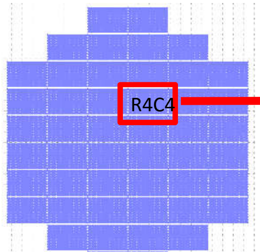
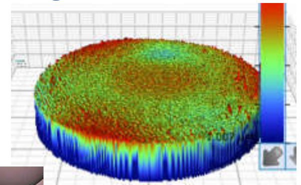
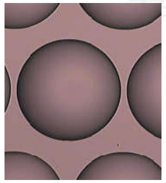
Microlens Array (IMT, 2013-present)

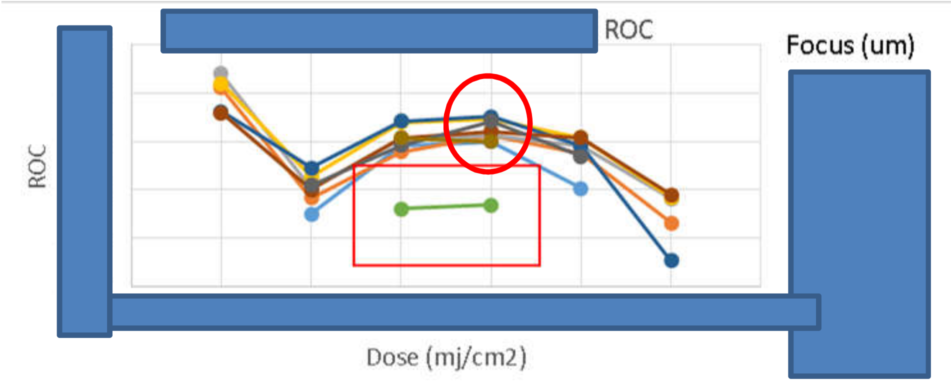


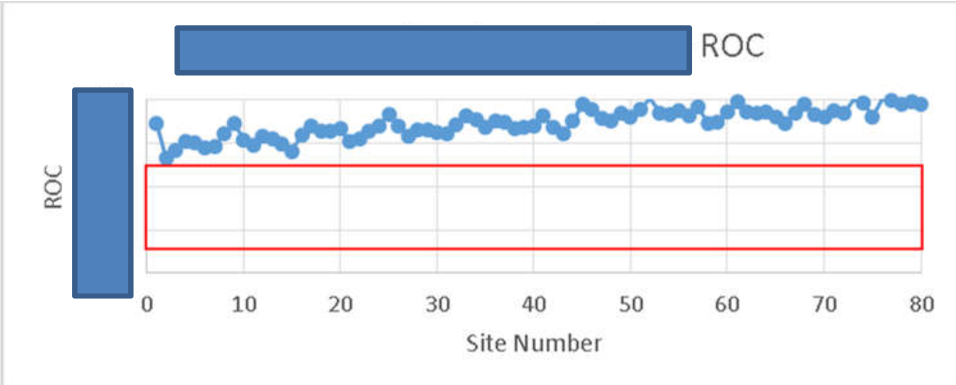
Large Data (3D profiles, uniformity)

