



Chip-size-accelerator-enabled single-electron FEL



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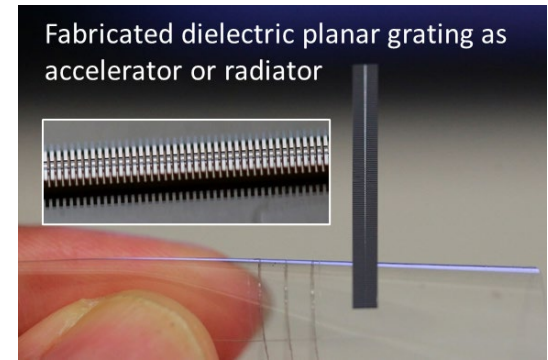
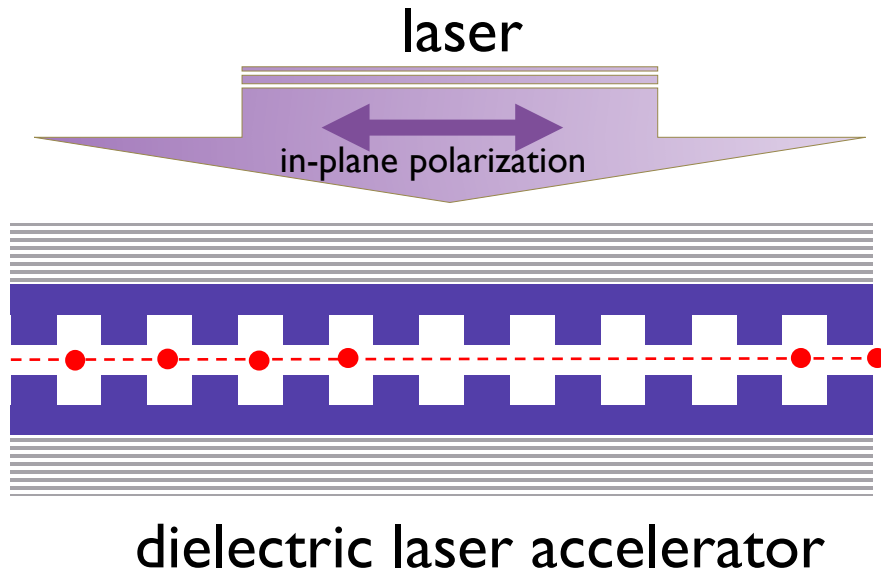
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Outline

1. Dielectric Laser Accelerator
2. Dielectric FEL Chip
3. FEL chip excited by a single electron
4. FEL chip excited by a train of single electrons
5. Conclusions

Dielectric Laser Accelerator



periodic single electrons in a nano-channel (in the near term)



FEL Chip

Yen-Chieh Huang, Luo-Hao Peng, Hossein Shirvani, Wen-Chi Chen, Karthickraj Muthuramalingam, Wei-Chih Wang, and Andrzej Szczepkowicz, "Single-electron Nano-chip Free-electron Laser," *APL Photonics* 7, 096101 (2022). (editor featured article and cover story of the journal).

