# Is it possible to make a perfect optical cavity?

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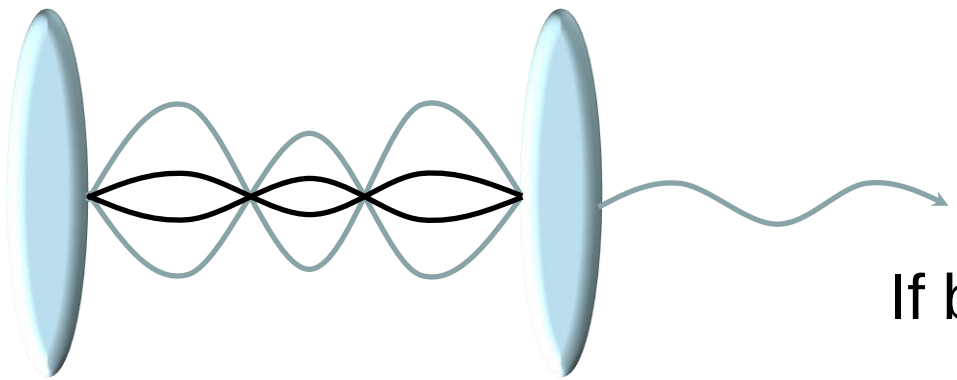
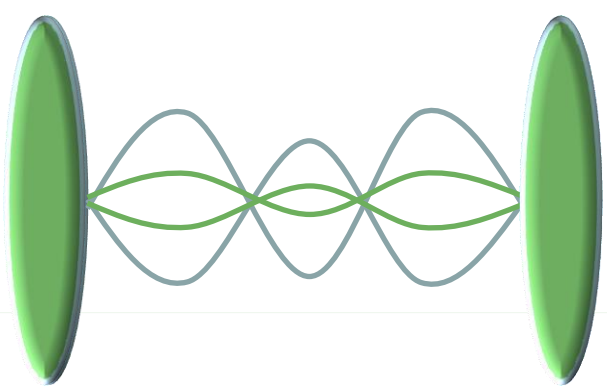
# How good can be a cavity?