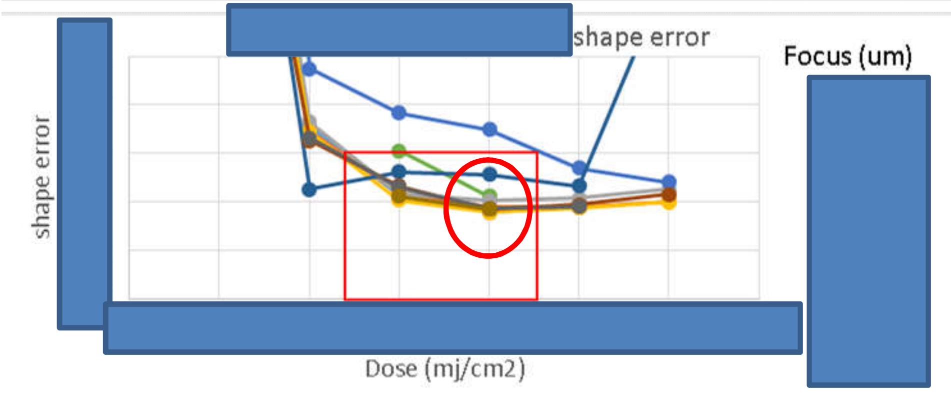
20,000 lenses on a wafer

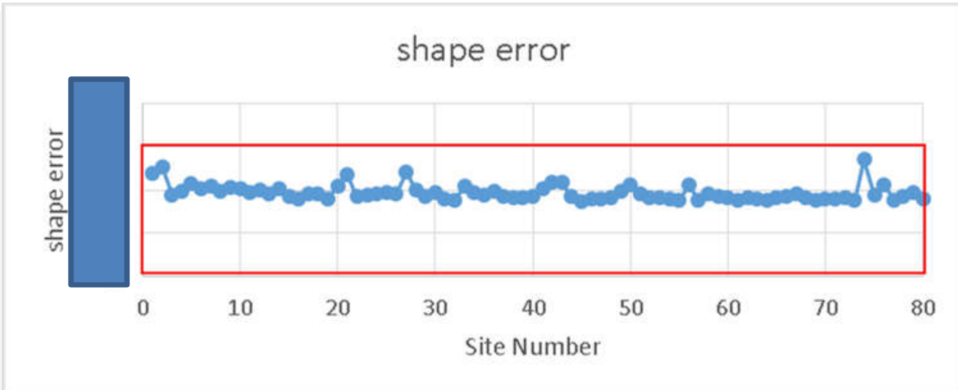






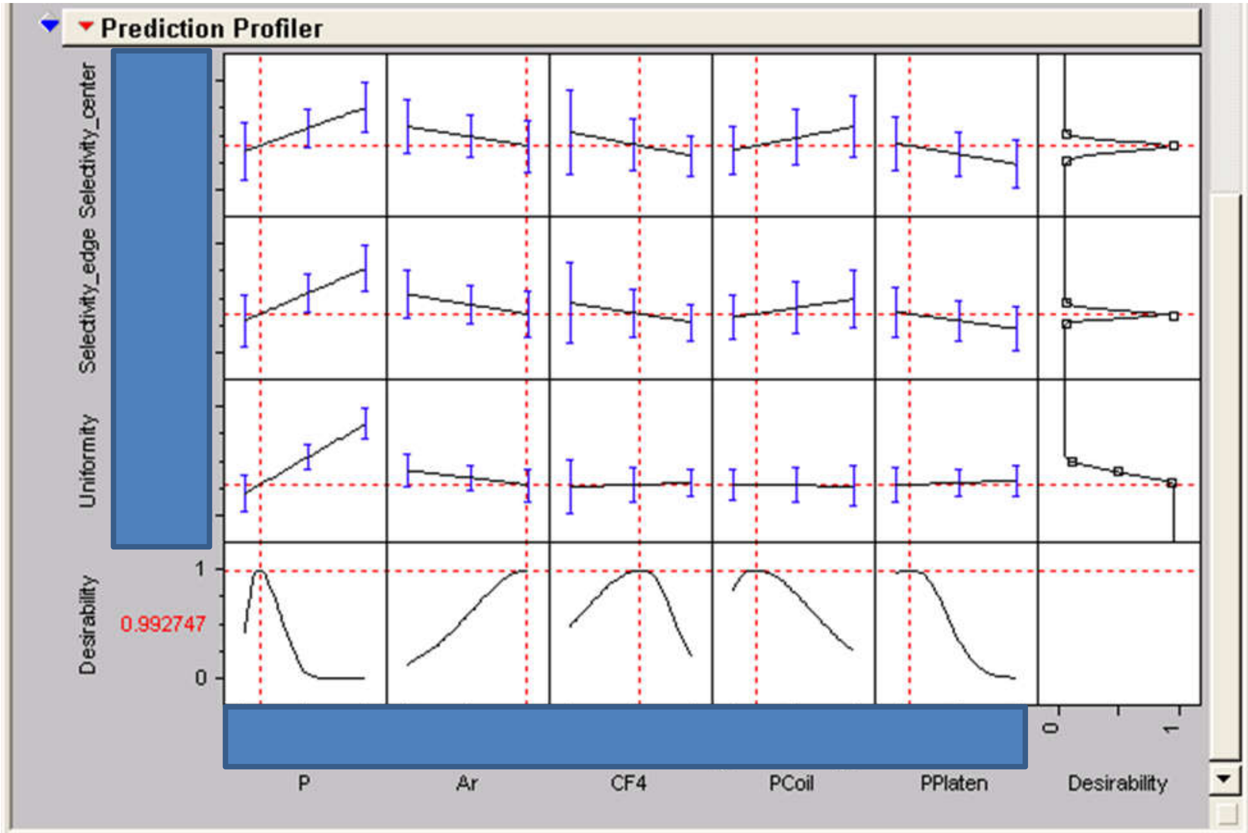






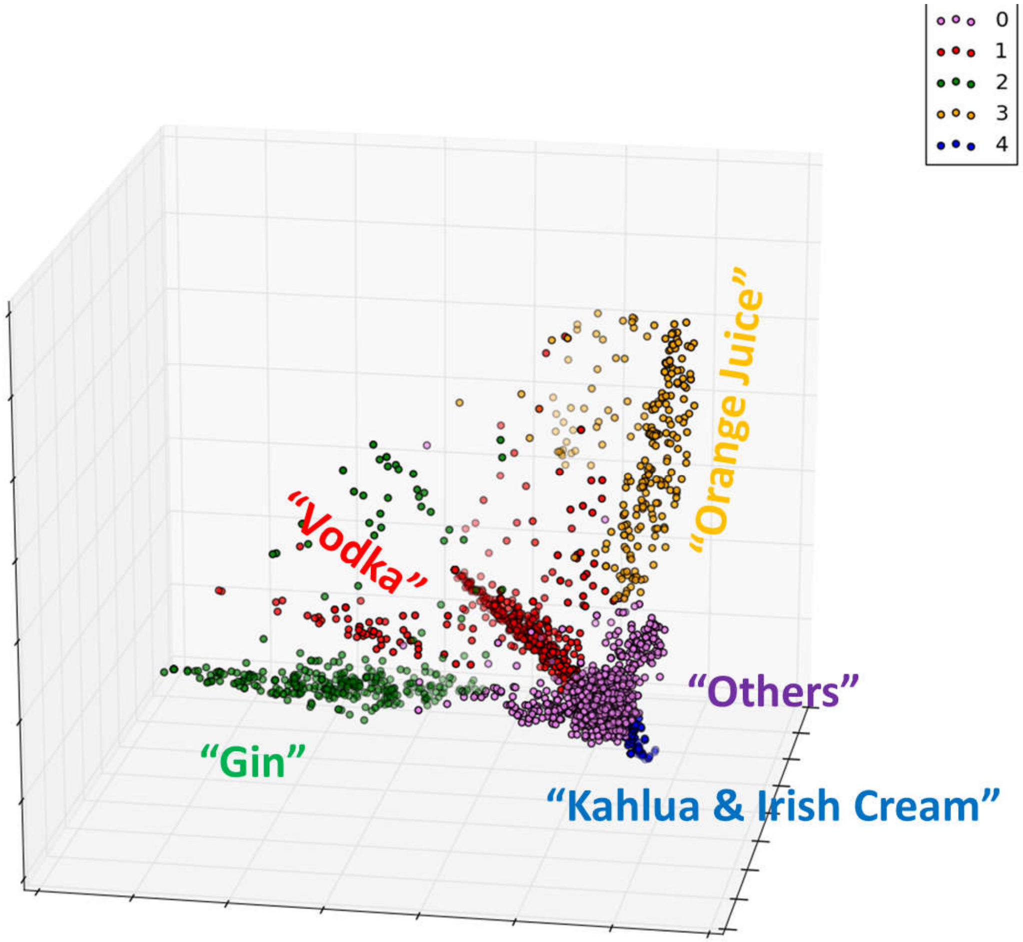
- Processed data essential for the success of this project.
- Transitioning to a volume production phase

JMP (IMT, 2013-present)



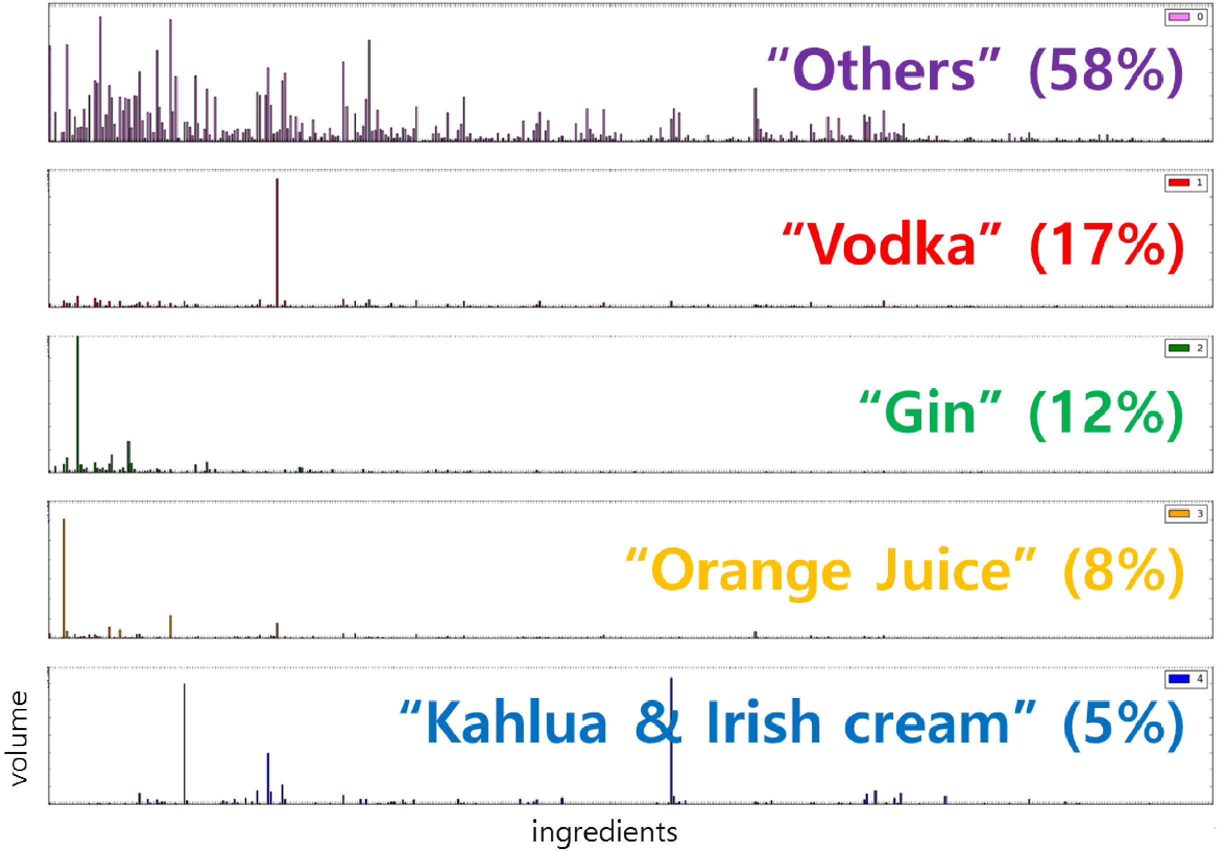
- SAS JMP used for optimizing process

Python (personal project, 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 (personal project, 2016)



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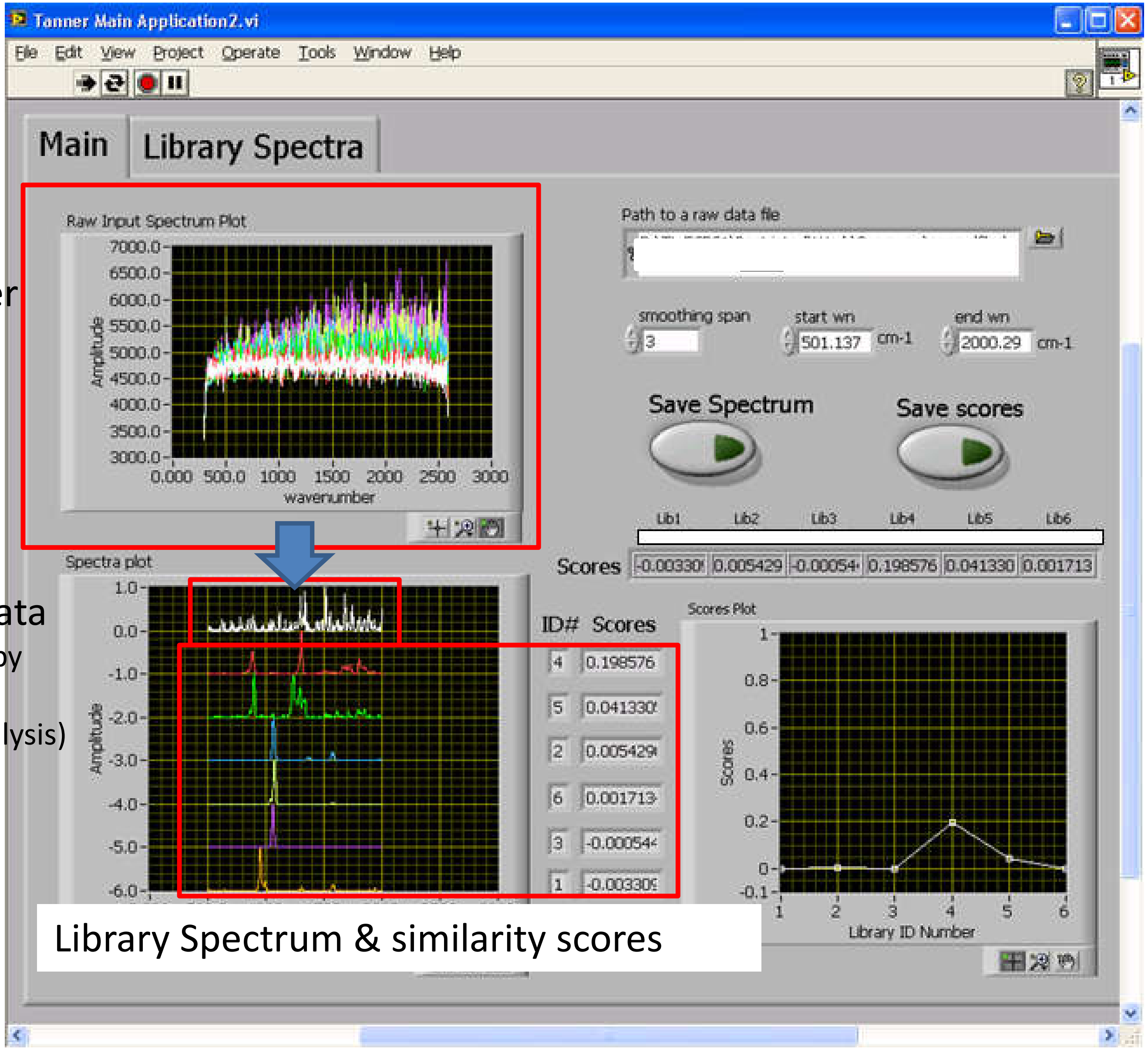
- Spectral Cluster algorithm was used to separate the groups
- Generated profiles of each market segment.

