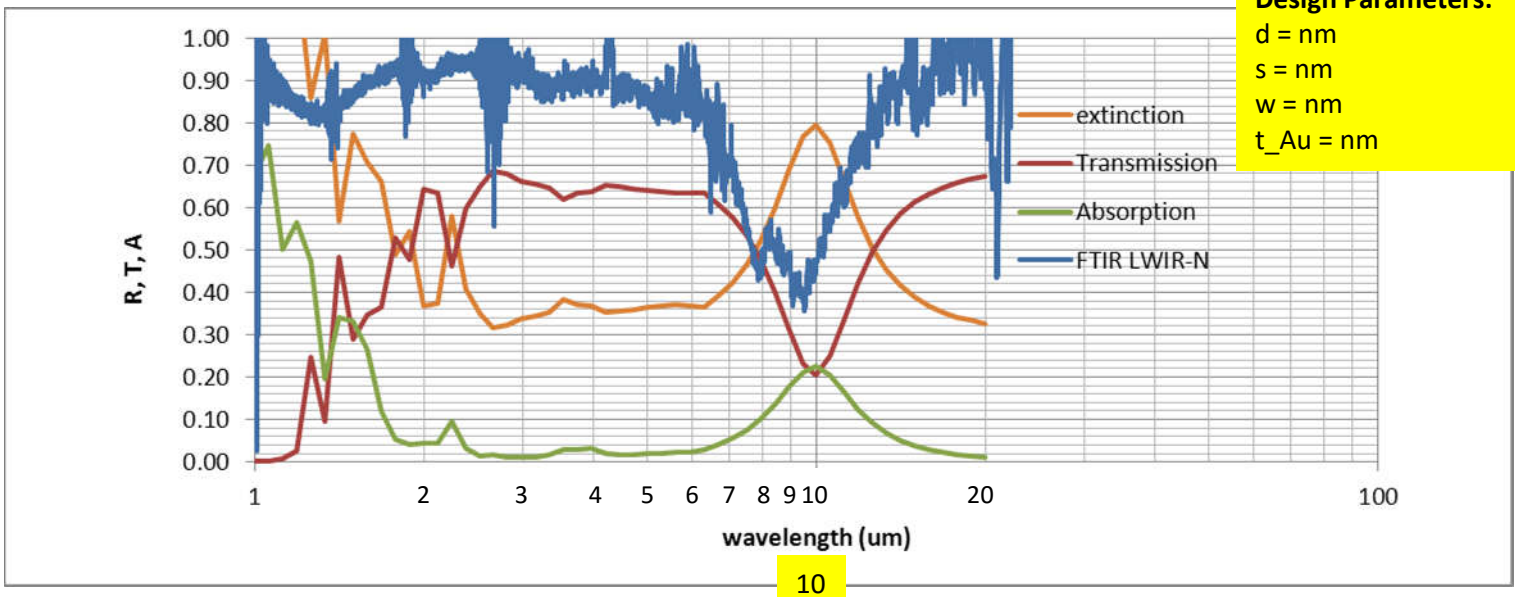
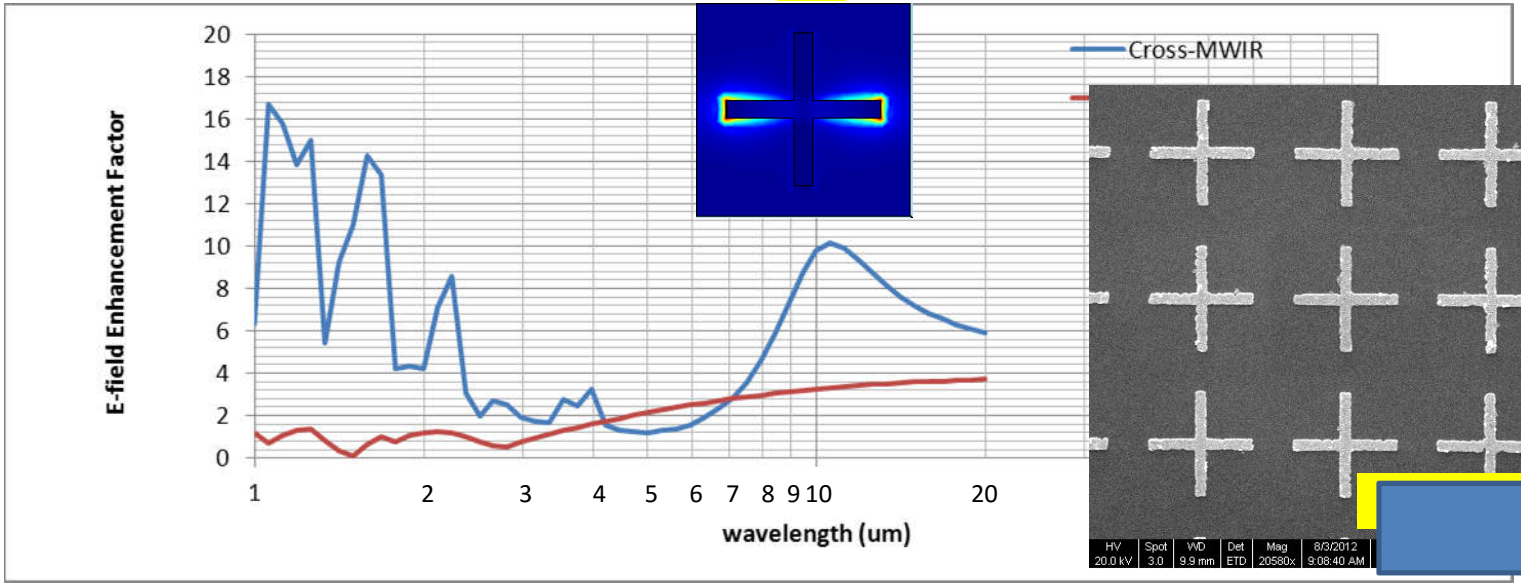
