# Tunable plasmonic nanostructures for strong absorption and field enhancement

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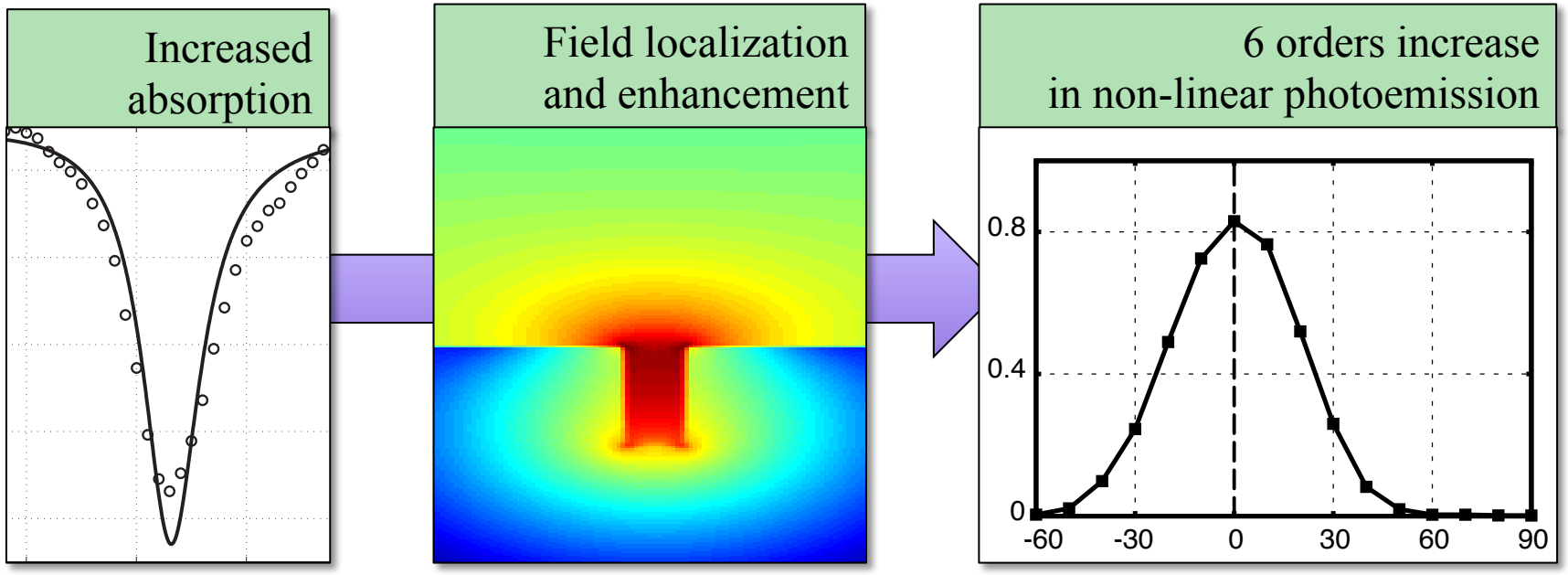
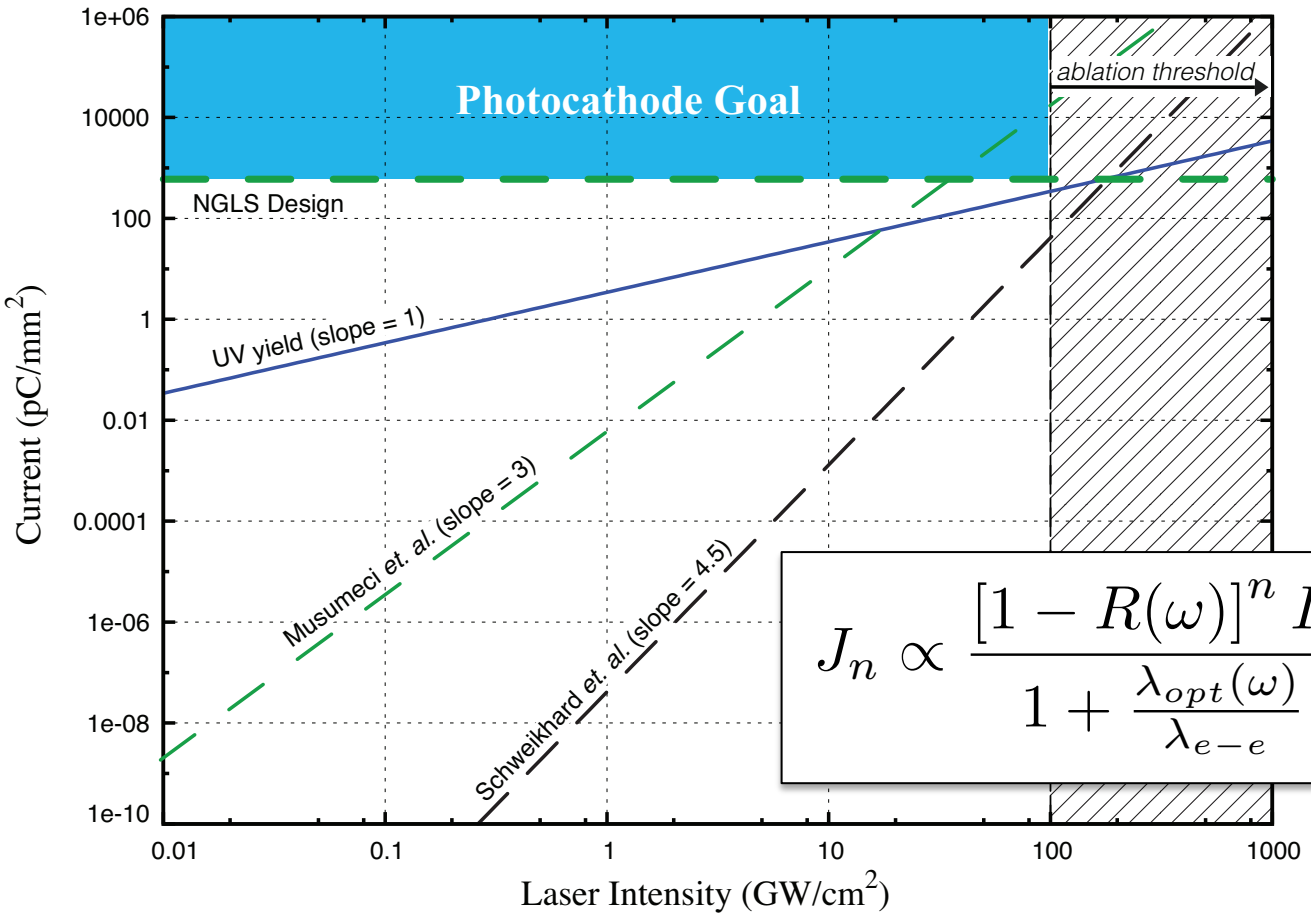
[2)] *Advanced Light Source, Lawrence Berkeley National Laboratory*
[3)] *Molecular Foundry, Lawrence Berkeley National Laboratory*
[4)] *Pacific Northwestern National Laboratory*