Chemical Detection (Tanner Research, 2009-2013)

Raw Data from spectrometer

Processed Data (noise reduced by Principal Component Analysis)



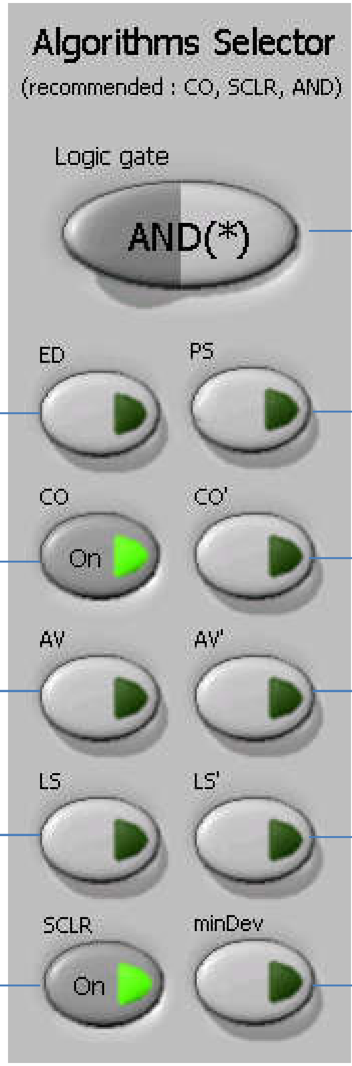
Library Spectrum & similarity scores

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)



Results combining logic (AND / OR)

Euclidean Distance

Peak Search

Correlation

Correlation of first derivatives

Absolute Values

Absolute Values first of derivatives

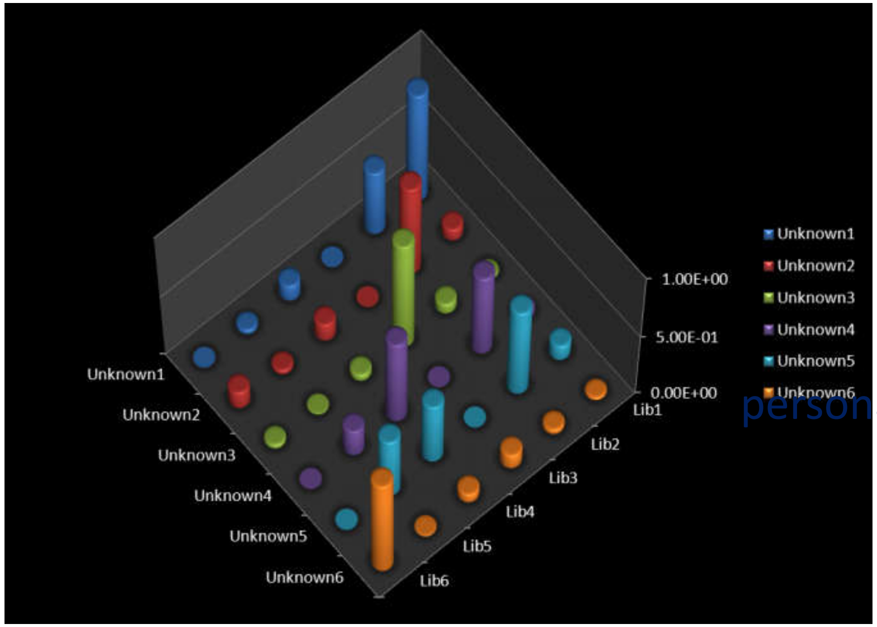
Least Squares

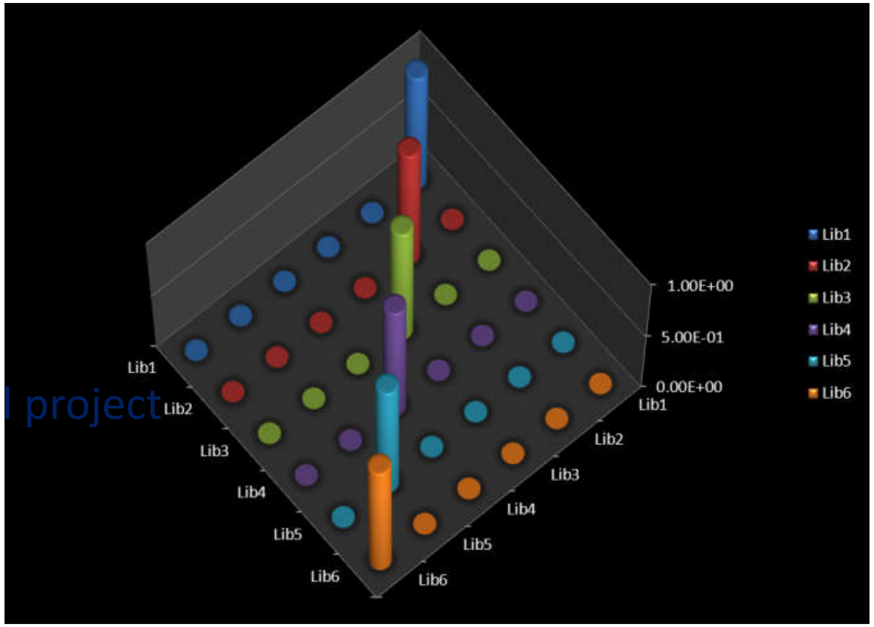
Least Squares of first derivatives

Single Chemical Library Regression (PCR)

Monte-Carlo method

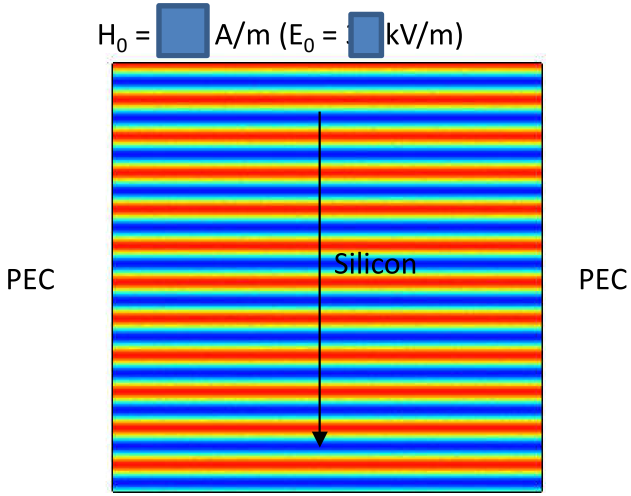
Chemical Detection (Tanner Research, 2009-2013)