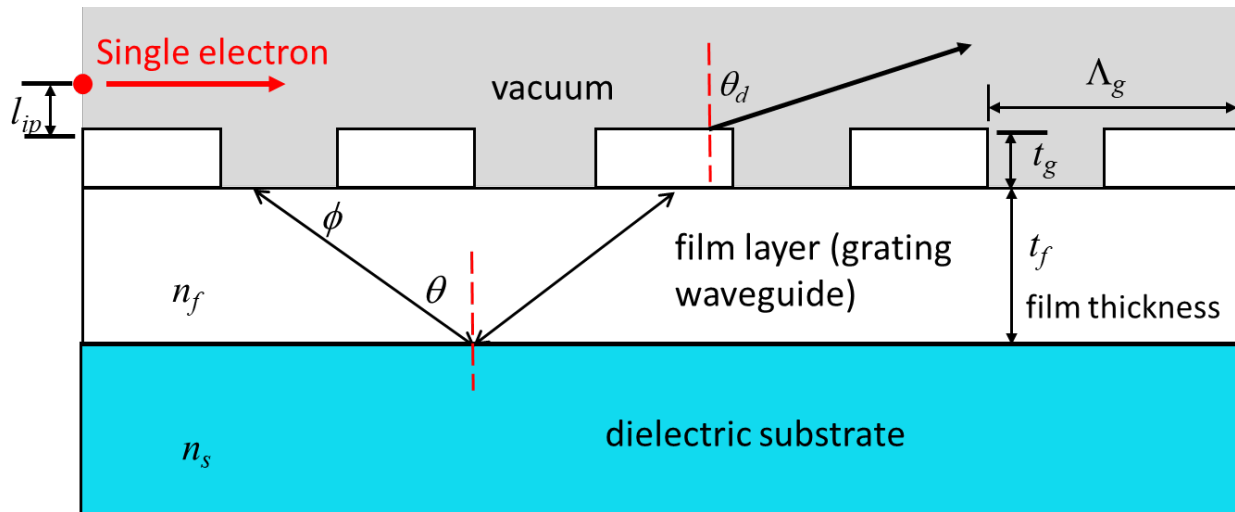
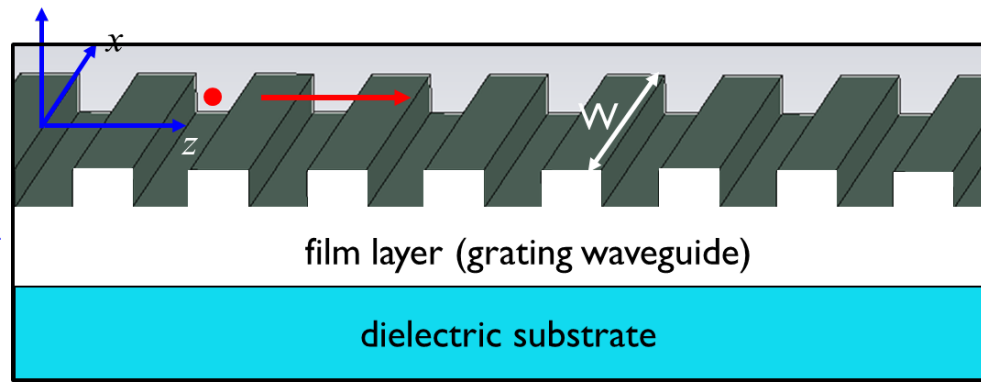
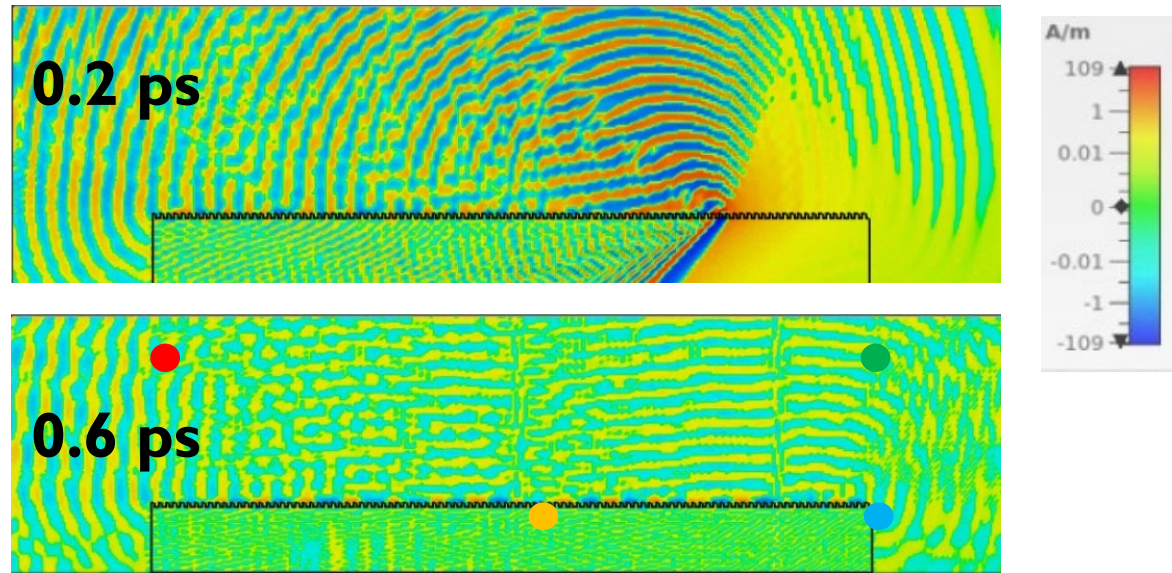
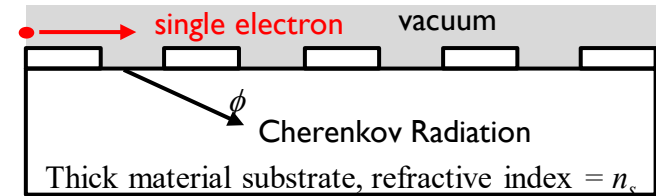