# Nanostructured Metal Surface



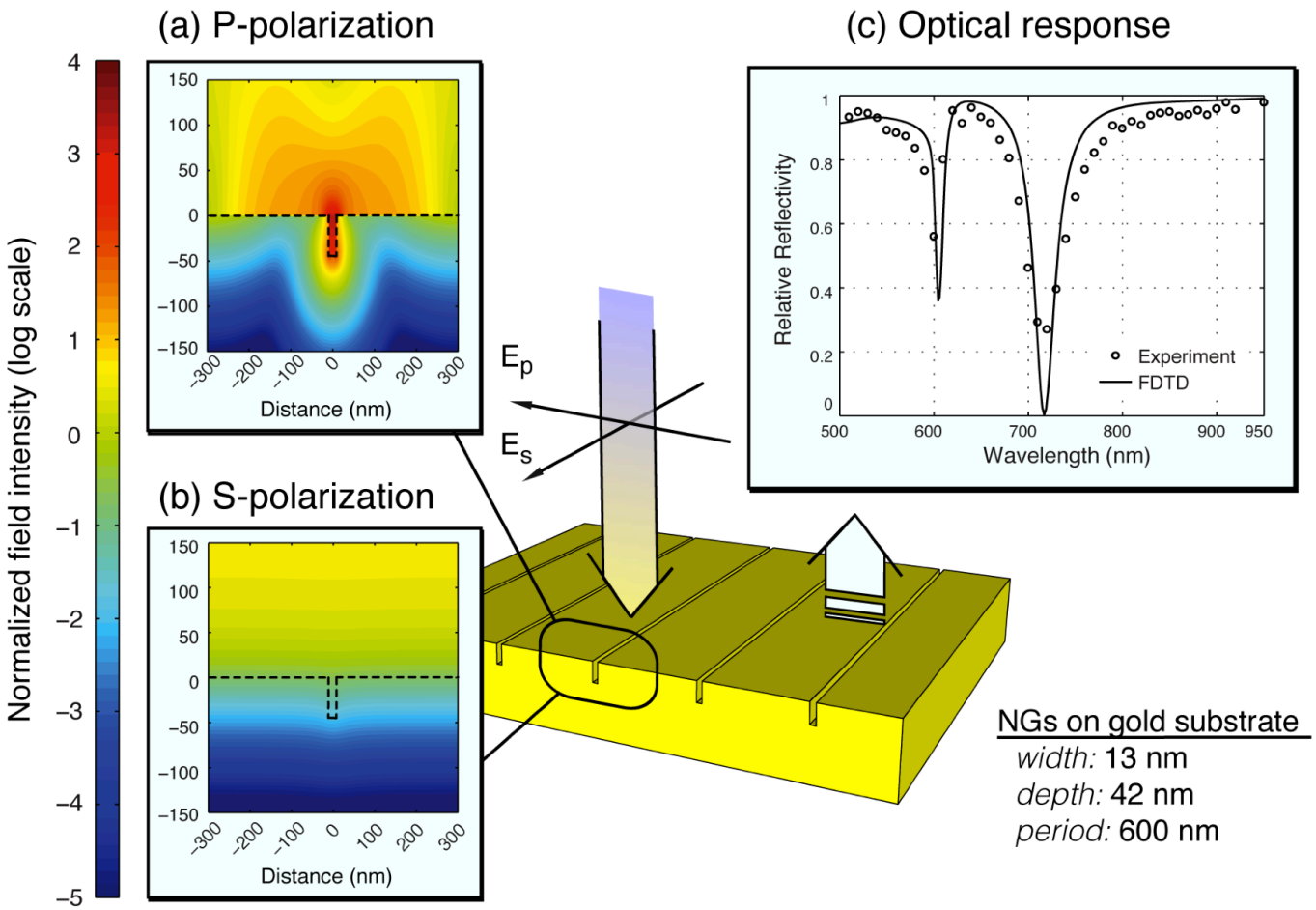
# Photoemission from metals




Reduce R(ω) and $\lambda_{opt}$

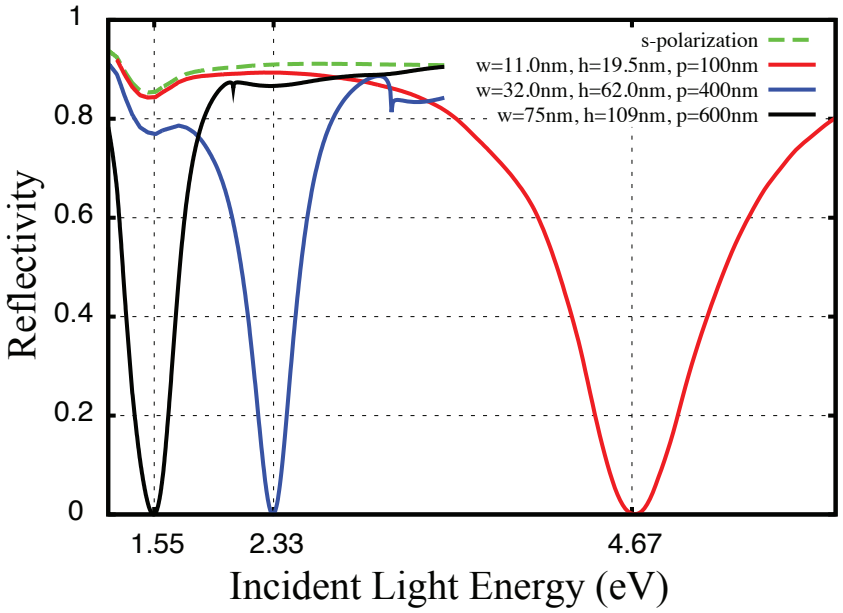
$$J_n \propto \frac{[1-R(\omega)]^n I^n}{1+\frac{\lambda_{opt}(\omega)}{\lambda_{e-e}}} F\left(\frac{nh\nu - e\Phi}{k_B T_e}\right)$$