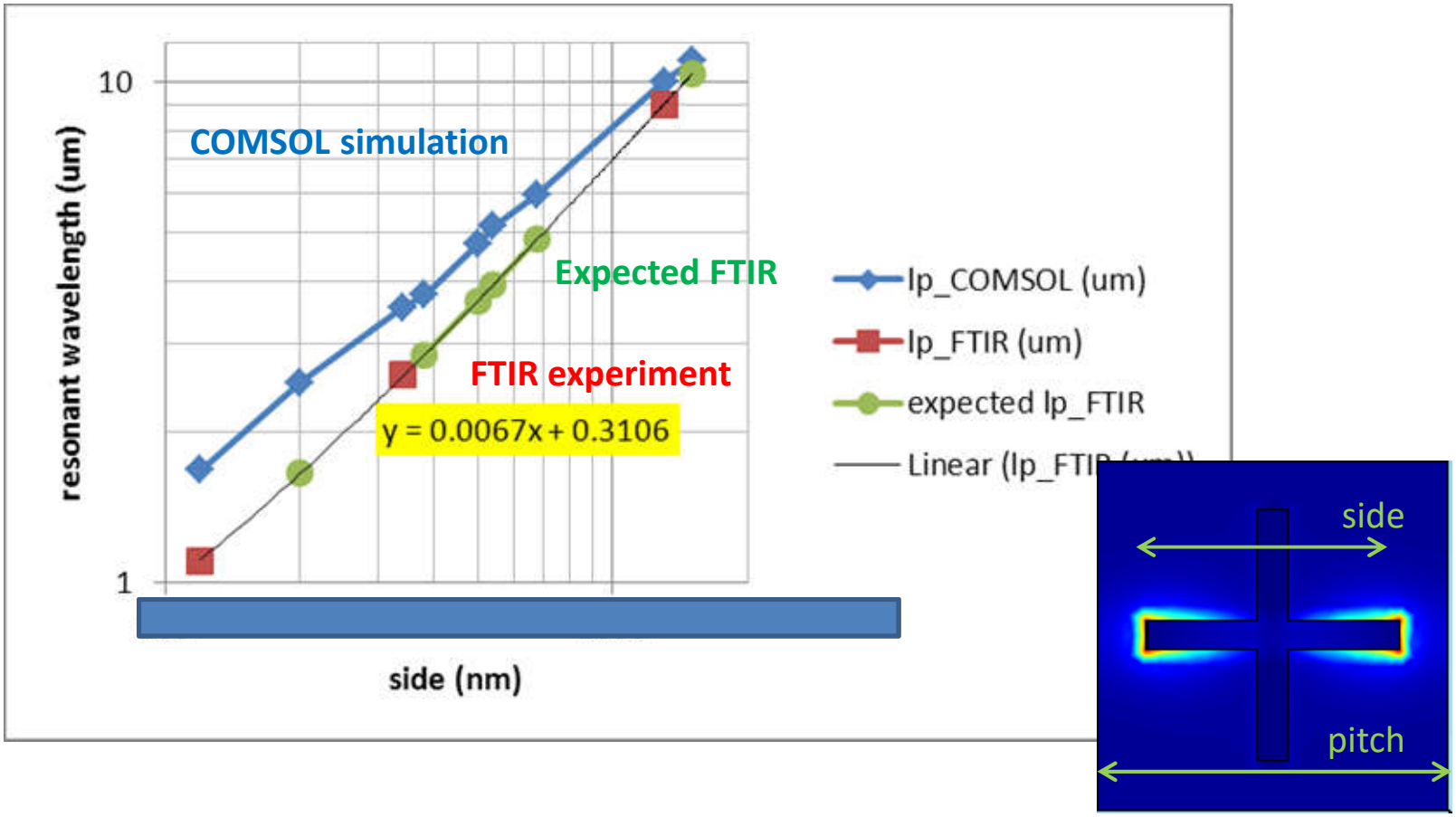