TABLE I. The first-order design parameters for a 1.5- μm nano-chip FEL with a silicon ($n_f = 3.4$) grating waveguide on a glass substrate ($n_s = 1.5$).

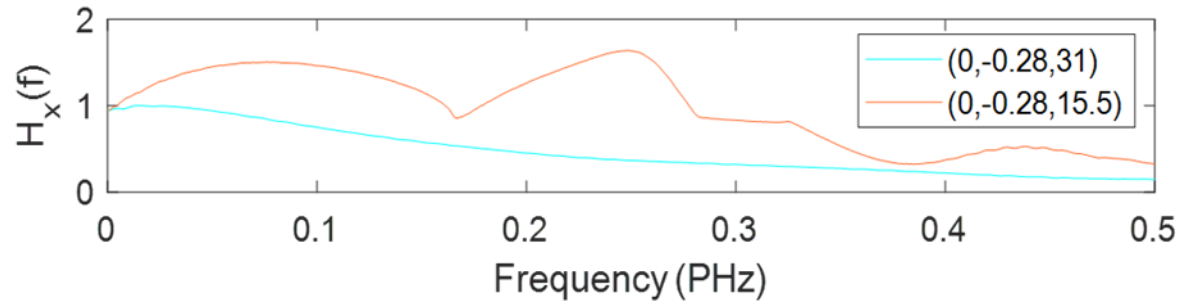
Design wavelength (μm)	Electron energy (keV)	Grating period Λ_g (nm)	Grating depth t_g (nm)	Film thickness t_f (nm)	Impact parameter l_{ip} (nm)
1.5	50	310	160	240	100

Radiation W/O Waveguide

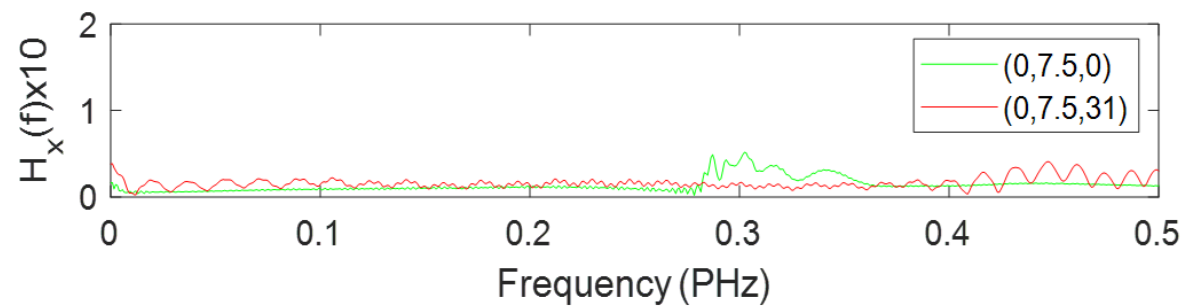
CST simulation



Internal radiation
(broadband)