# Nano-groove (NG) grating

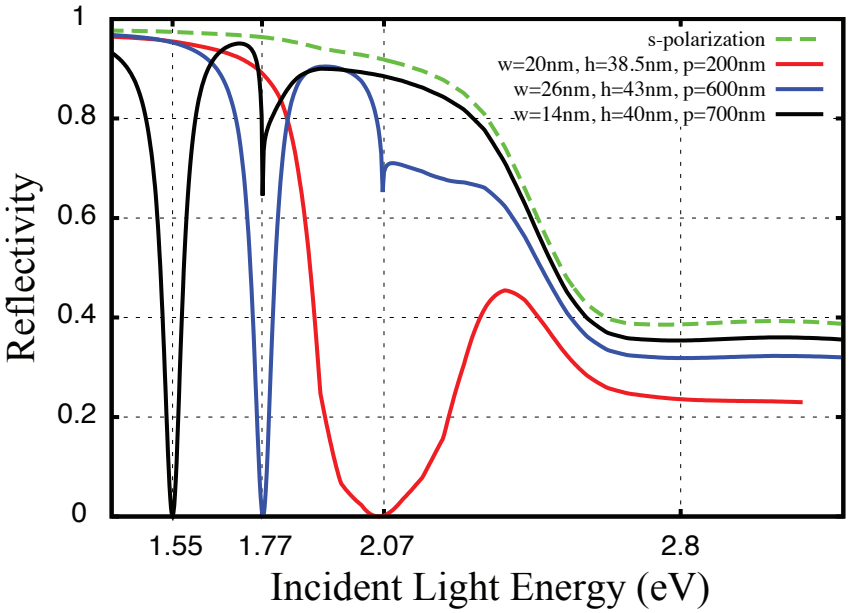


# Flexible Design

(a) Reflectivity Response in Aluminum



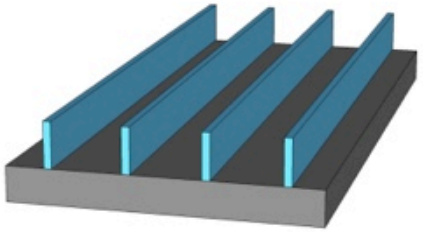

(b) Reflectivity Response in Gold



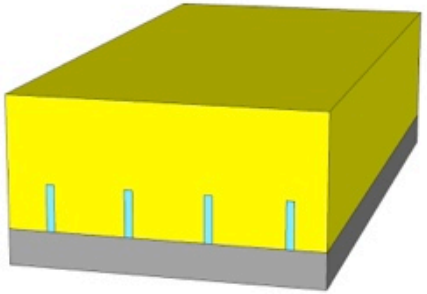

Resonance is achieved by optimizing the period ***p***, NG width ***w***, and NG depth ***h***.

# Template-based fabrication

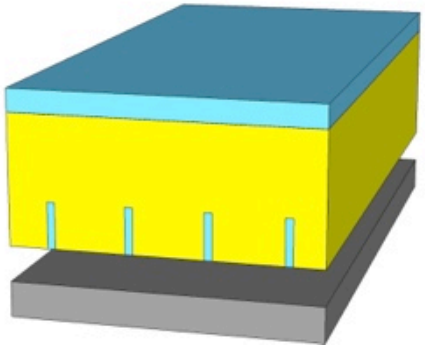
(a) E-beam template



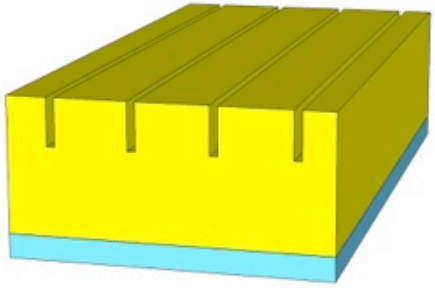
(b) Gold evap.