10

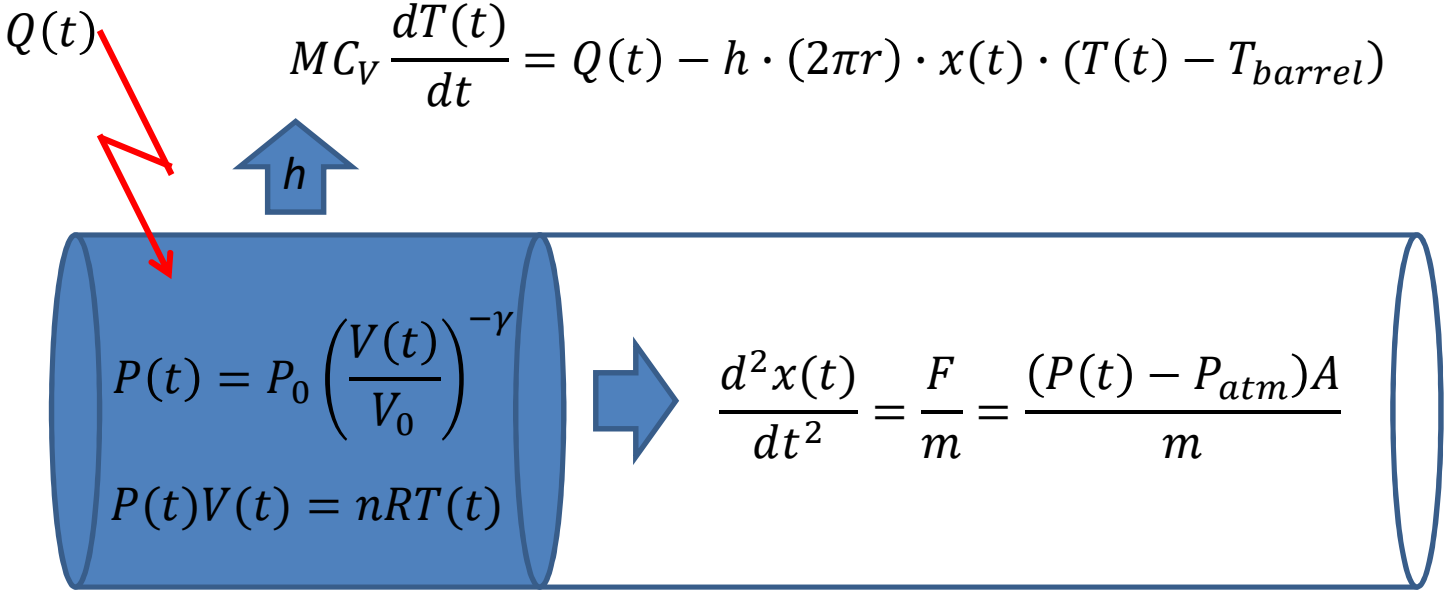


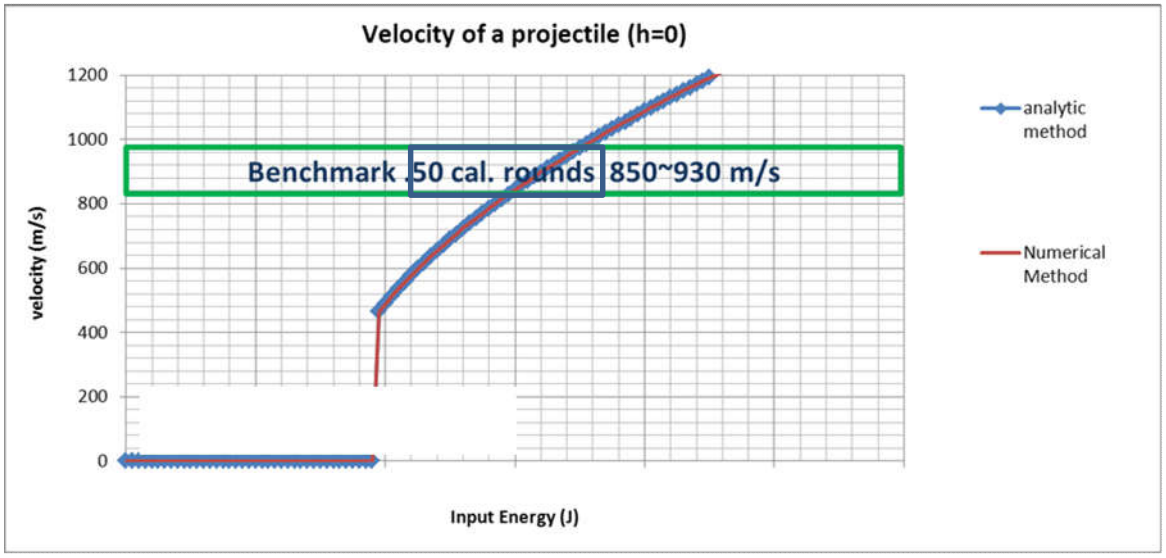
Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