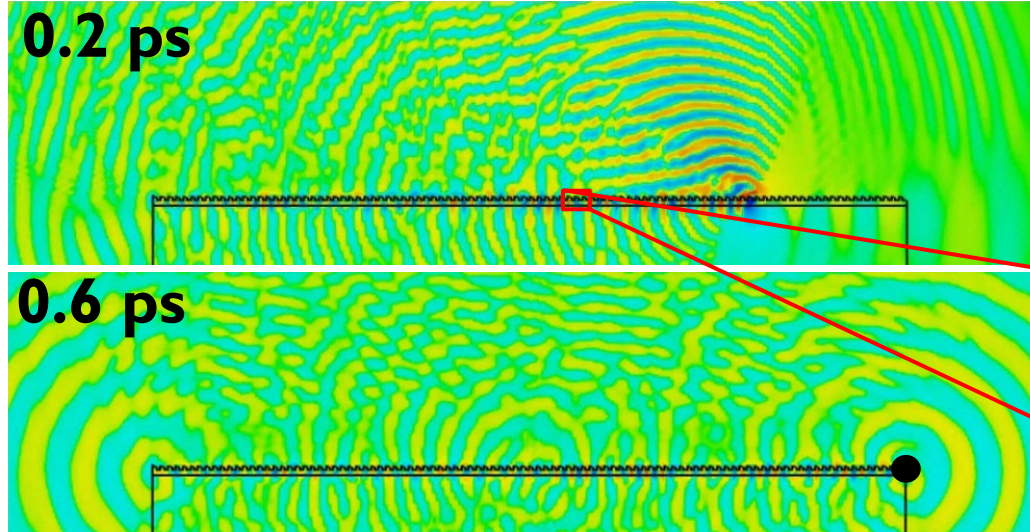
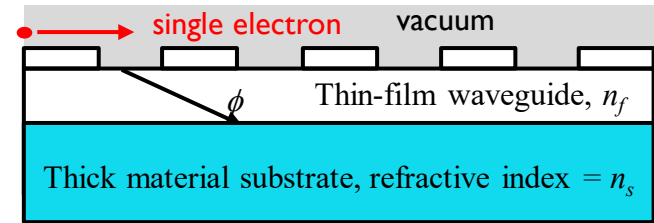


External radiation
(weak & broadband)



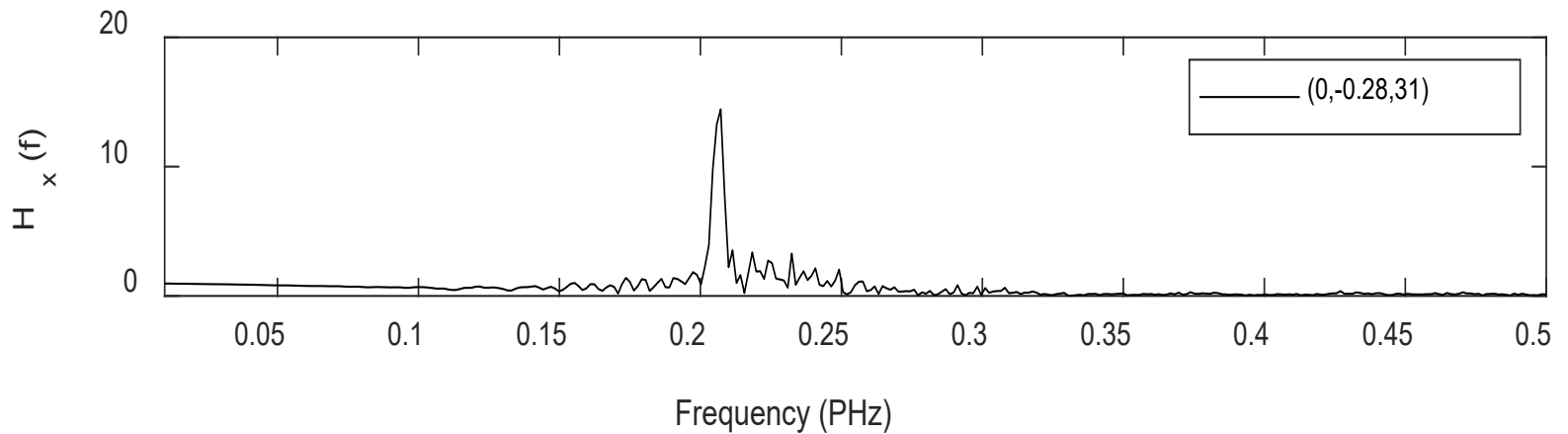
Grating-waveguide FEL driven by 1 electron