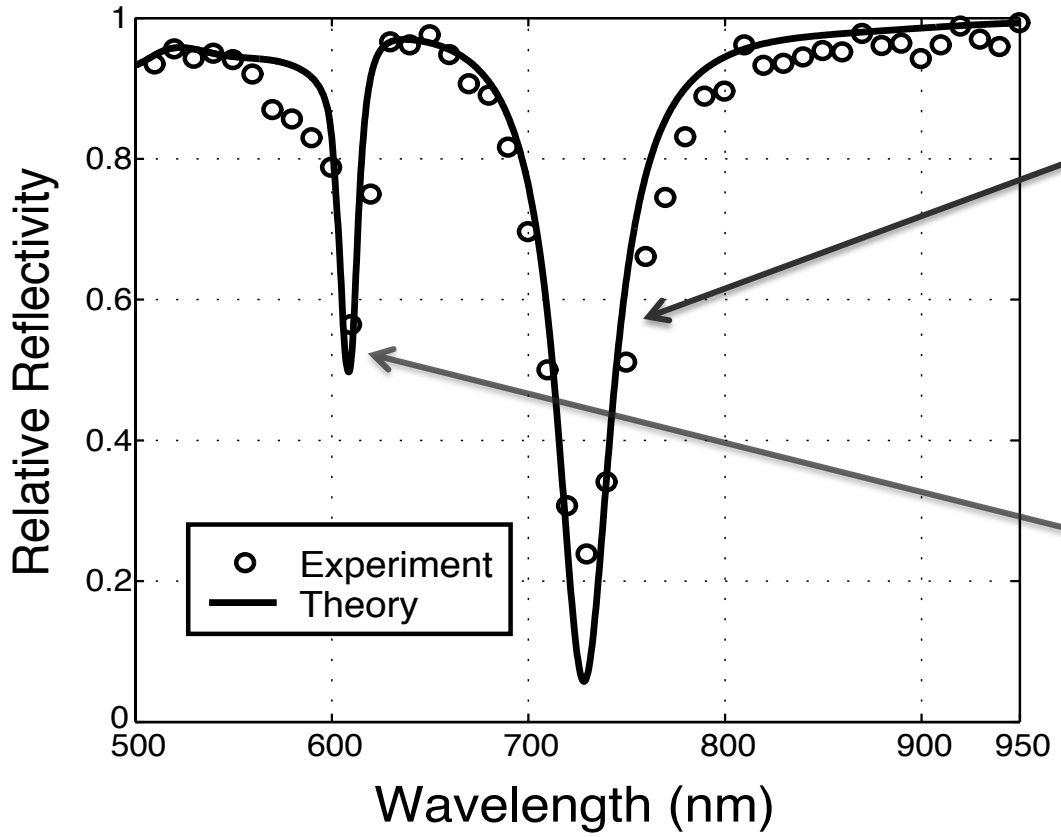
(c) Peel-off



(d) Final device



# Plasmonic trapping




**Groove Plasmon**

- SPPs inside grooves
- Localized light trapping
- Large angular and spectral bandwidth

**Grating Plasmon**

- SPPs @ top surface
- Angle dependent
- Narrow bandwidth

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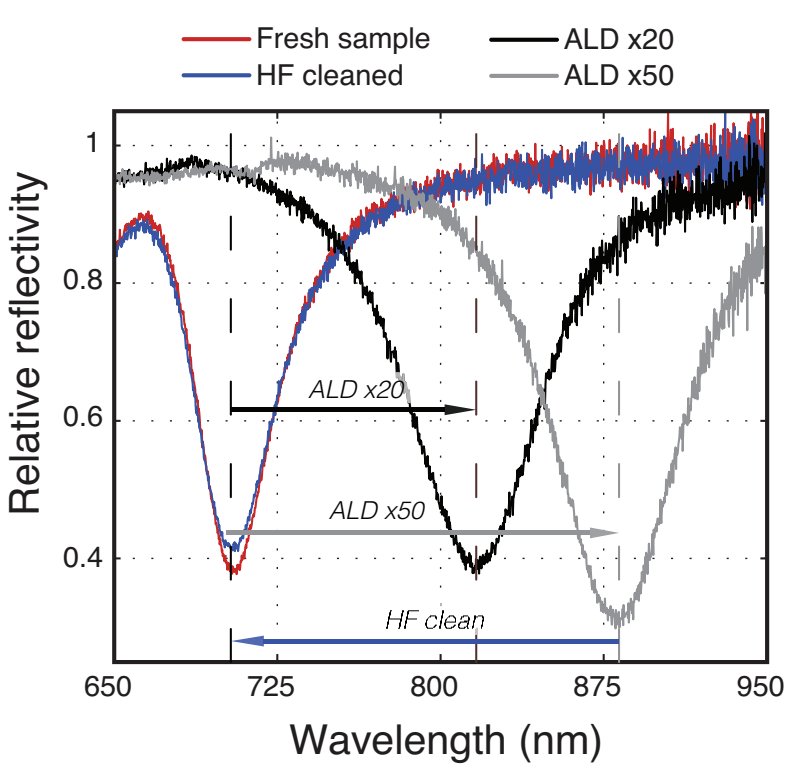
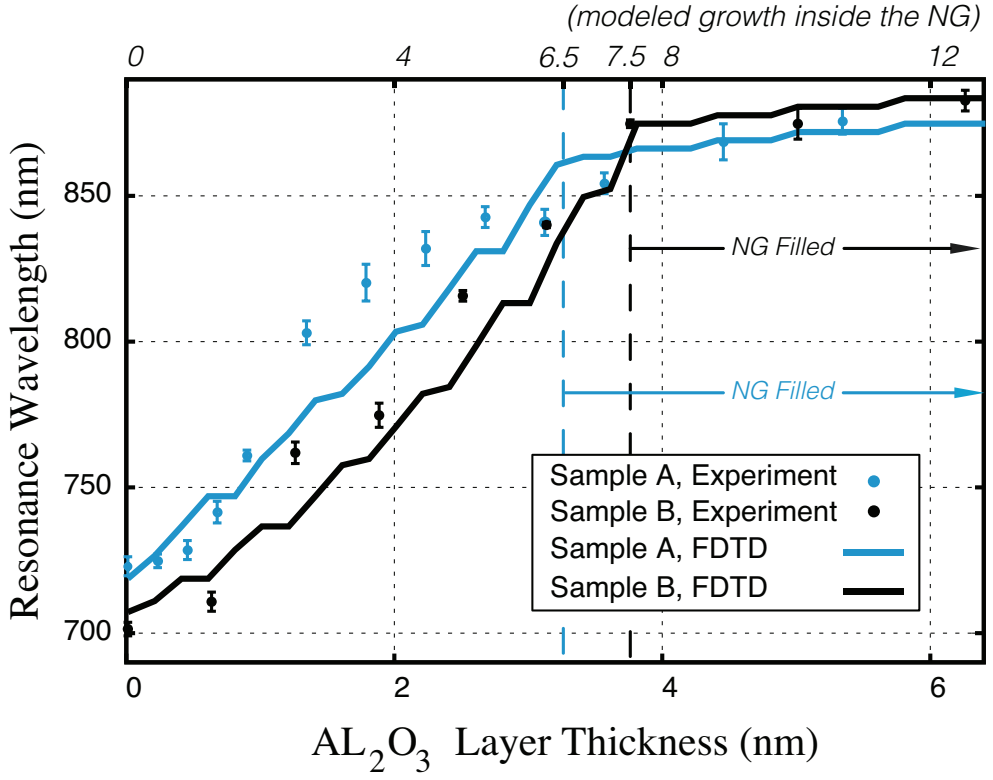
# Post-fabrication tuning