)

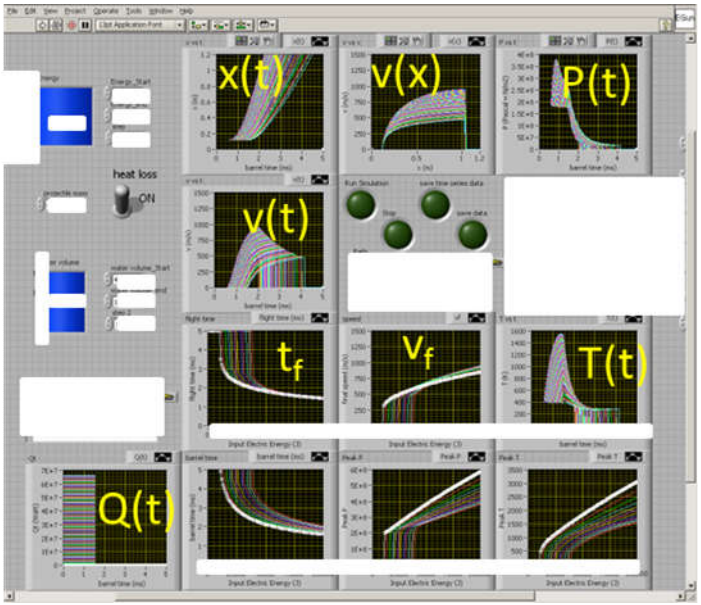


Numerical Methods Simulation (Tanner Research, 2009-2013)