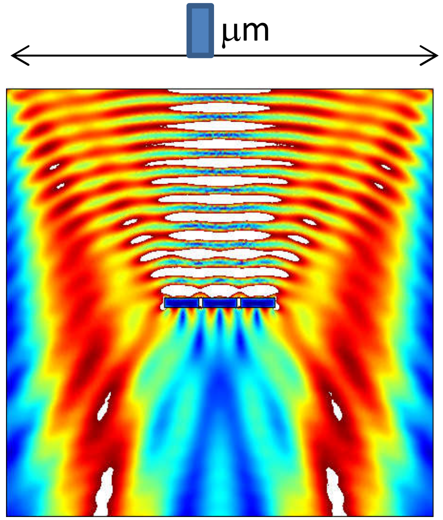


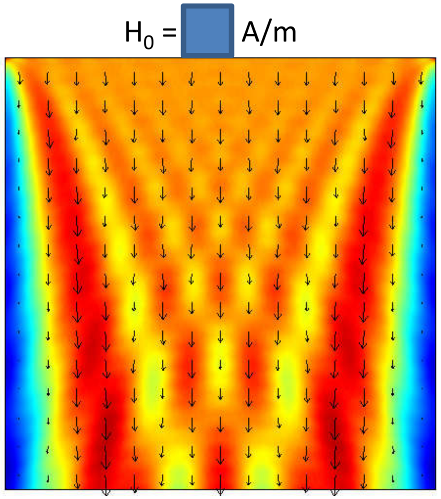


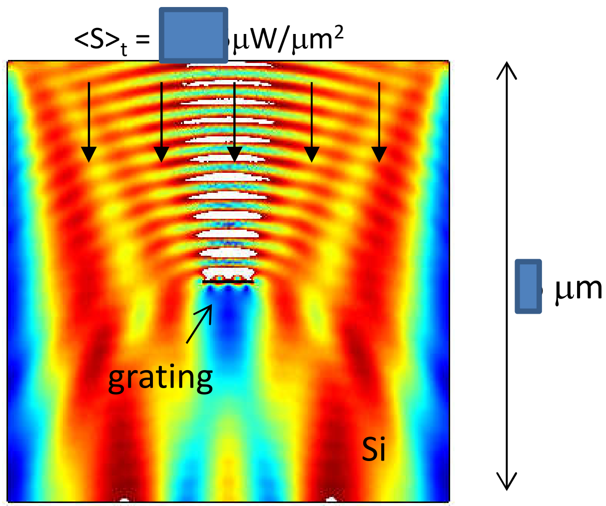
- This standoff-chemical detection system passed rigorous field tests (accuracy, recall) at customer's proving ground. Customer later asked us to deliver software only.

Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)





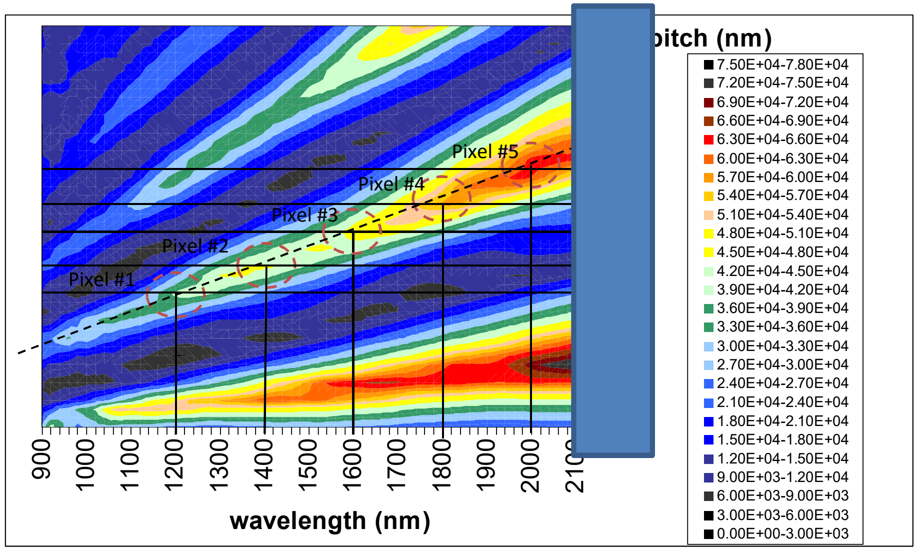




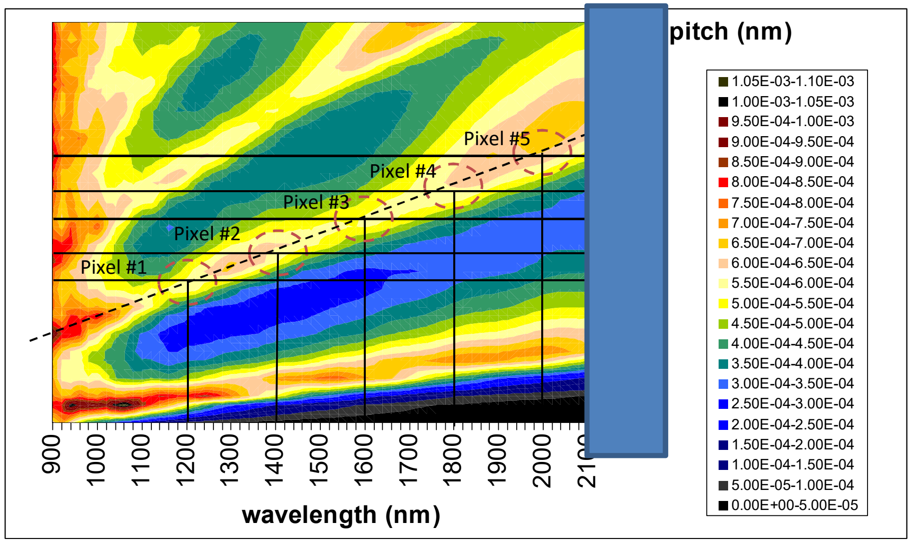
Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)

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



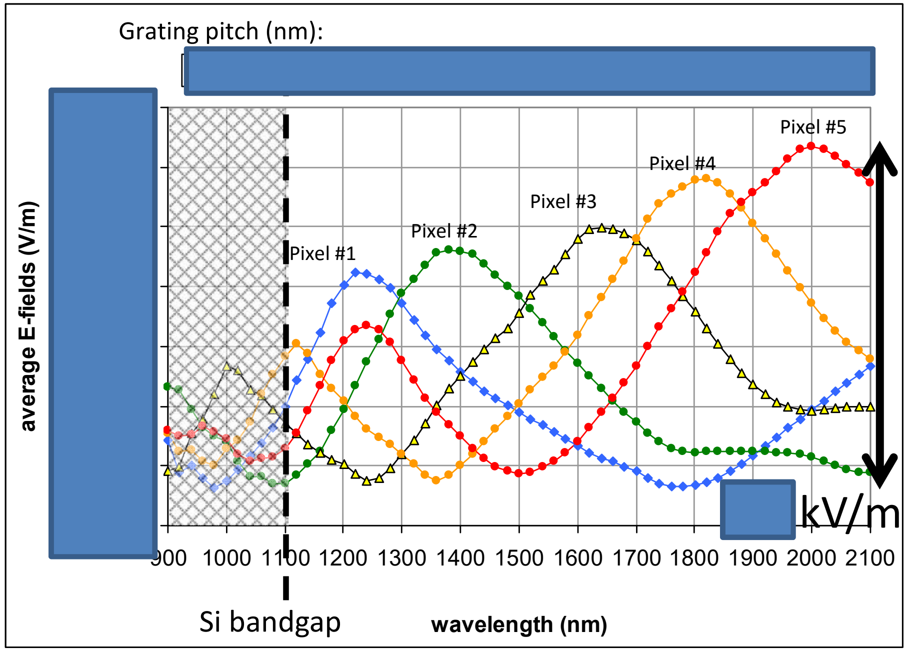
ΔT

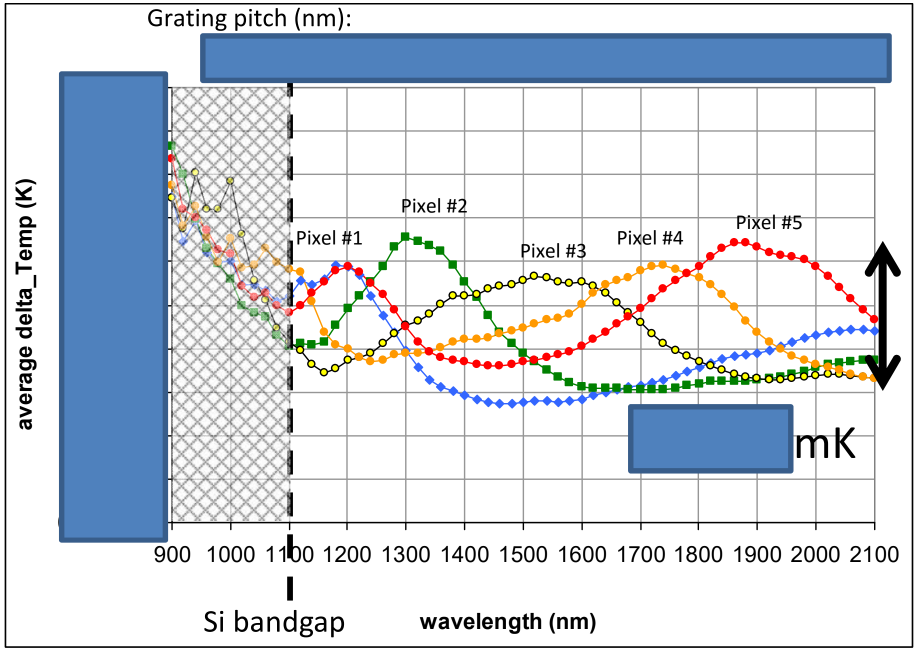


Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)