(a) Resonance shift

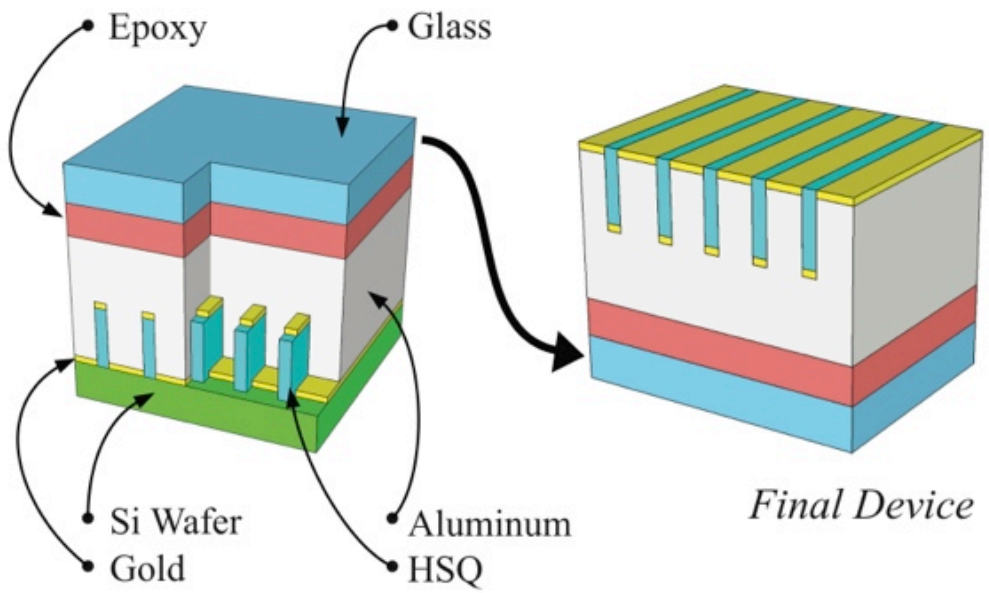



(b) Resonance tuning

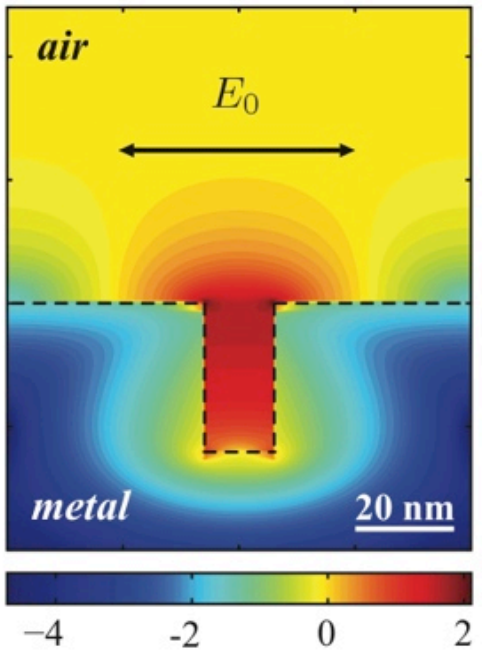


# Complex NG structure

(a) Fabrication Schematic

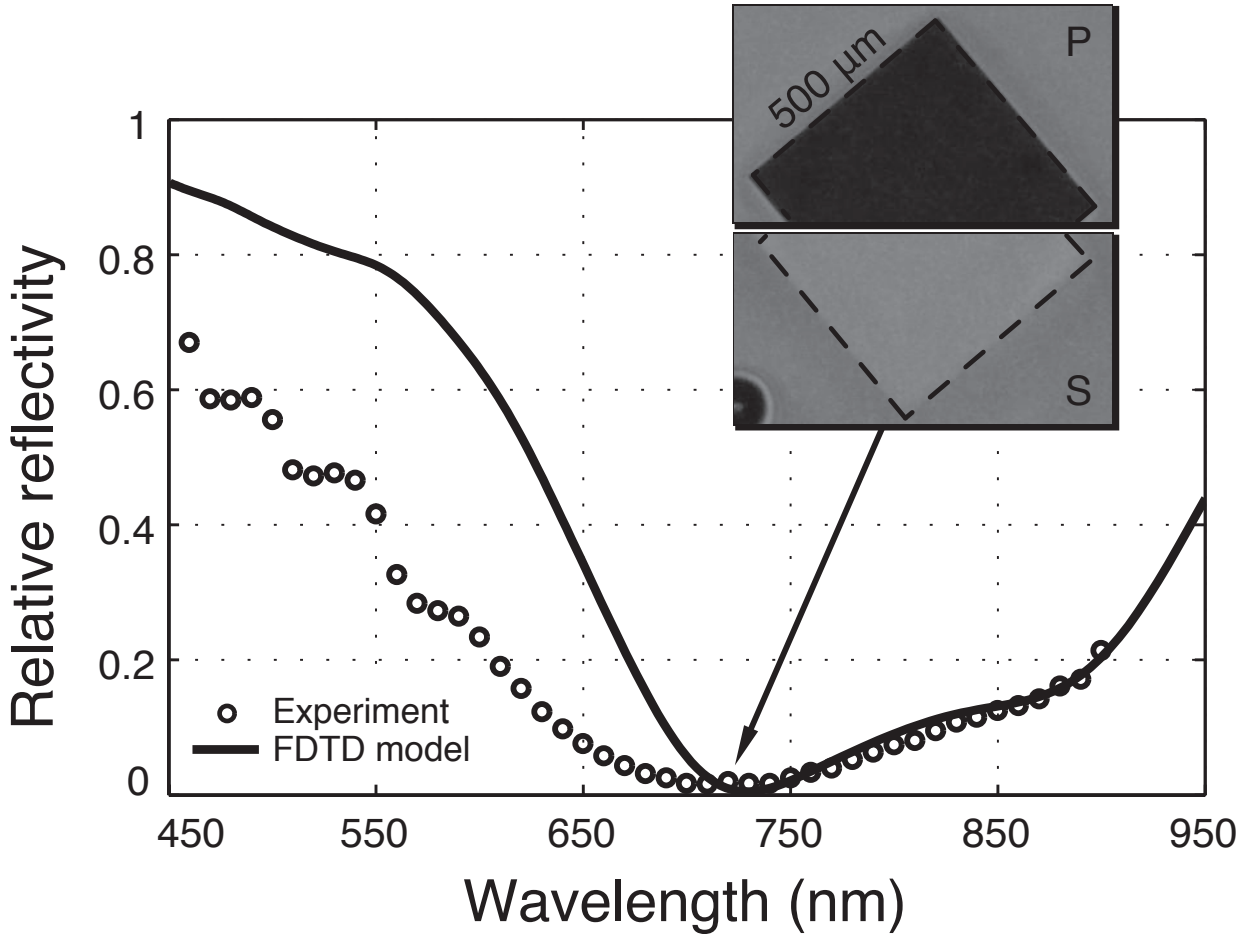



(b) $|E_x^2 + E_y^2|$

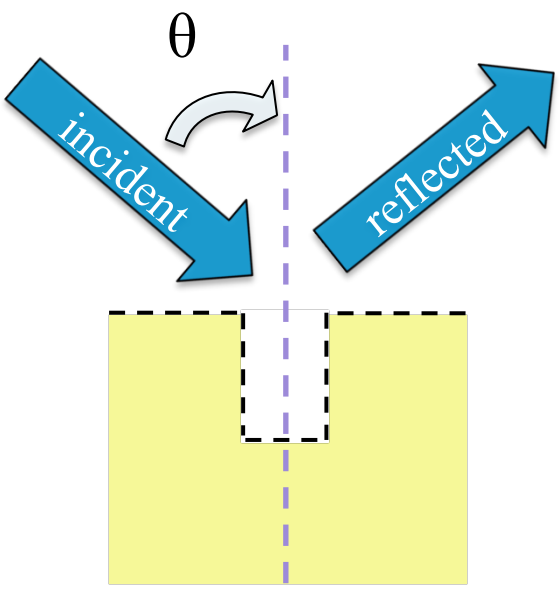