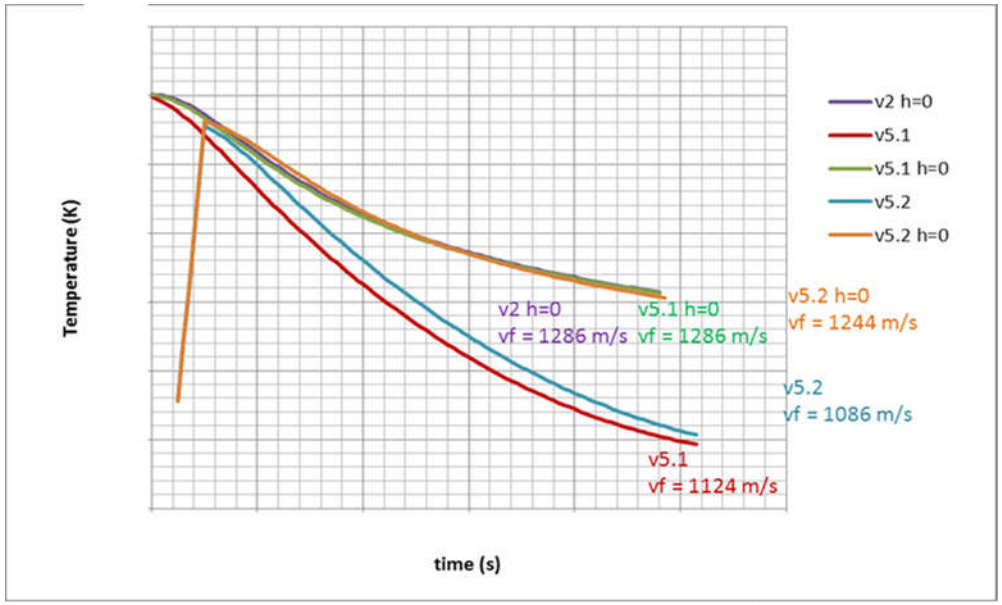
$$MC_V \frac{dT(t)}{dt} = Q(t) - h \cdot (2\pi r) \cdot x(t) \cdot (T(t) - T_{barrel})$$

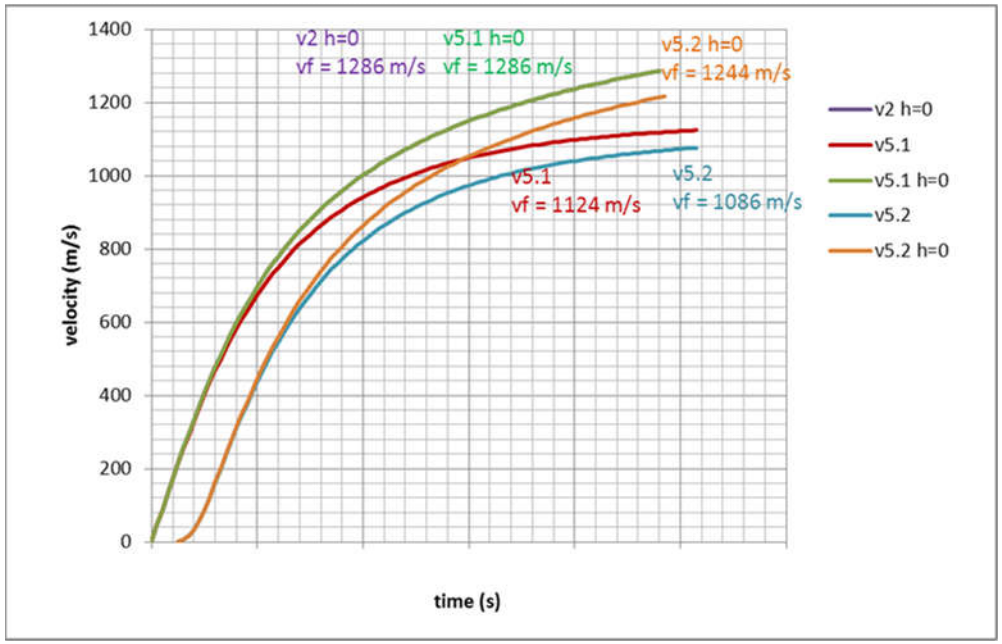






Numerical Methods Simulation (Tanner Research, 2009-2013)