Average E-fields on the gaps

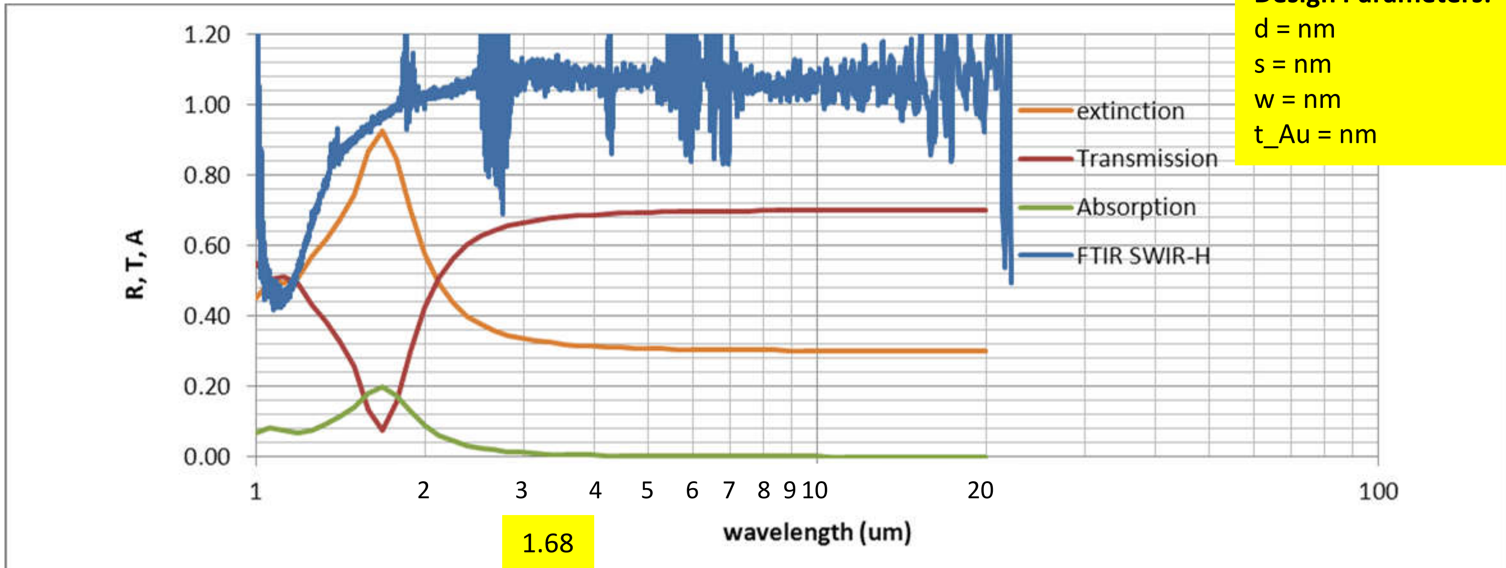
average ΔT (temperature change due to ohmic heating) on the gaps



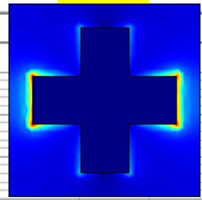


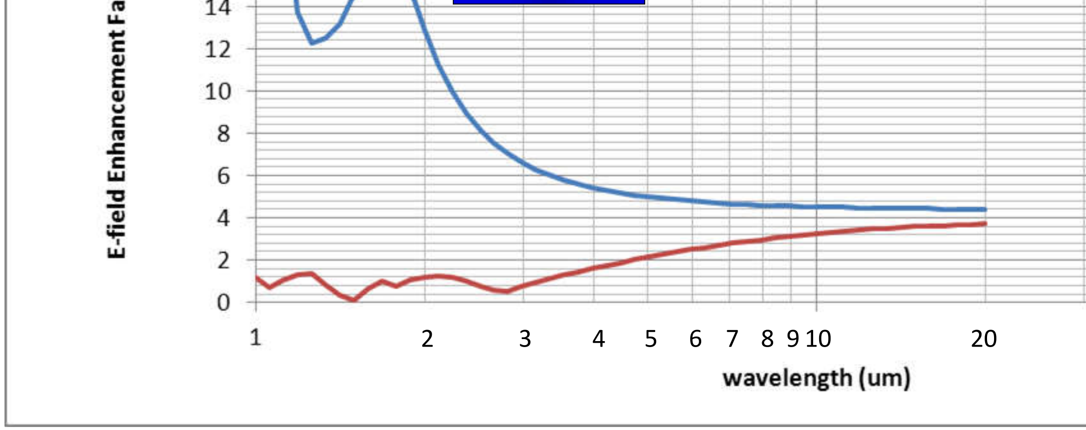
Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)

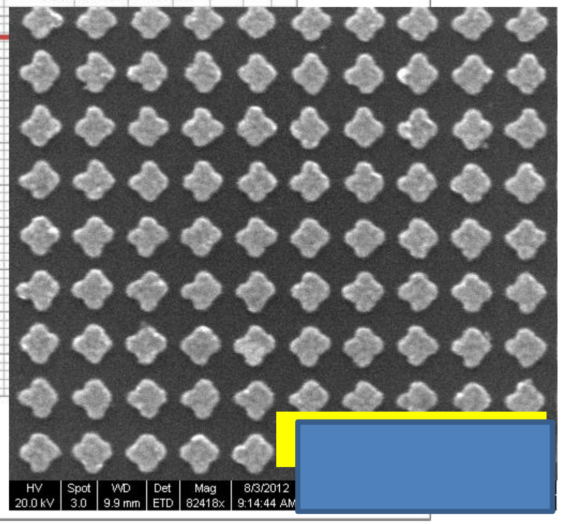
Design Parameters:
d = nm
s = nm
w = nm
t_Au = nm



1.68







Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)

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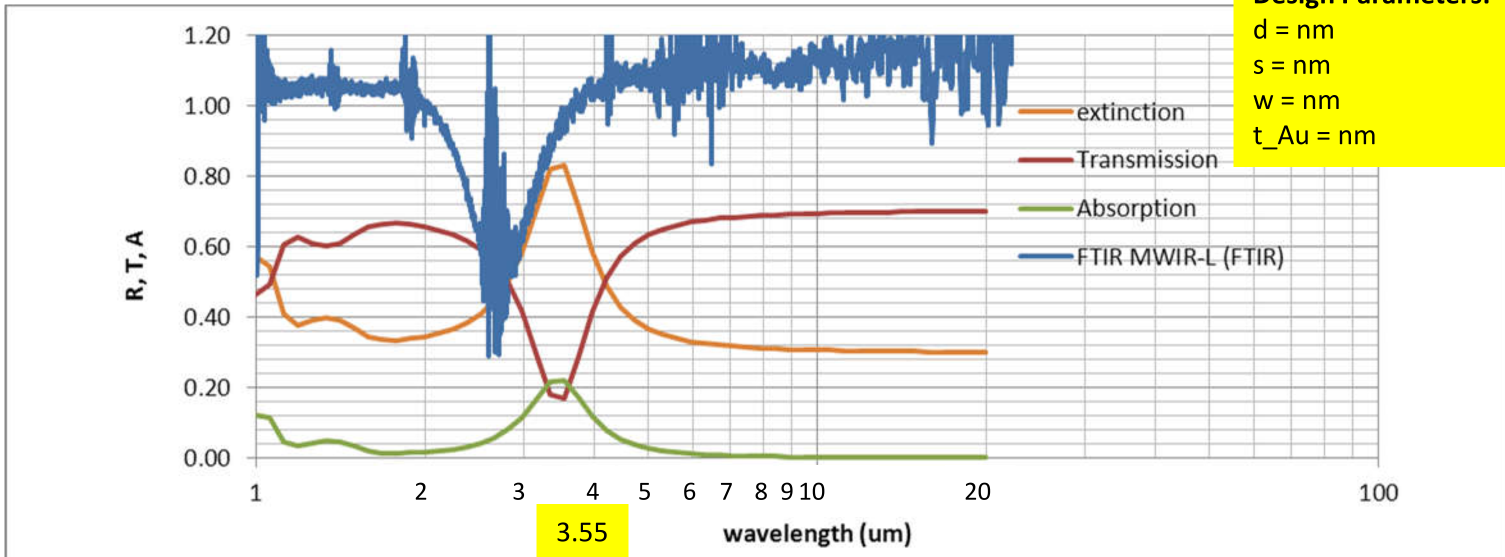
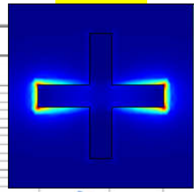
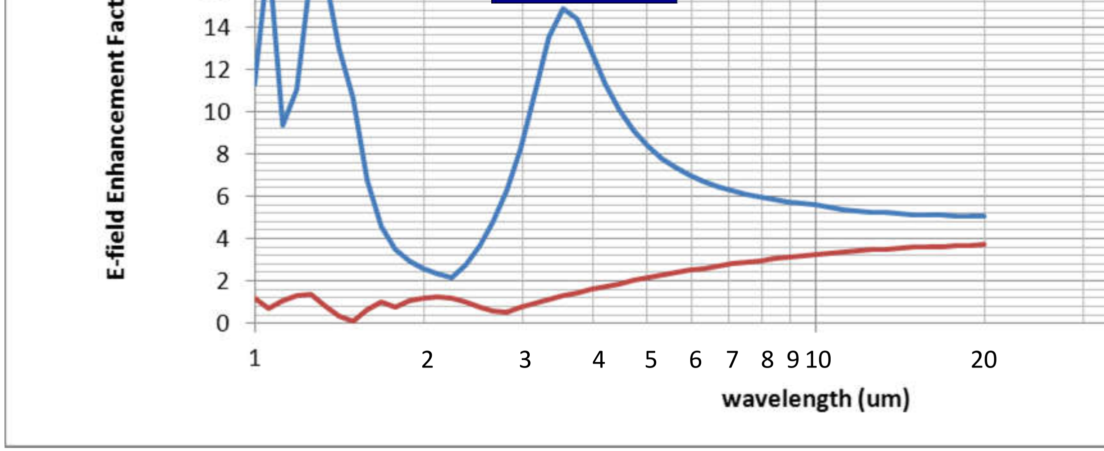
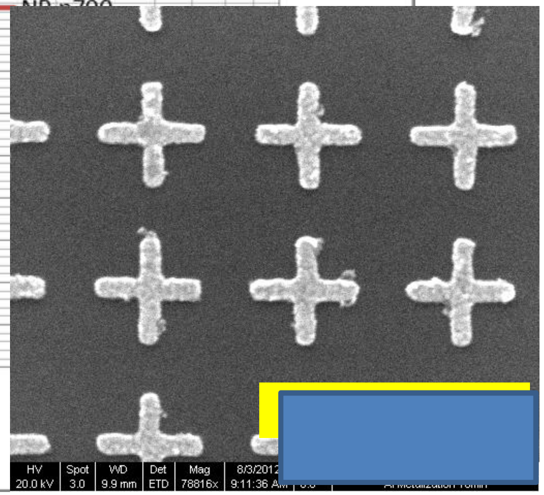