- Radiation losses
- Material losses





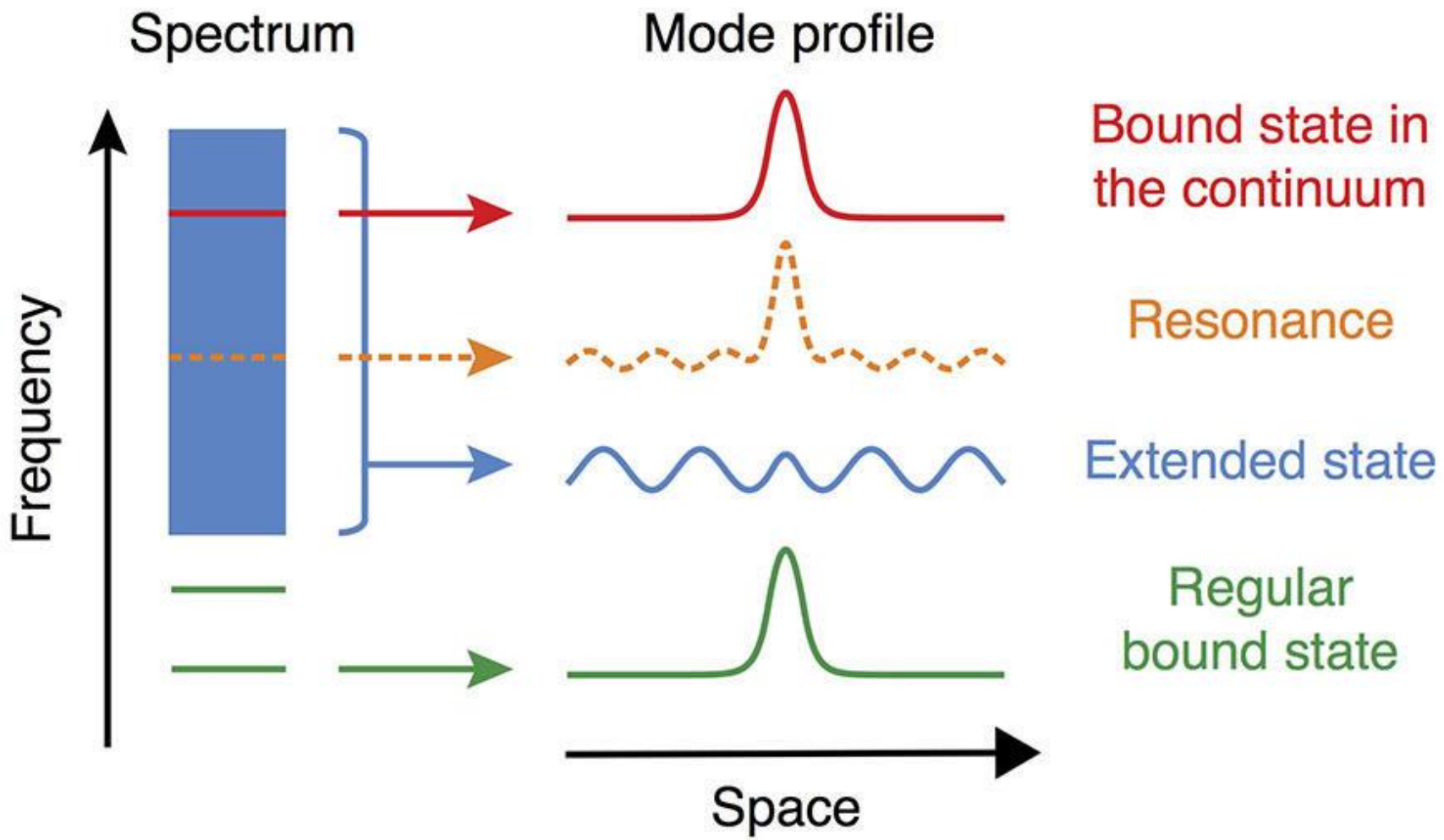
If both losses are suppressed

Lifetime: $\tau_{cav} = \infty$

Linewidth: $\Delta\omega = 0$

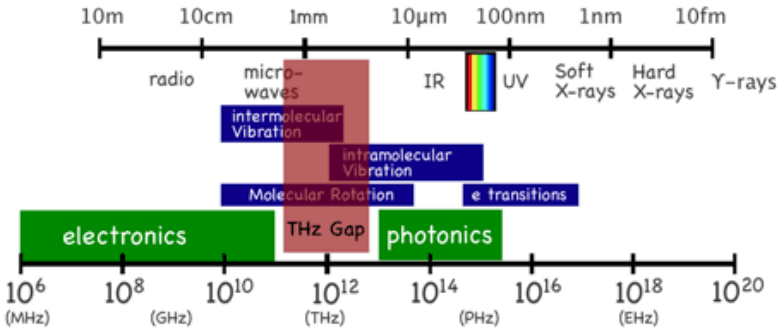
Q-factor: $Q = \frac{\omega}{\Delta\omega} = \infty$

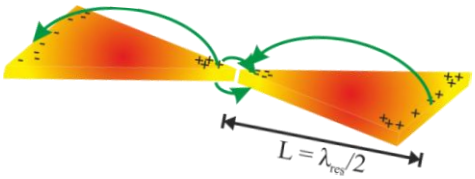
# Bound states in the continuum (BICs)




Hsu, Zhen, Stone, Joannopoulos and Soljacic, Nature Reviews (2016)

# THz spectroscopy




$\nu$ = 100 GHz … 10 THz

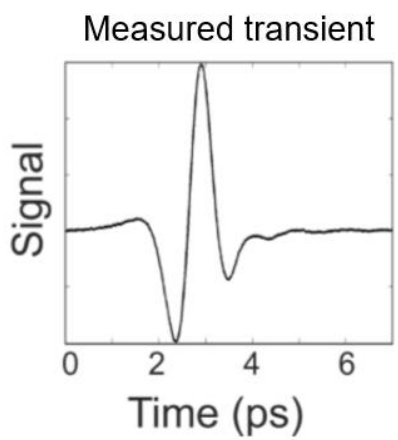
$\lambda$ = 3 mm … 30 μm

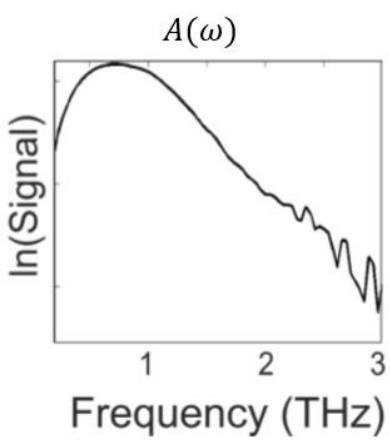
THz spectroscopy limited to large (thick) samples