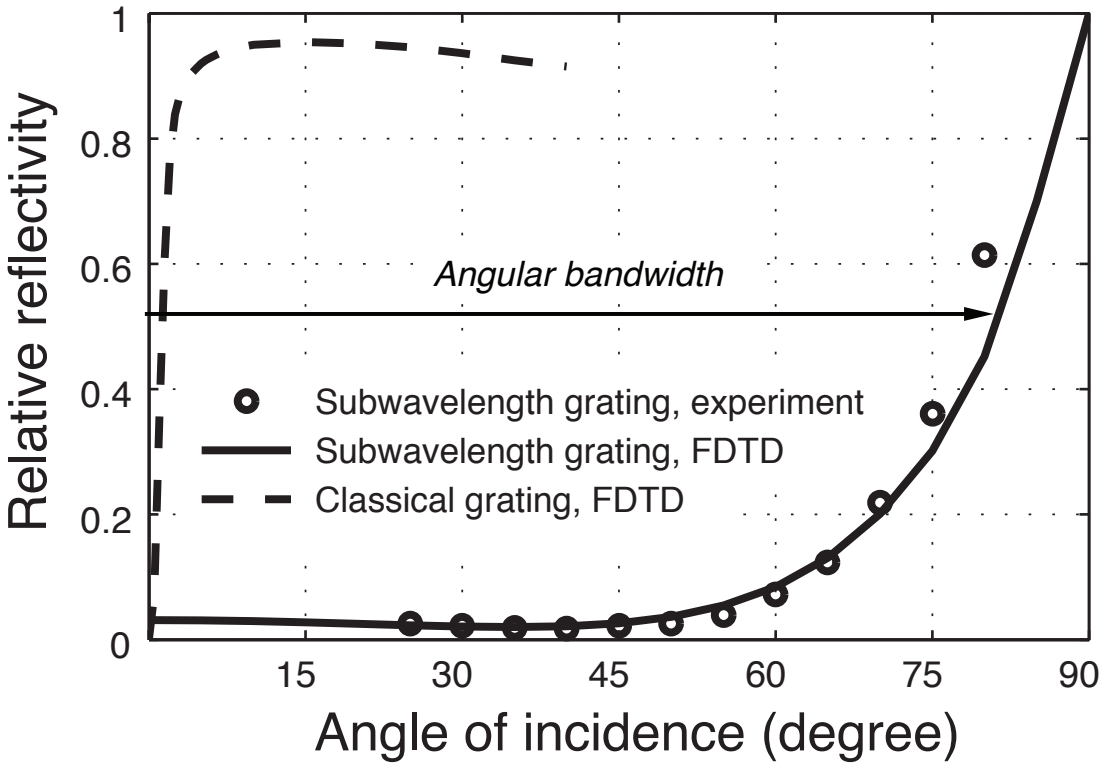

$\boldsymbol{p}$ = 100 nm, $\boldsymbol{w}$ = 14 nm, $\boldsymbol{h}$ = 60 nm

# Large spectral bandwidth

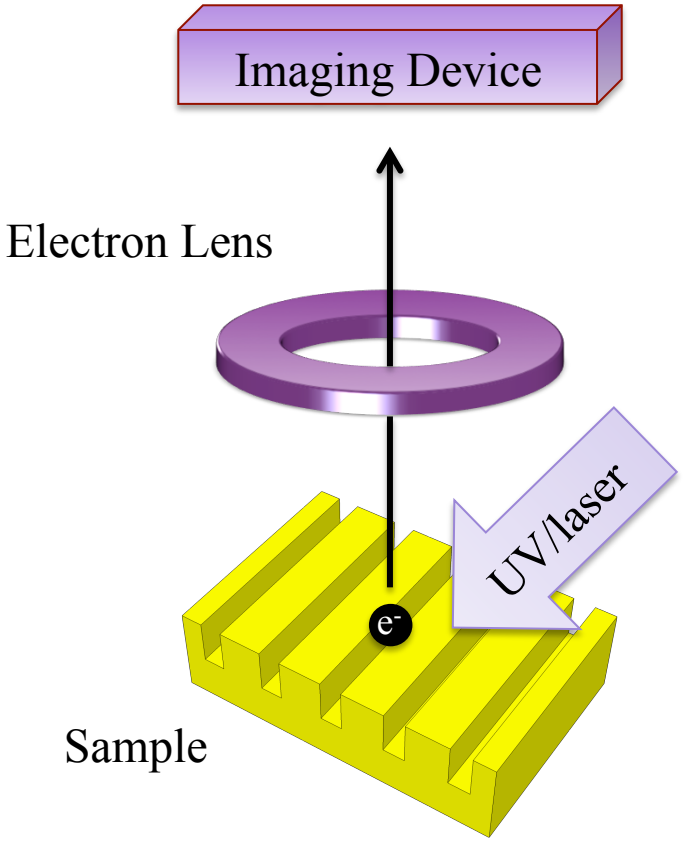


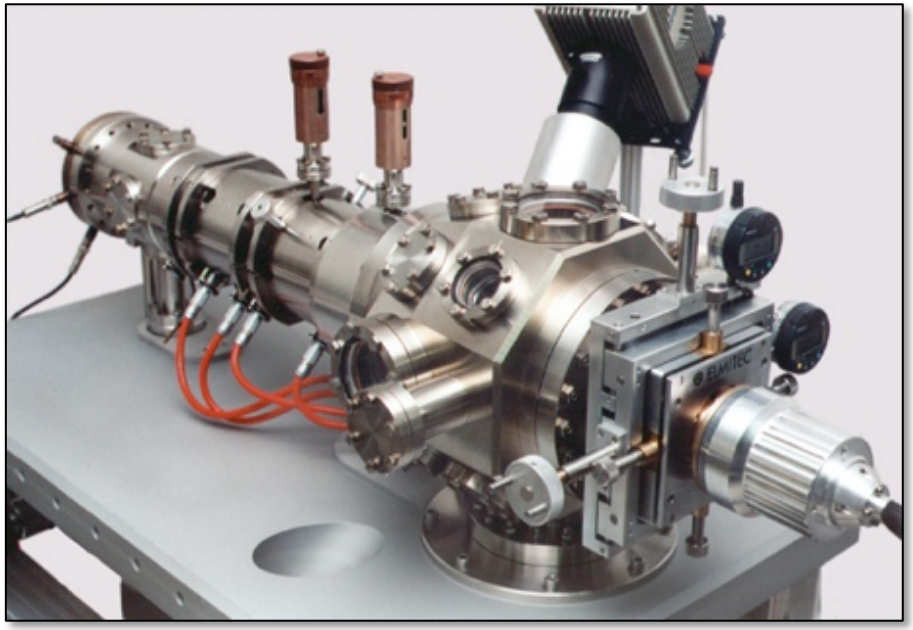