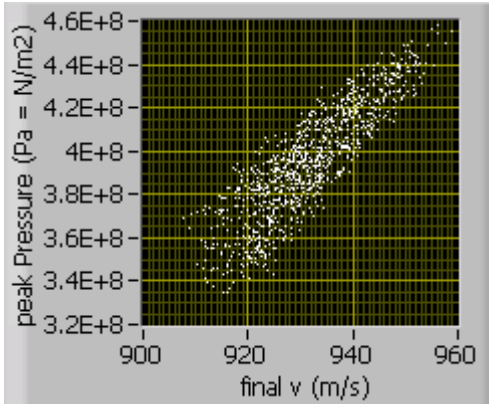




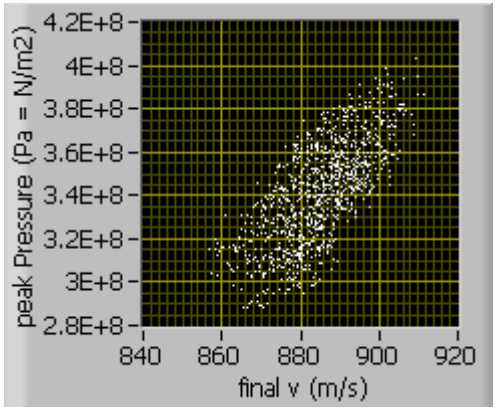
Numerical Methods Simulation (Tanner Research, 2009-2013)

Monte-Carlo Method (optimization)

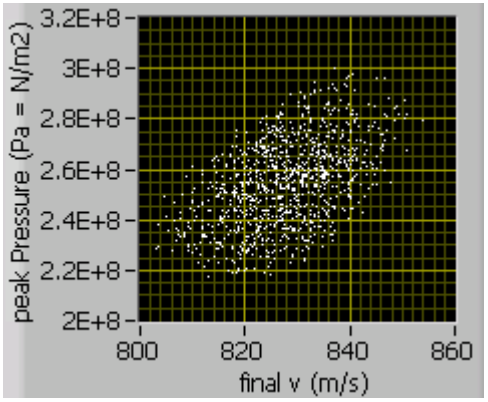
A



B



C



- Peak pressure – related to the breakage of the system.
- Final v – relevant to the performance of the system.

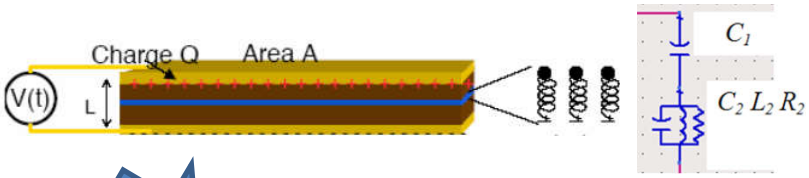
THz Detector (UCSB Ph.D. 2003-2009)

$$\ddot{x} + \Gamma\dot{x} + \omega_p^2 x = -\frac{eE_{THz}}{m^*} e^{j\omega t}$$

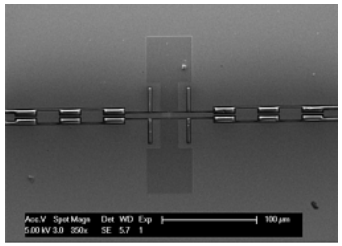
$$\Re_I = \frac{I_{signal}}{P_{in}} = \alpha \frac{e}{\varepsilon\varepsilon_0 \Gamma'} \mathrm{Re}(\mu) \frac{dn}{dV_G} \quad \text{(A/W)}.$$

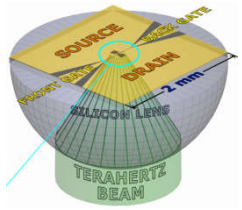
$$NEP_I = \frac{\sqrt{4k_B T / R_{SD}}}{\Re_I} \quad \text{(W/Hz}^{1/2}\text{)}.$$