CST simulation

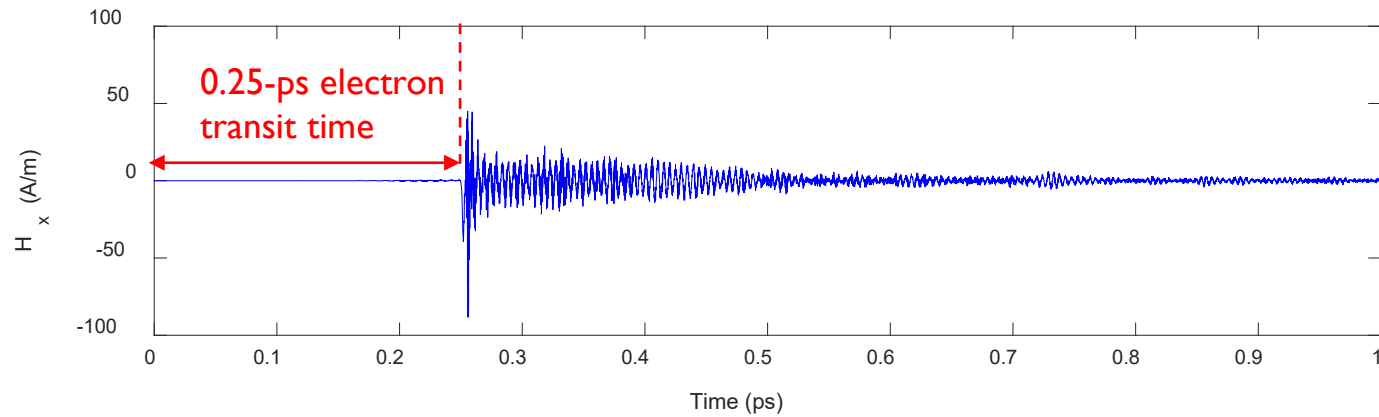
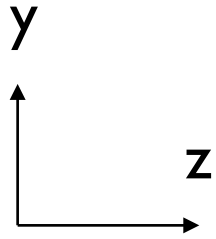