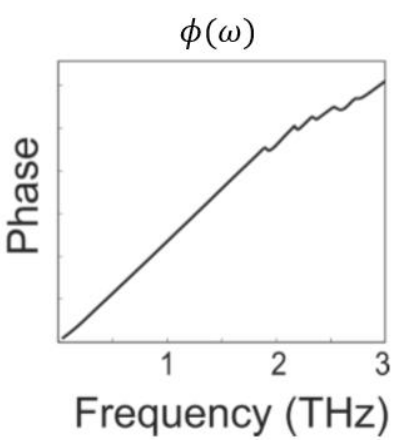
Resonant systems at THz frequencies

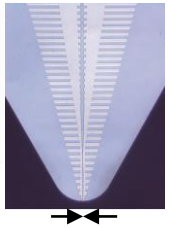
$\Downarrow$

THz trapping and large local field enhancements



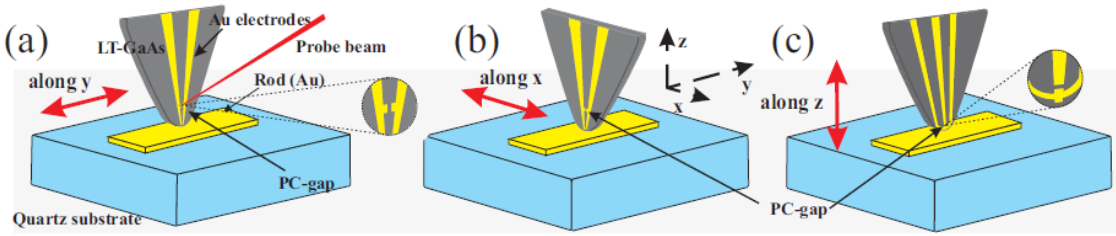



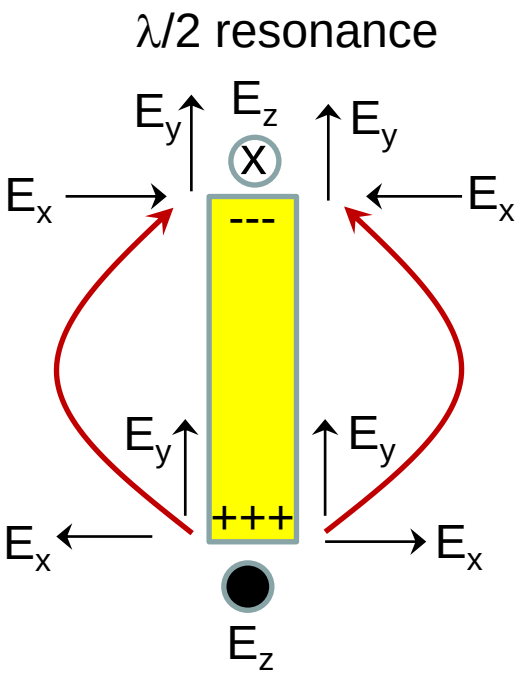