# Large angular bandwidth



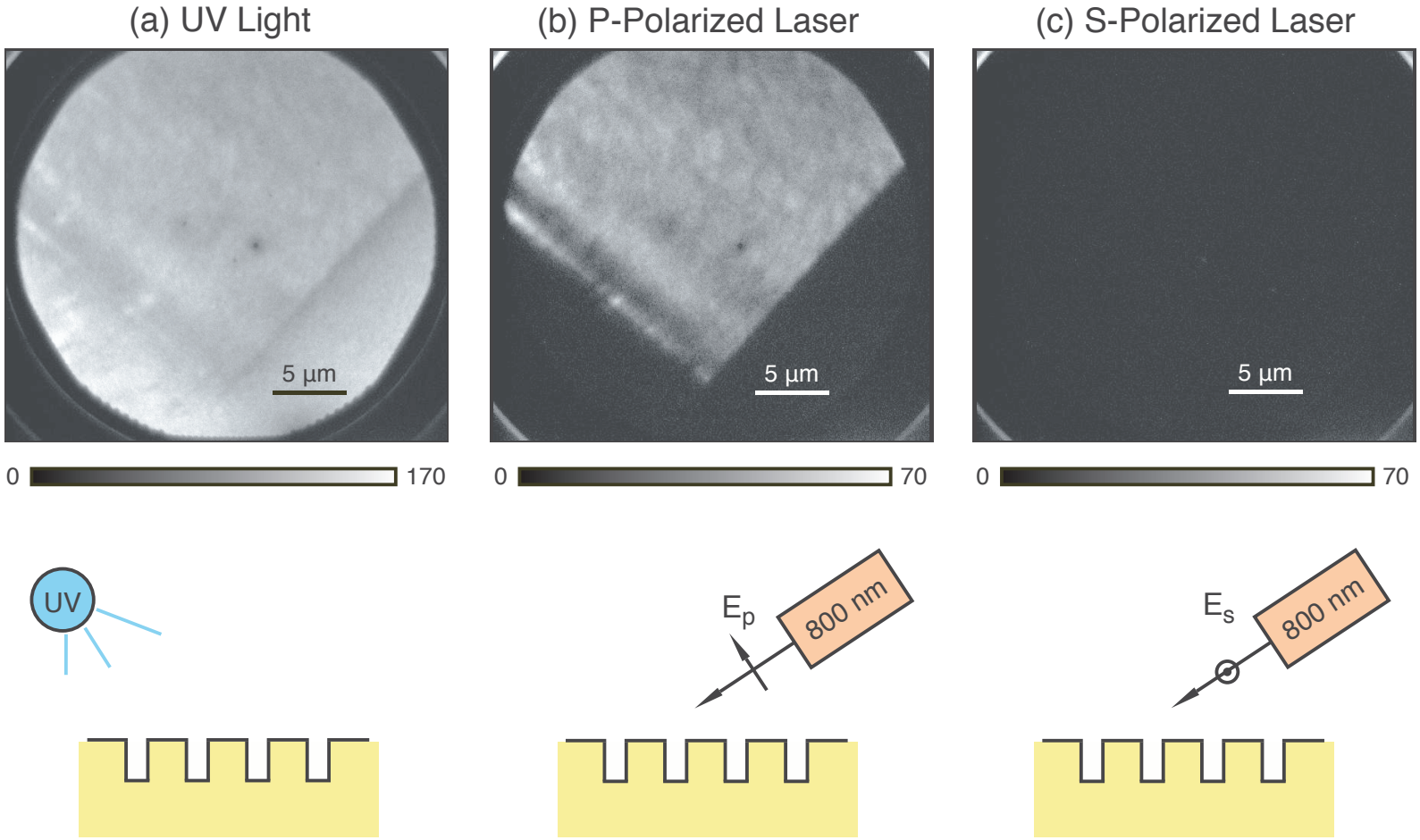
# Enhanced non-linear effects



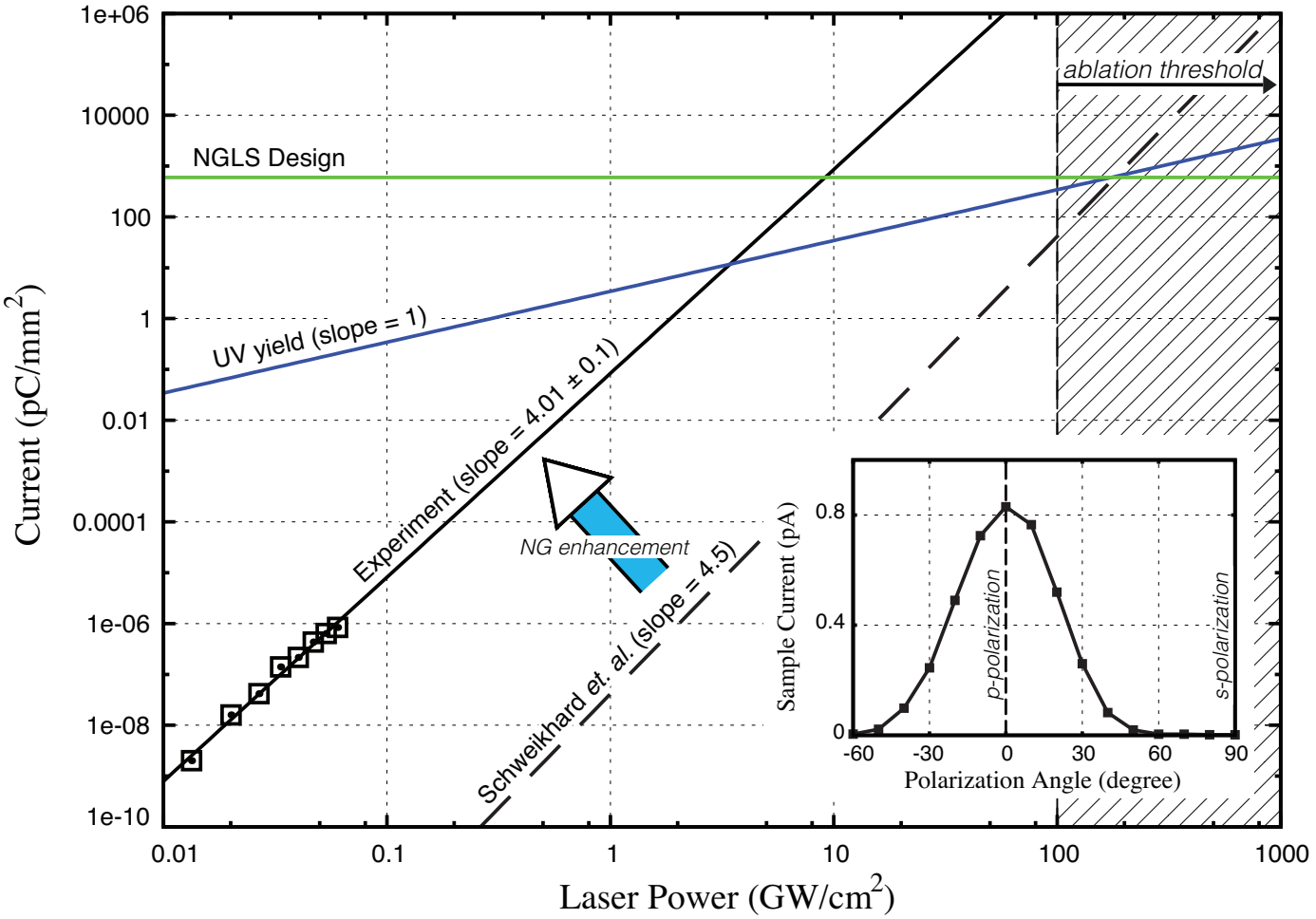



Elmitec PEEM III @ Pacific Northwest National Lab

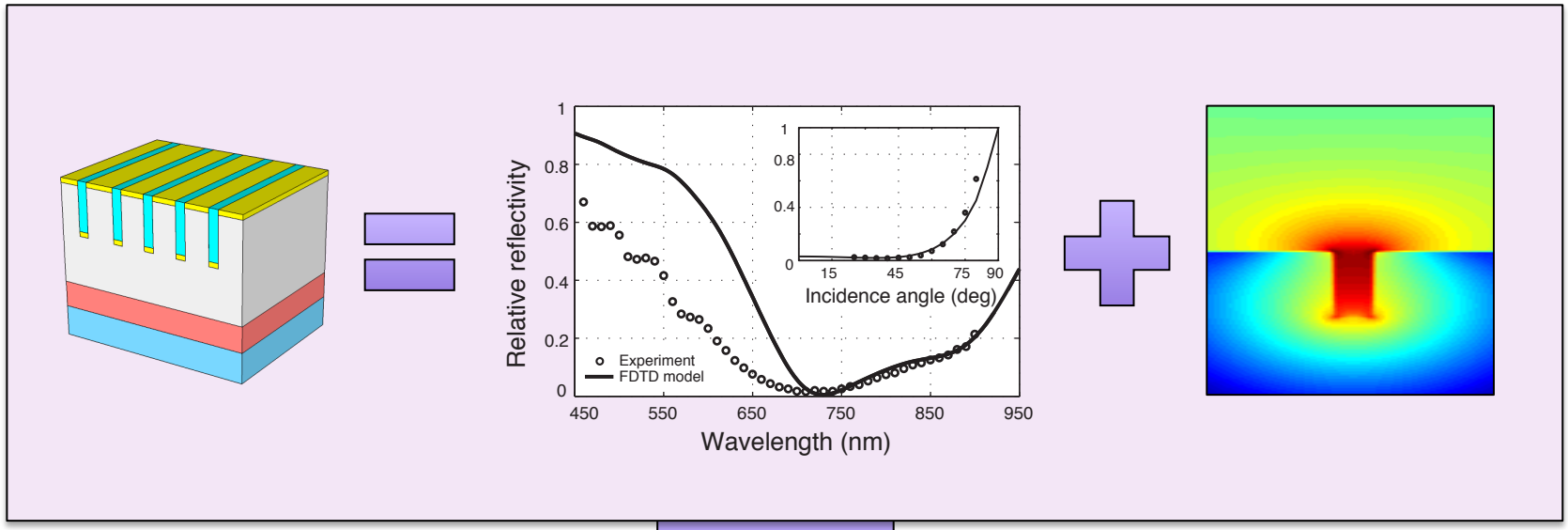
# PEEM IMAGES


(a) UV Light
(b) P-Polarized Laser
(c) S-Polarized Laser
5 µm
5 µm
5 µm
0
170
0
70
0
70
UV
$E_p$
800 nm
$E_s$
800 nm

# 6 orders photoemission increase



# A plasmonic grating




6 orders increase in non-linear photoemission

# Thank you for your attention!



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