$$\Lambda_g = \frac{\lambda_z}{2}$$

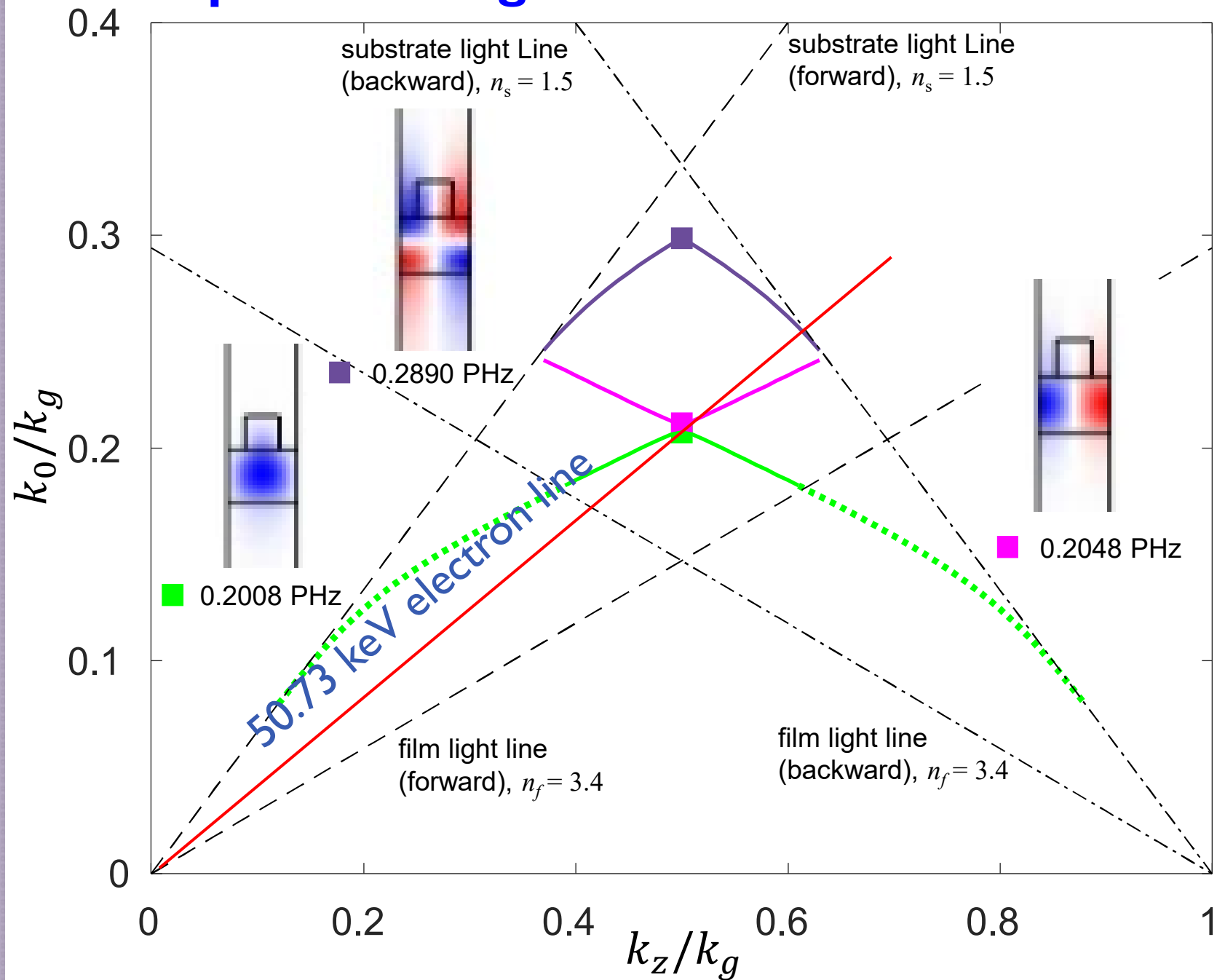
Bragg resonance