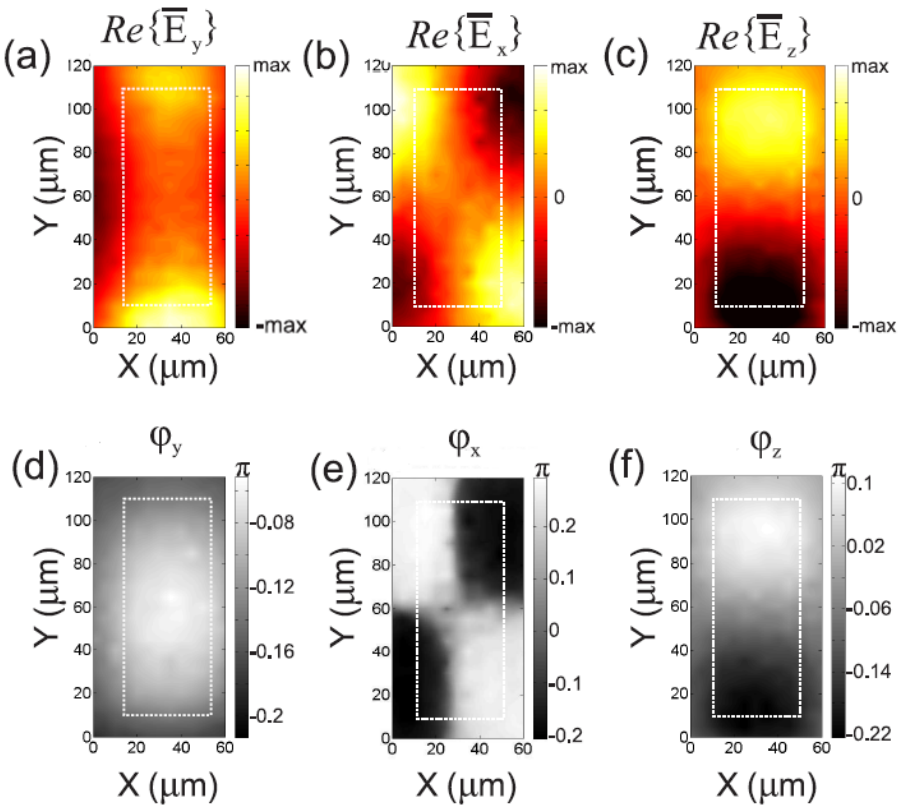


5 μm

# Full vectorial mapping of resonant THz near-fields

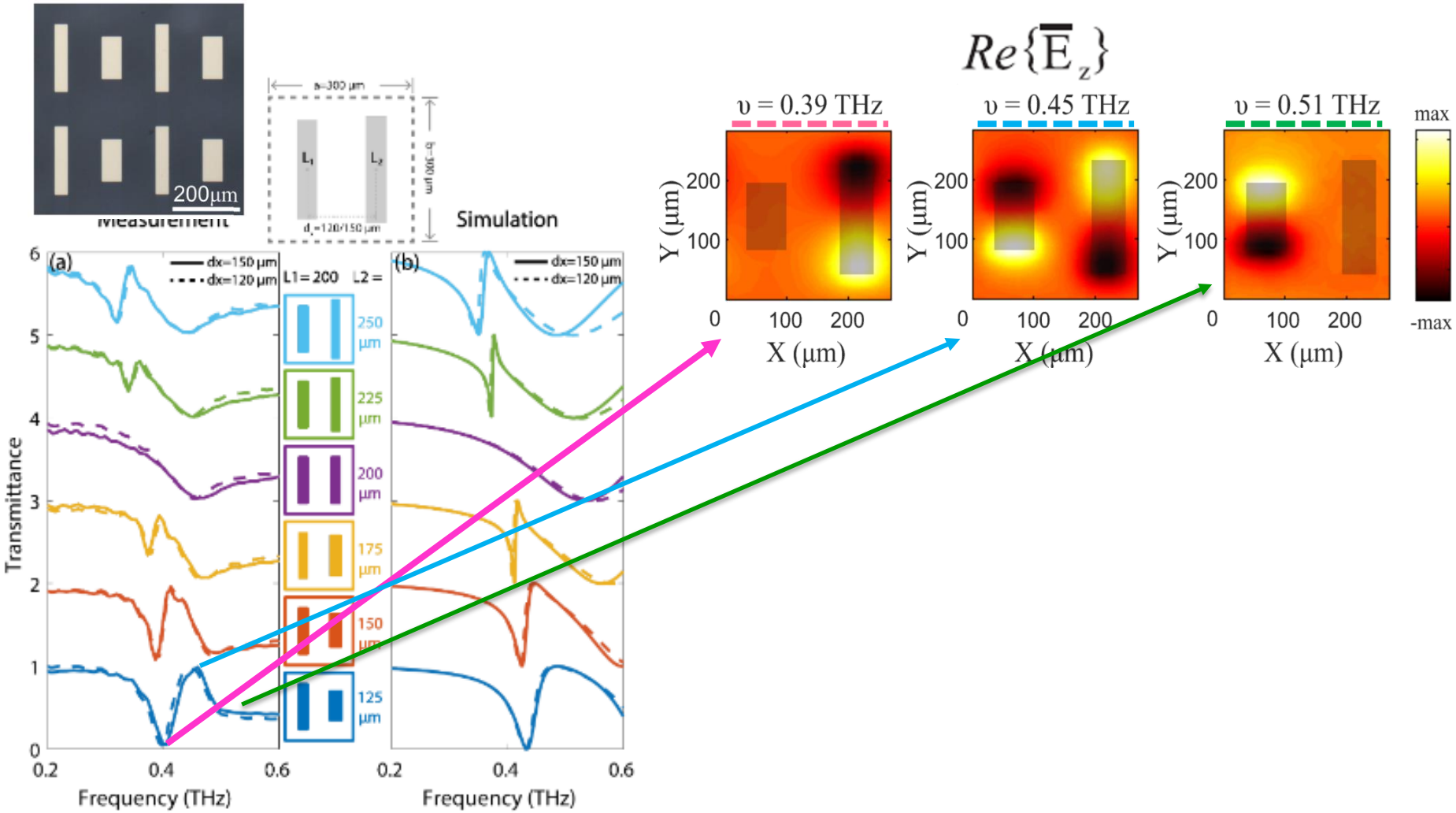



Batthacharya … JGR, APL Photonics (2016); Phys. Rev. B 93, 035438 (2016)

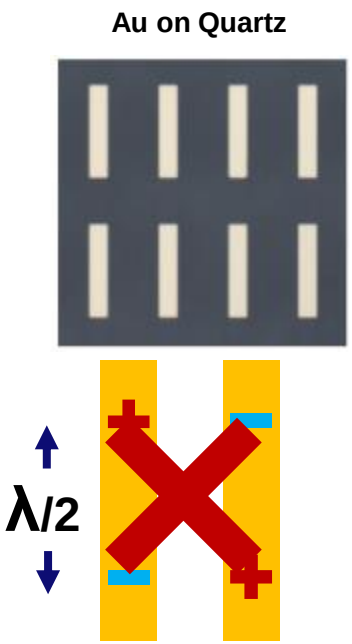
# From Electromagnetic Induced Transparency to BICs