3.55







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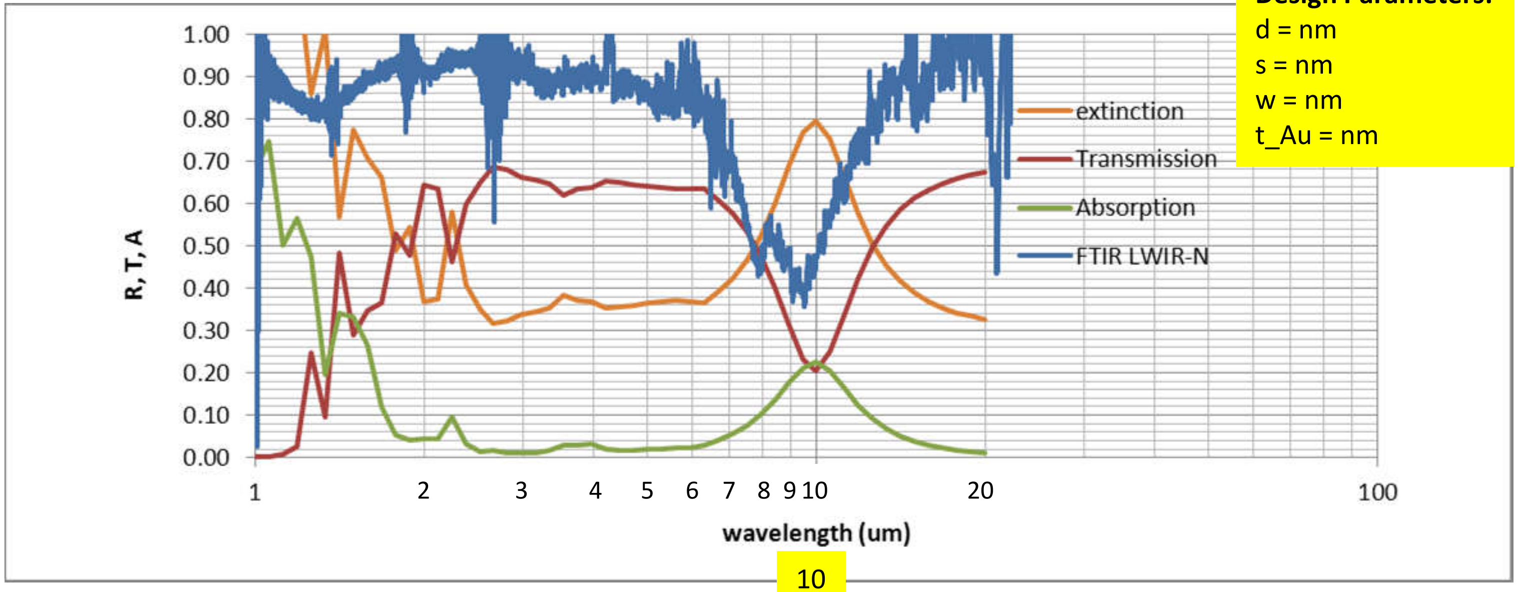
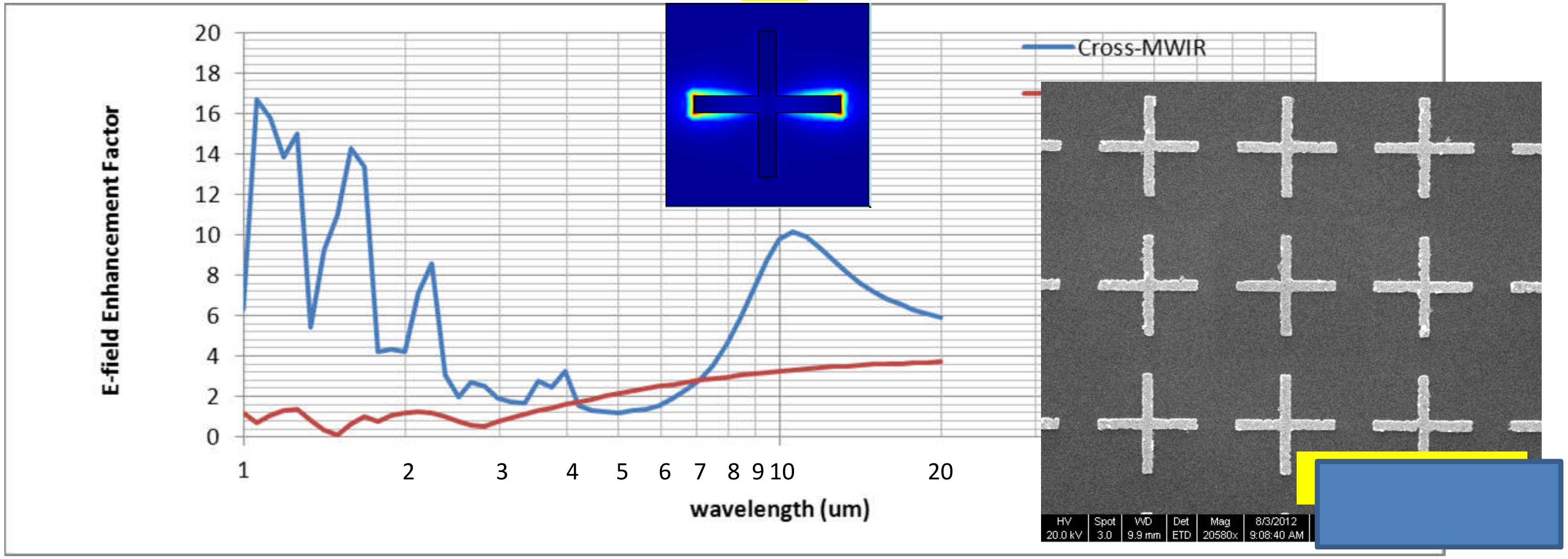
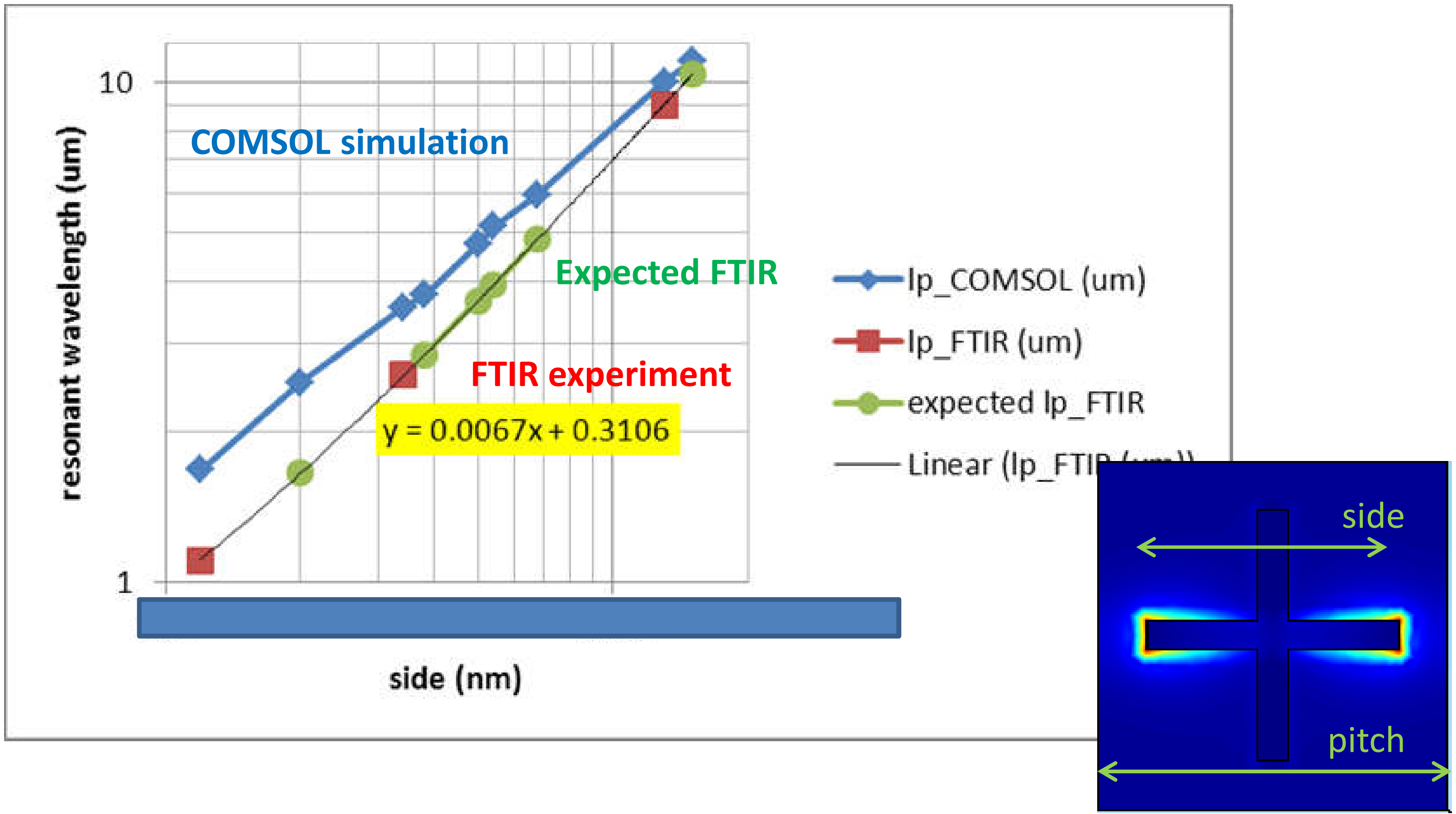