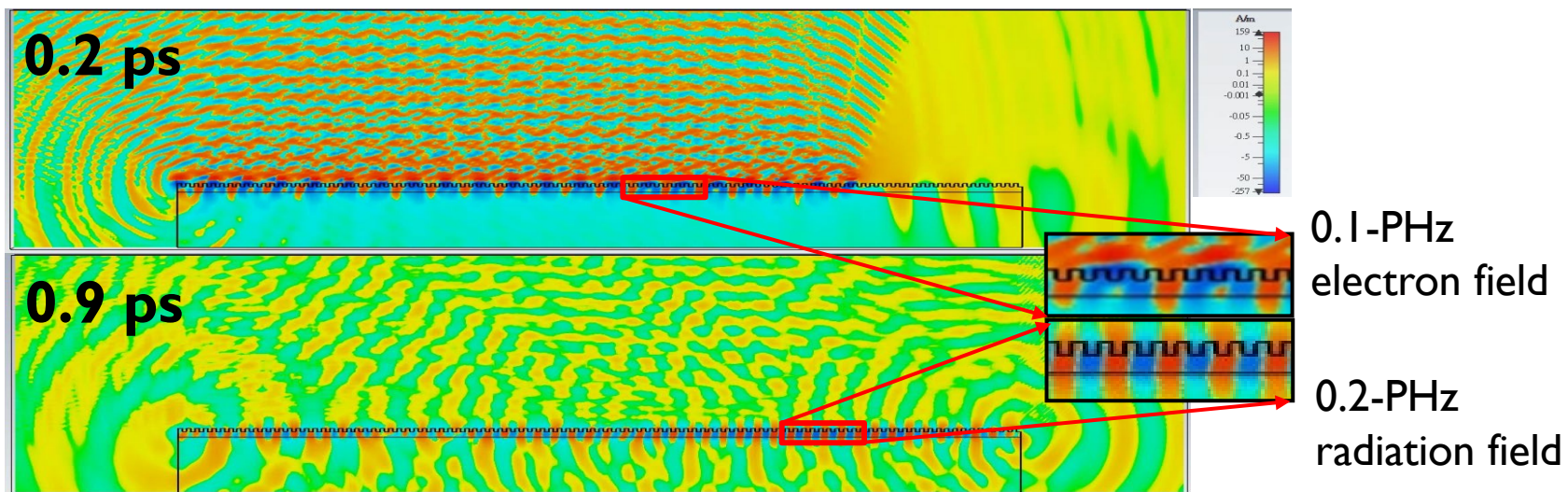
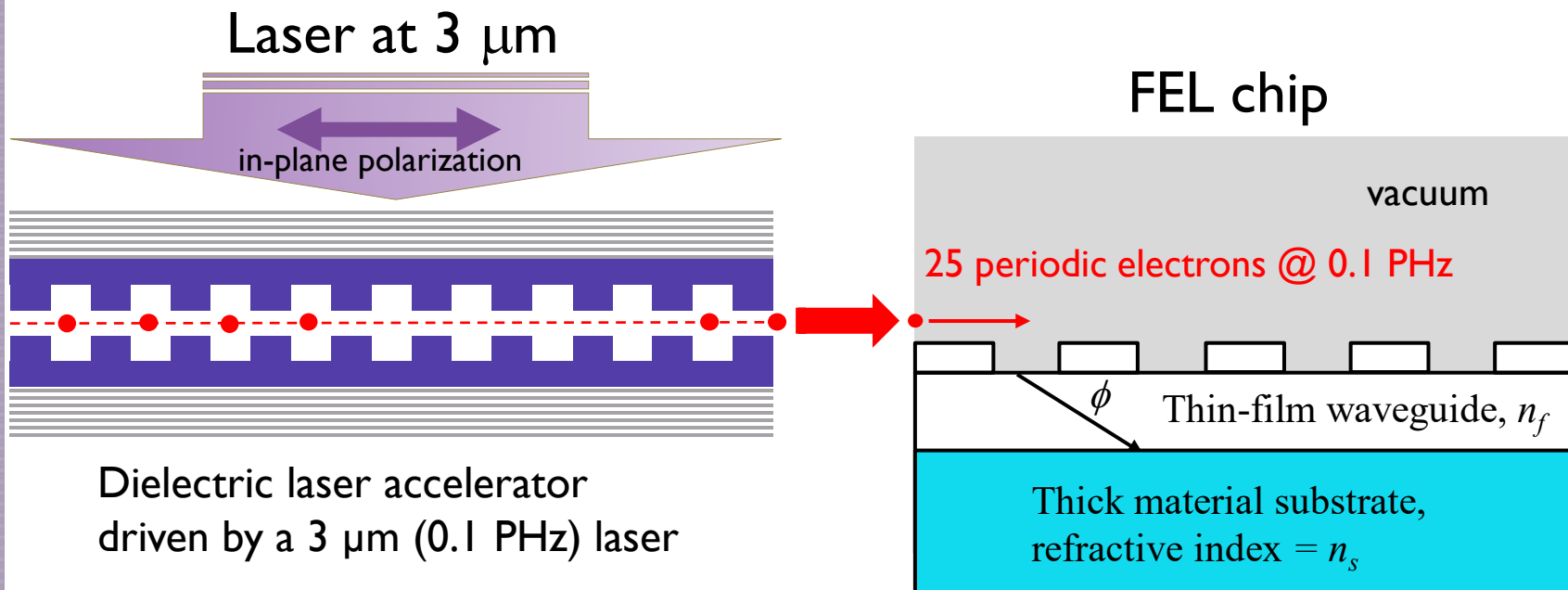
H_x Field Animation