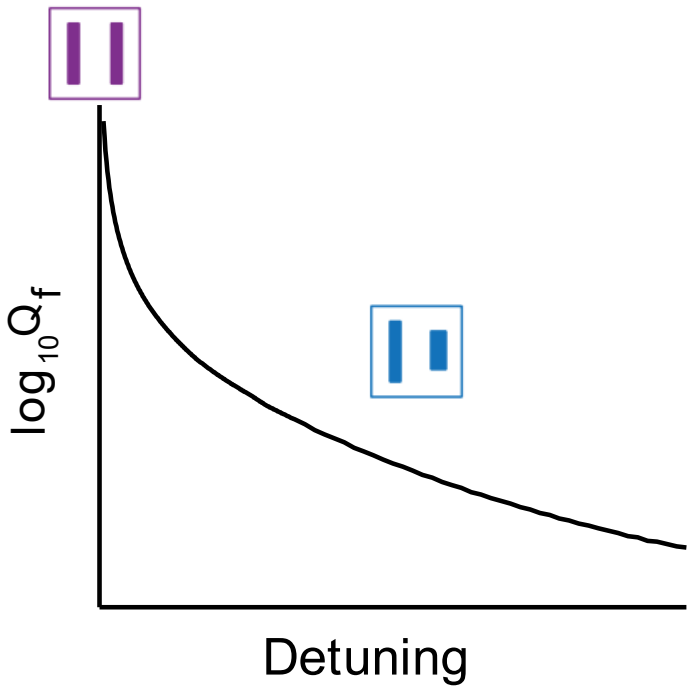


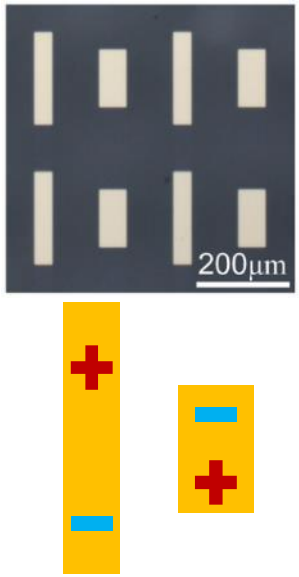


M.C. Schaafsma… JGR, ACS Photonics 3, 1596 (2016)
N. van Hoof … JRG, APL Photon. 4, 036104 (2019)
D. Abujetas, Sanchez-Gil ... JGR, Optica 6, 996 (2019)