10



Multispectral Infrared Metamaterial (Tanner Research, 2009-2013)



Numerical Methods Simulation (Tanner Research, 2009-2013)

$Q(t)$

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

h

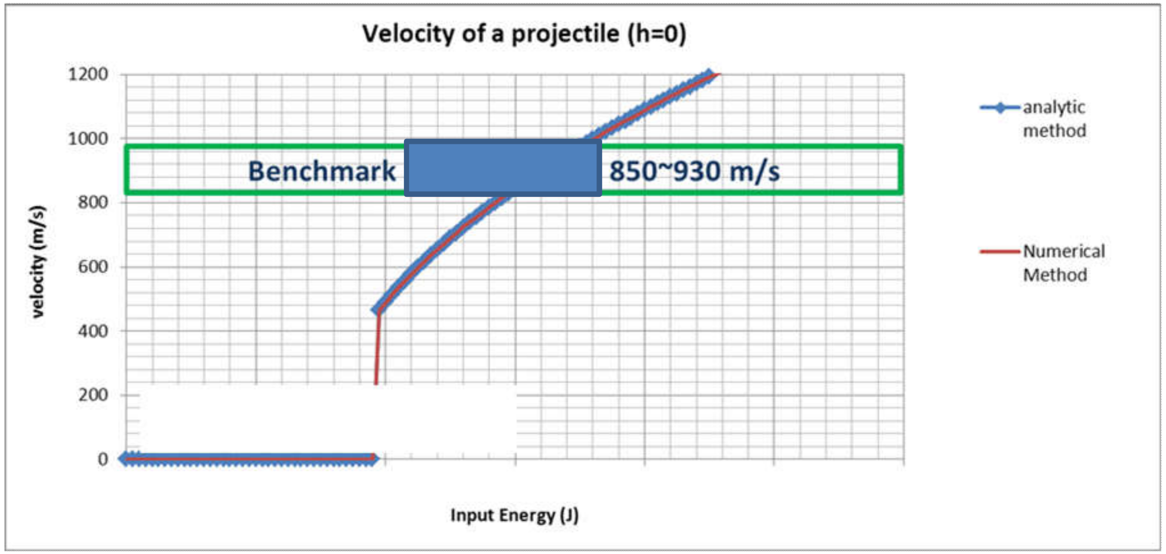
$$P(t) = P_0 \left(\frac{V(t)}{V_0}\right)^{-\gamma}$$