Device Modeling

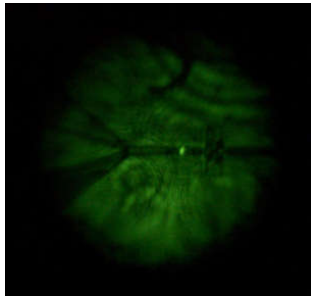


Fabrication

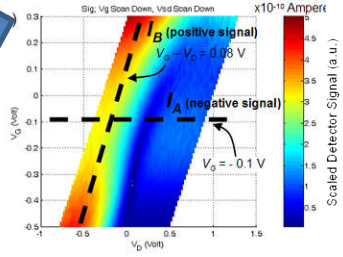


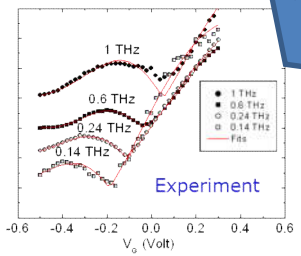


Measurements

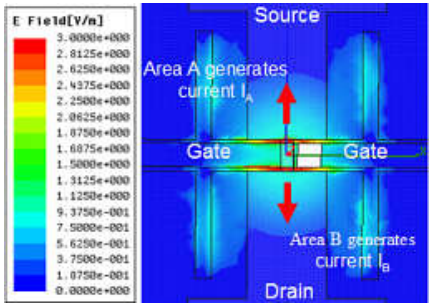


Data Analysis

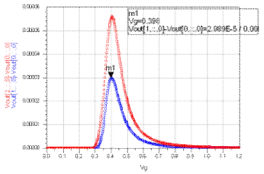




FEM EM Simulation



Device Model Revision

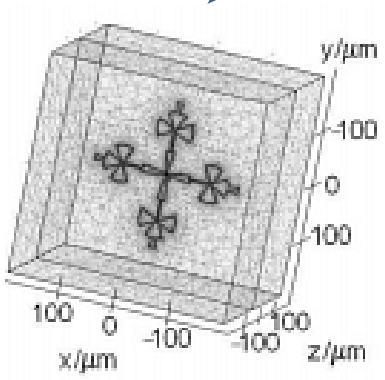


THz Mixer (Tanner Research, 2009-2013)

$$j_{SD} = n(\omega_G) e v(\omega_{SD})$$

$$U_r = \eta \left[\frac{U_g^{\mathrm{THz}} U_{\mathrm{DS}}^{\mathrm{THz}} \cos\varphi}{2\left(U_g^{\mathrm{DC}} - U_{\mathrm{DS}}^{\mathrm{DC}}\right)} - \frac{\left(U_{\mathrm{DS}}^{\mathrm{THz}}\right)^2}{4\left(U_g^{\mathrm{DC}} - U_{\mathrm{DS}}^{\mathrm{DC}}\right)} \right]$$

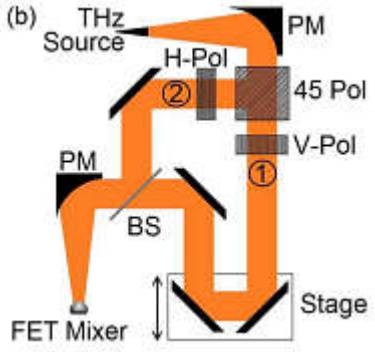
Device Modeling

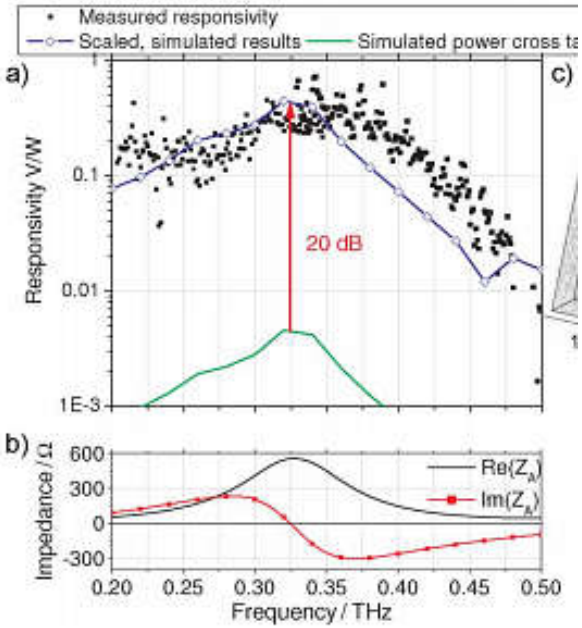


FEM EM Simulation

Cleanroom Fabrication

Measurements





Data Analysis

Thank you!