# From Electromagnetic Induced Transparency to BICs

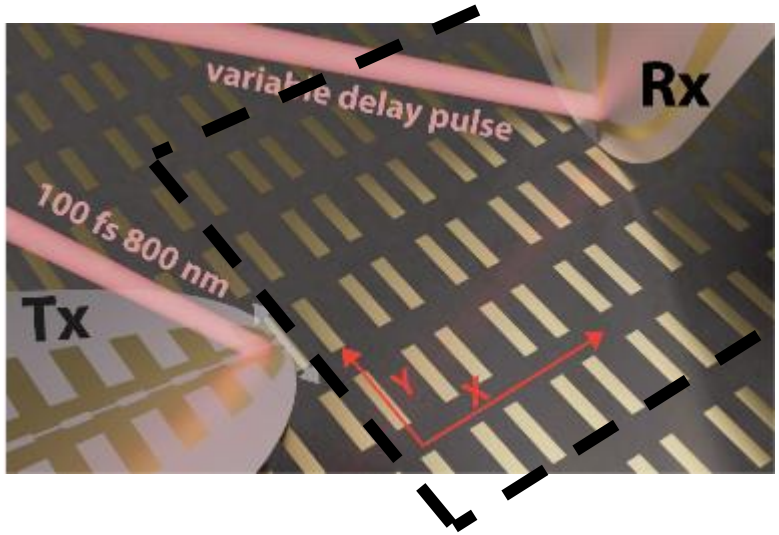


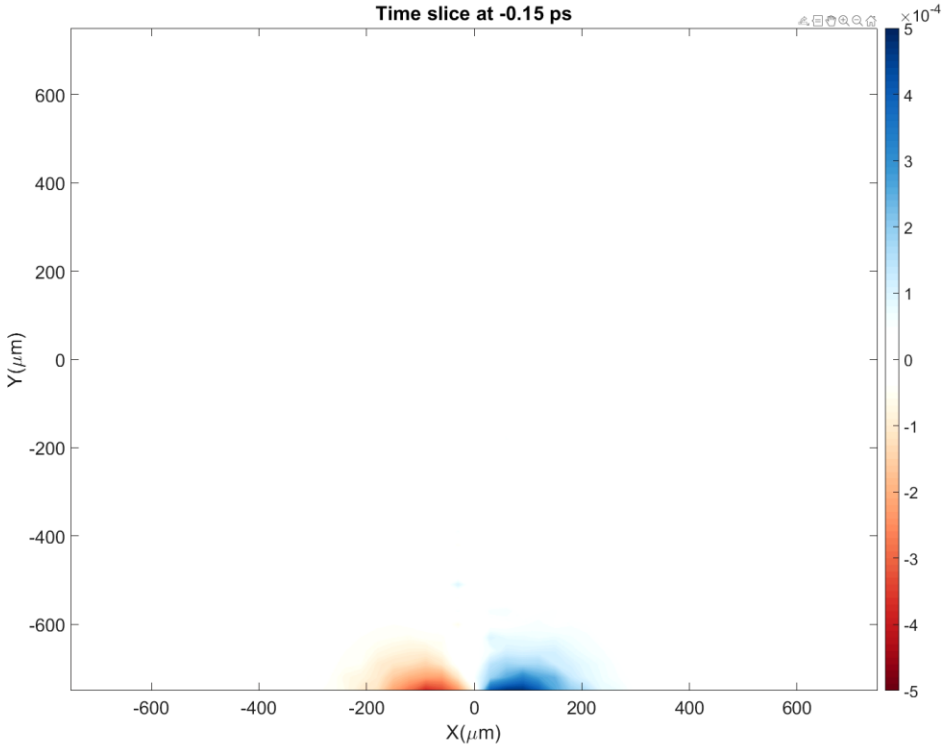




**BIC cannot be probed from the far-field**

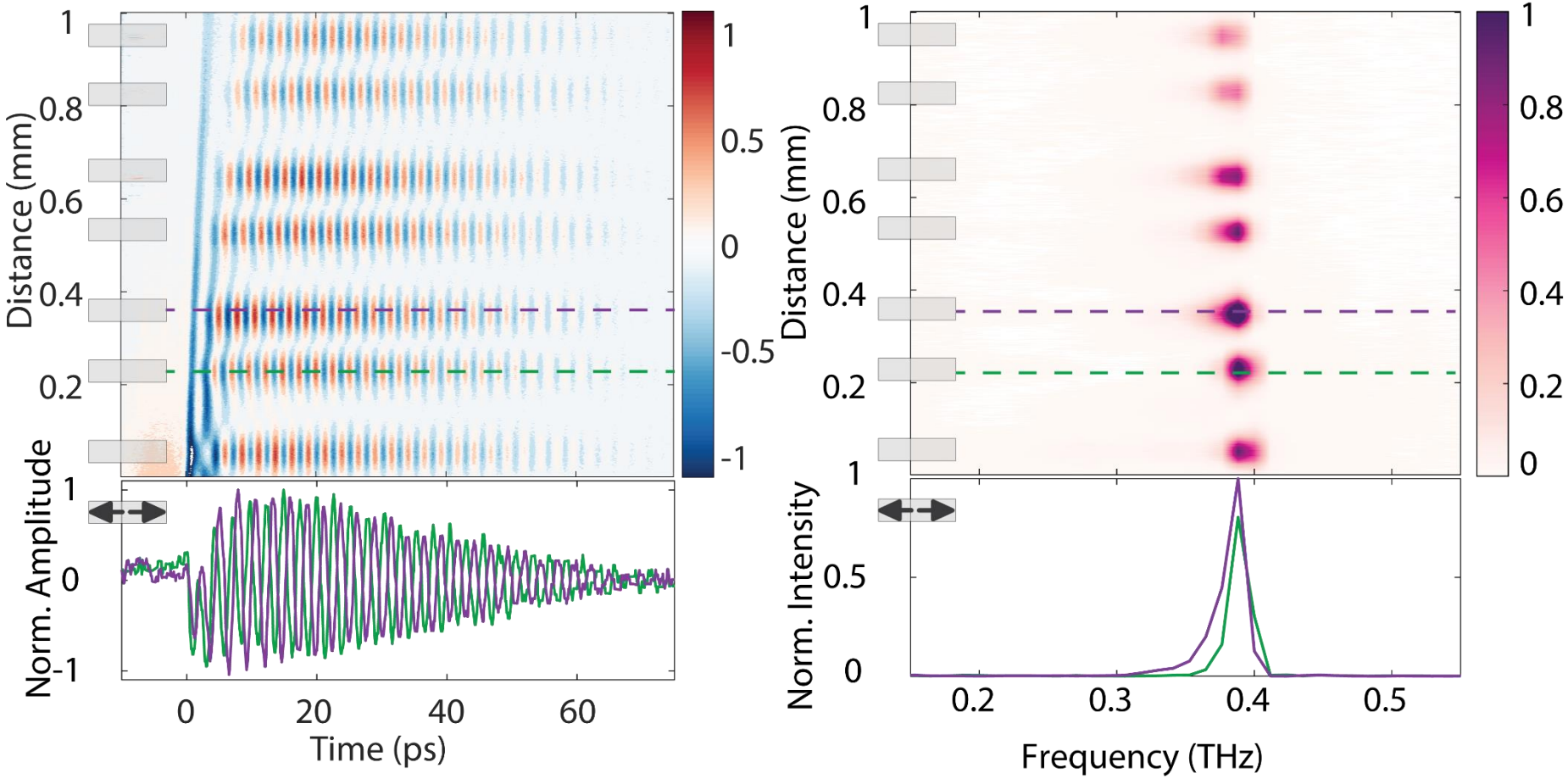
# BIC proved in the near field




ACS photonics 8 (10), 3010-3016 (2021)