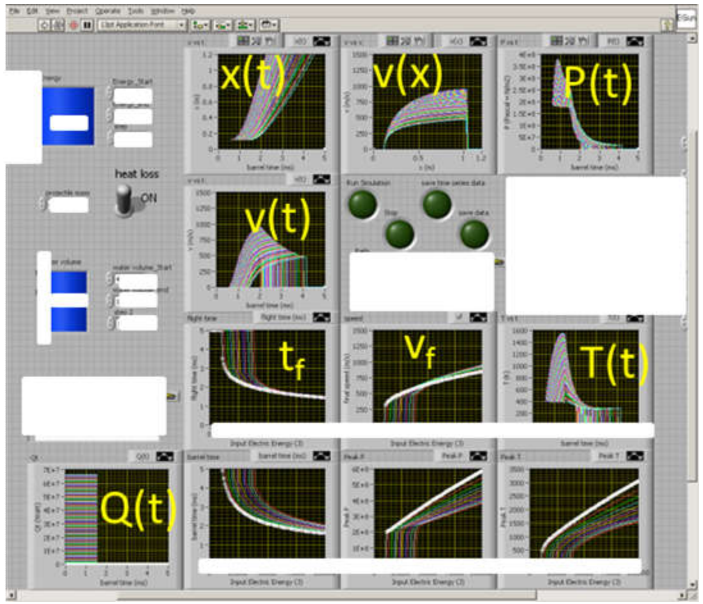
$$P(t)V(t) = nRT(t)$$

$$\frac{d^2x(t)}{dt^2} = \frac{F}{m} = \frac{(P(t) - P_{atm})A}{m}$$

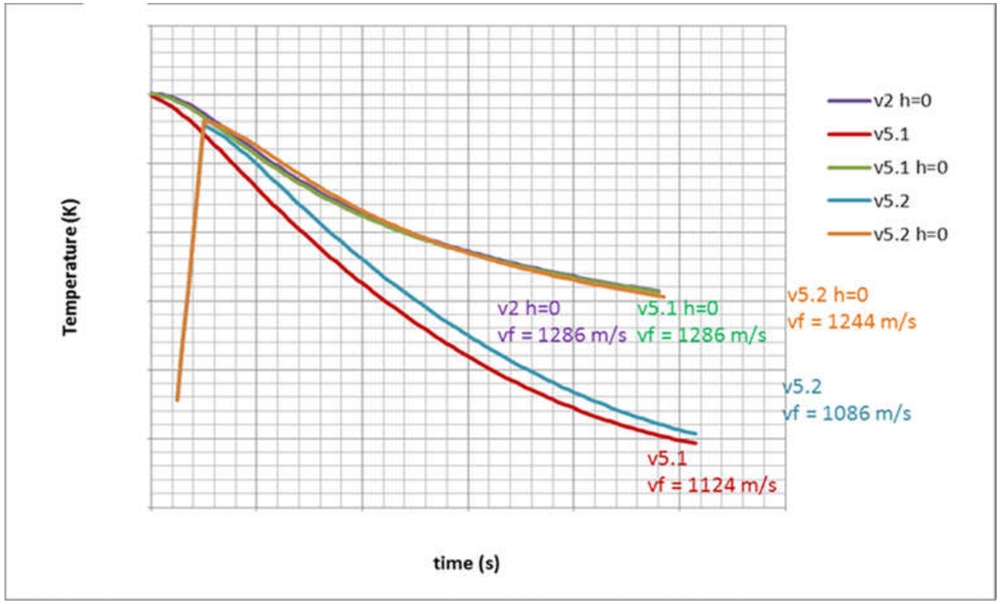
$v_f = ?$

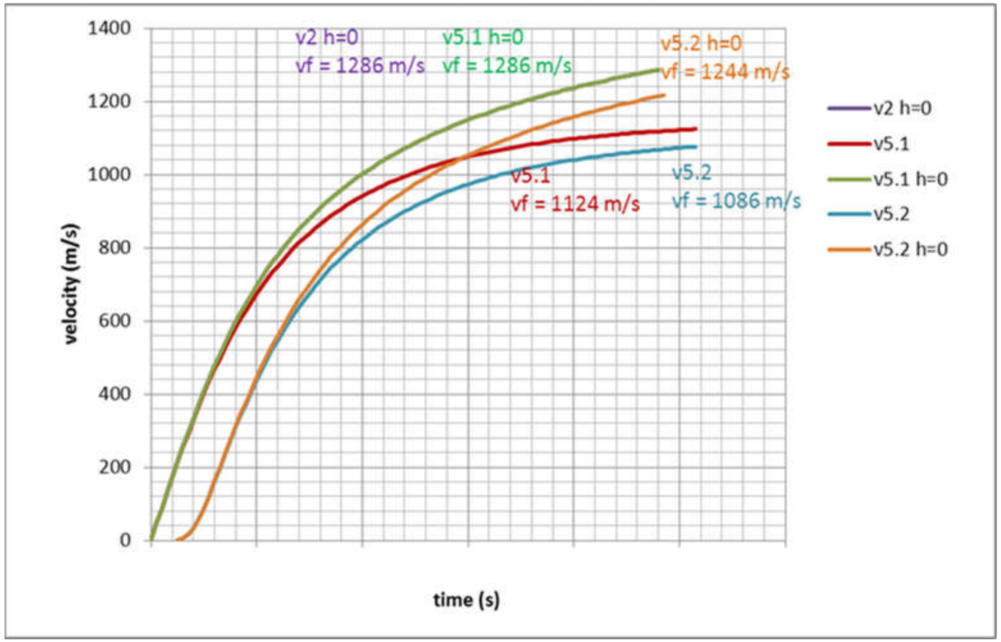
$t_f = ?$





Numerical Methods Simulation (Tanner Research, 2009-2013)

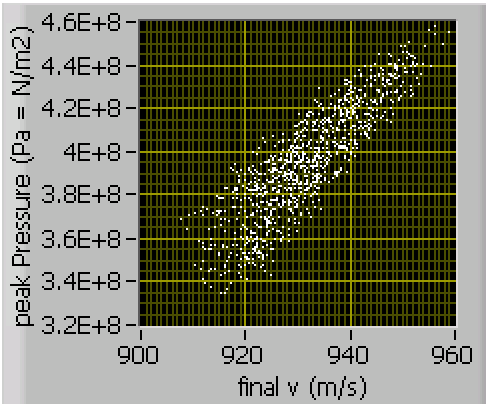




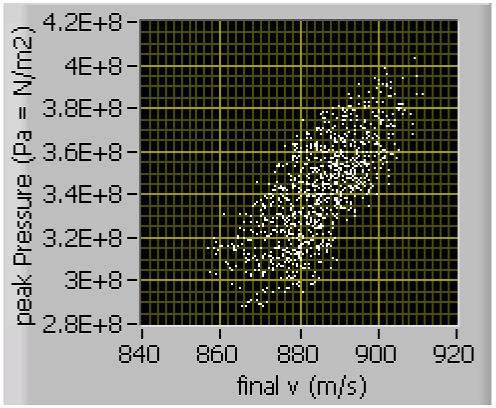
Numerical Methods Simulation (Tanner Research, 2009-2013)

Monte-Carlo Method (optimization)

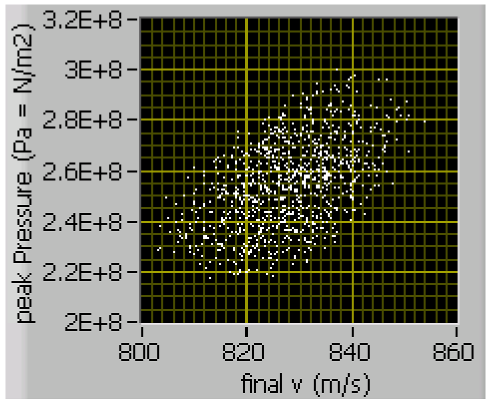
A



B



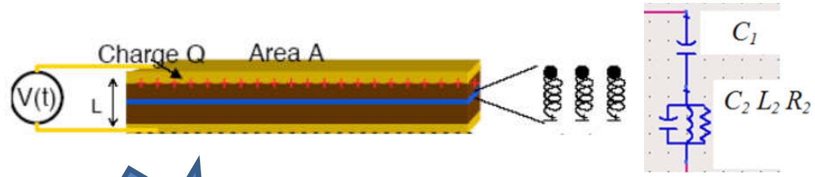
C



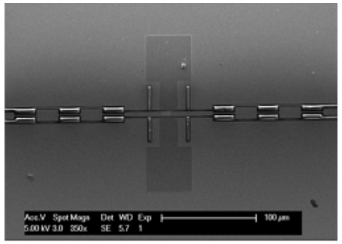
- Peak pressure – related to the breakage of the system.
- Final v – relevant to the performance of the system.

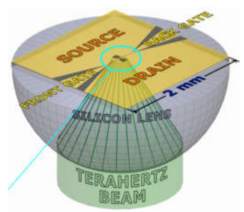
THz Detector (UCSB Ph.D. 2003-2009)

Device Modeling

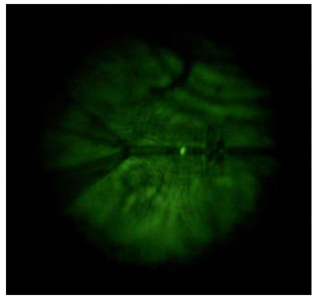


Fabrication

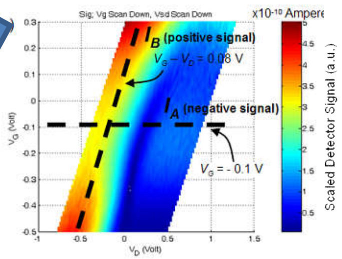


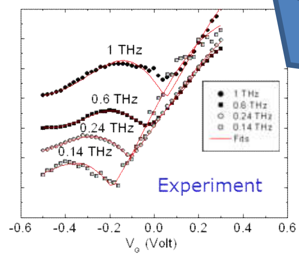


Measurements

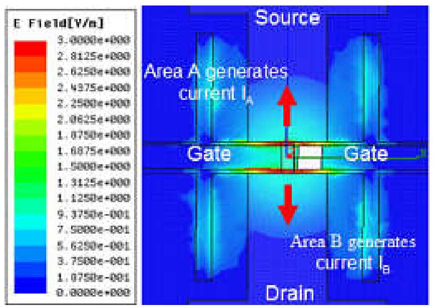


Data Analysis





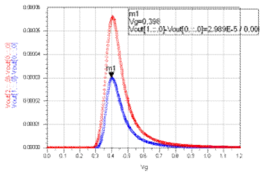
FEM EM Simulation



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

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

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



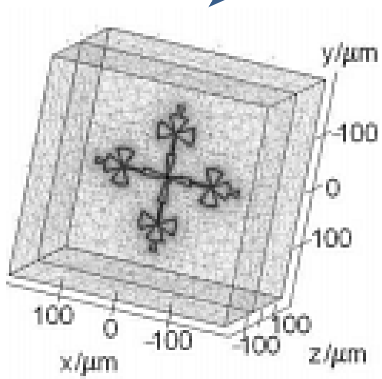
Device Model Revision

THz Mixer (Tanner Research, 2009-2013)

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

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

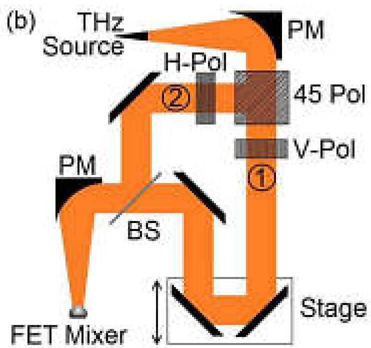
Device Modeling

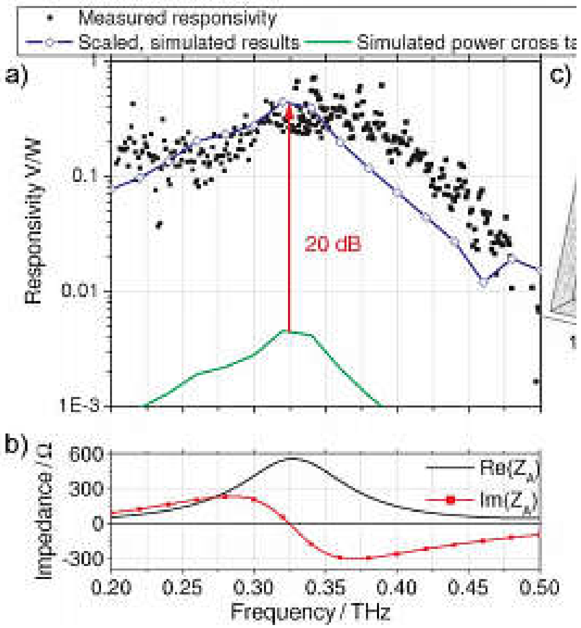


FEM EM Simulation

Cleanroom Fabrication

Measurements





Data Analysis

Thank you!

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swkim94@gmail.com
https://www.linkedin.com/in/sangwoo-kim