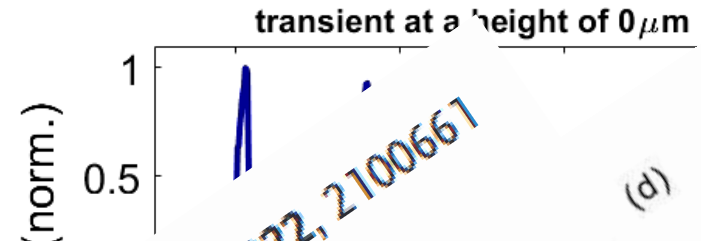
# BIC – line measurements

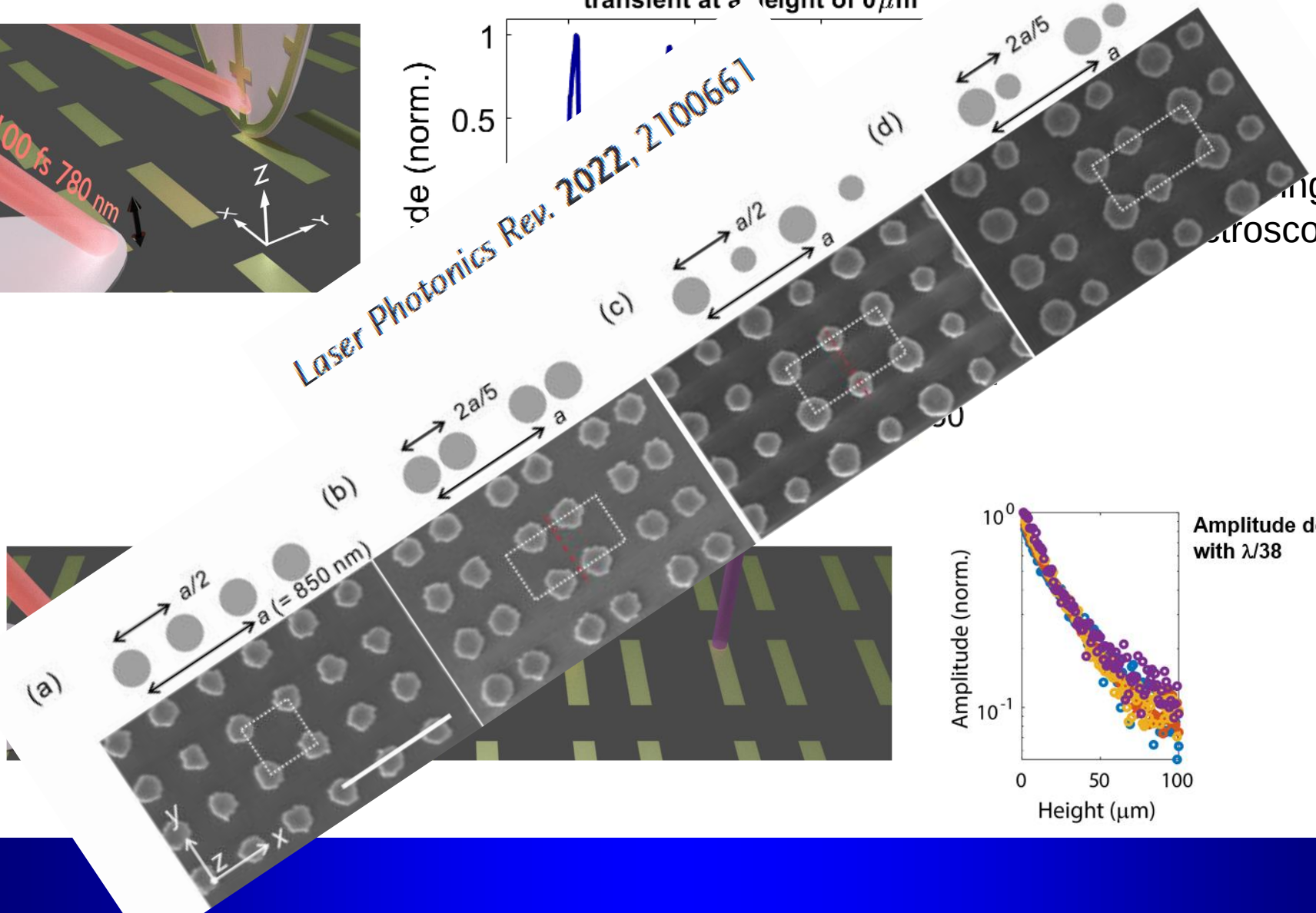



ACS photonics 8 (10), 3010-3016 (2021)

# BIC – height confinement





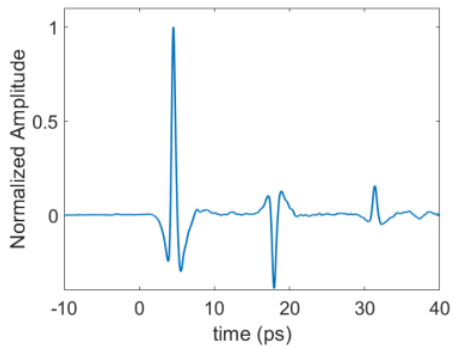


**Amplitude decays with λ/38**

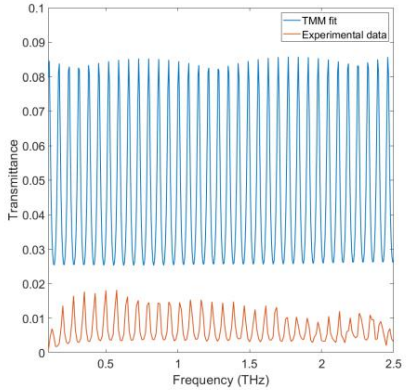
# THz semiconductor doping profiling

| | Layer | Thickness | Doping concentration(/cm$^3$) | |
|---|---|---|---|---|
| | P-GaN:Mg | 100nm | Mg:1.2*10$^{19}$ | |
| | P-AlGaN | 50nm | Mg:1.4*10$^{20}$ | |
| | | | Al:1.5*10$^{20}$ | |
| Barrier | GaN | 5 nm | No-doping | MQW-Loop 10 |
| Well | InGaN | 3.5nm | | |
| | U-GaN | 350nm | Si:1.5×10$^{17}$ | |
| | N2-GaN | 2.0um | Si:1.0×10$^{19}$ | |
| | N-AlGaN | 100nm | Si:1.0×10$^{18}$ | |
| | N1-GaN | 0.5um | Si:5.0×10$^{18}$ | |
| | U-GaN | 2.5um | No-doping | |
| | 4" 650+/-25um Sapphire Substrate | | | |

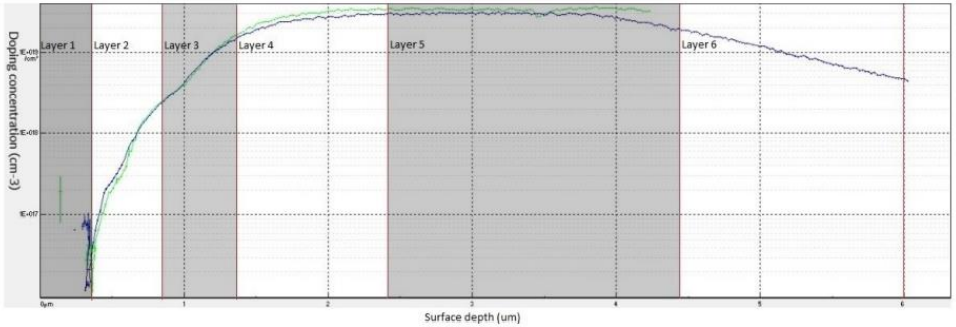
THz transient transmission



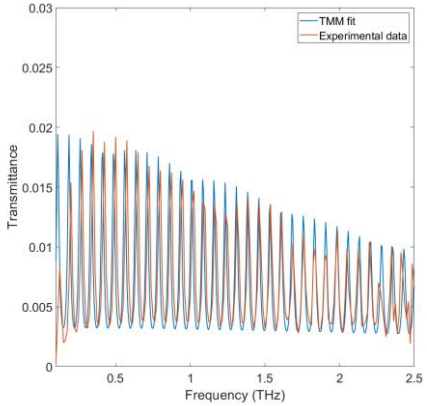

Measured THz transmittance spectrum (red) vs. expected transmittance with manufacturer specifications of doping (blue)




Destructive (standard) doping profiling measurements to retrieve correct values of the doping profile




Measured THz transmittance spectrum (red) vs. calculated transmittance with measured doping profiling measurements (blue)

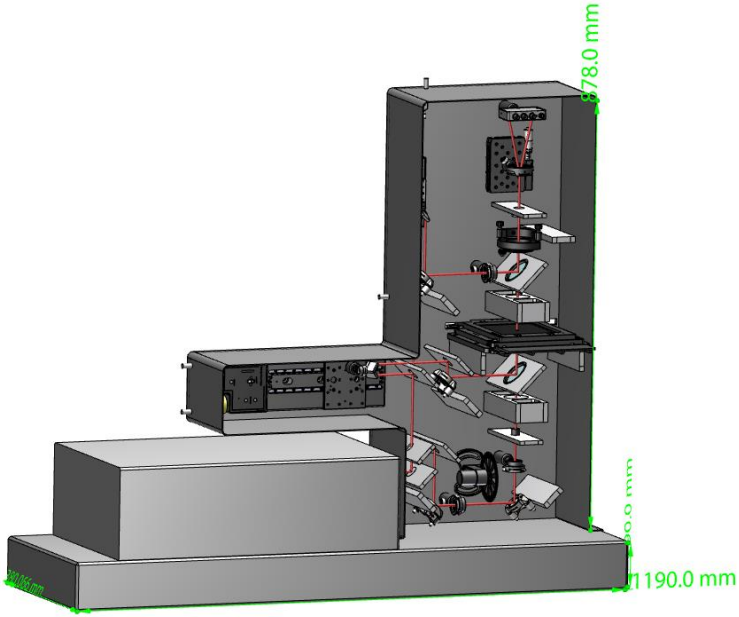



Mohammad Ramezani, Maira Perez Sousa, Mats Brinkman

TeraNova

# Contact free and non-destructive semiconductor doping profiling

TeraNova



# Thank you !

www.surfacephotonics.org

www.teranova.nl

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