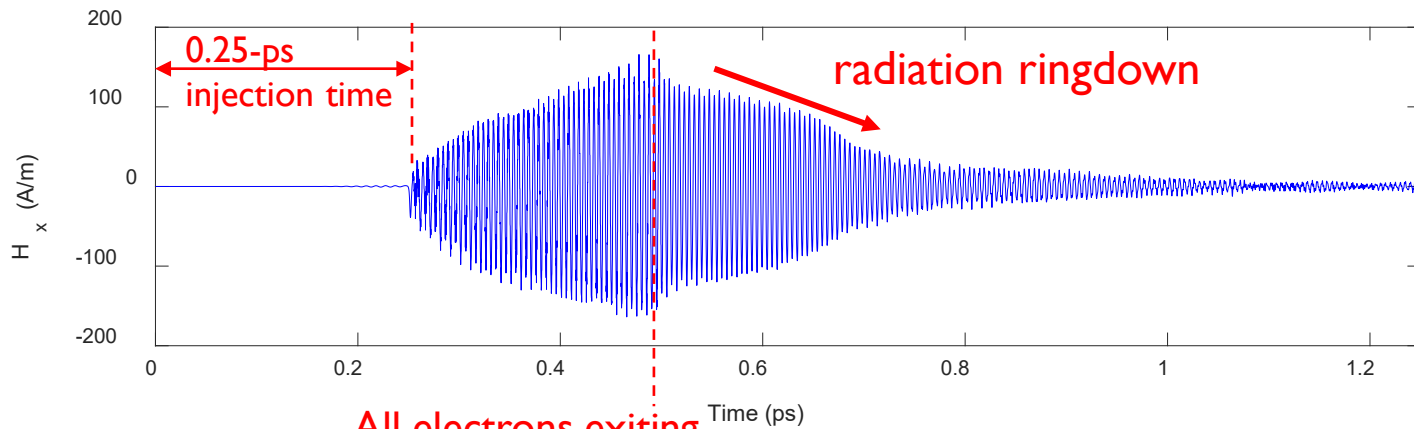
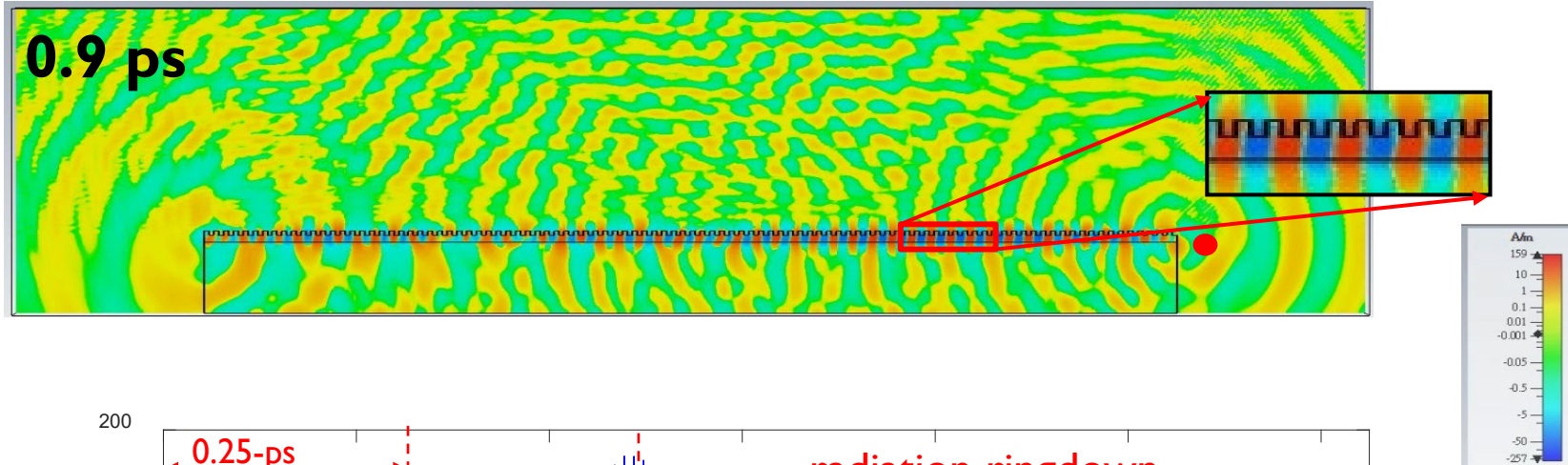
Dispersion Diagram



Grating-waveguide FEL driven by Periodic Single Electrons

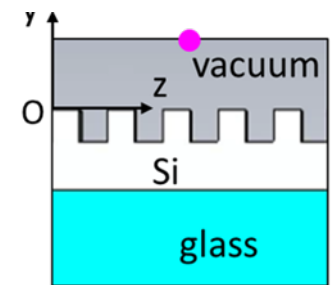
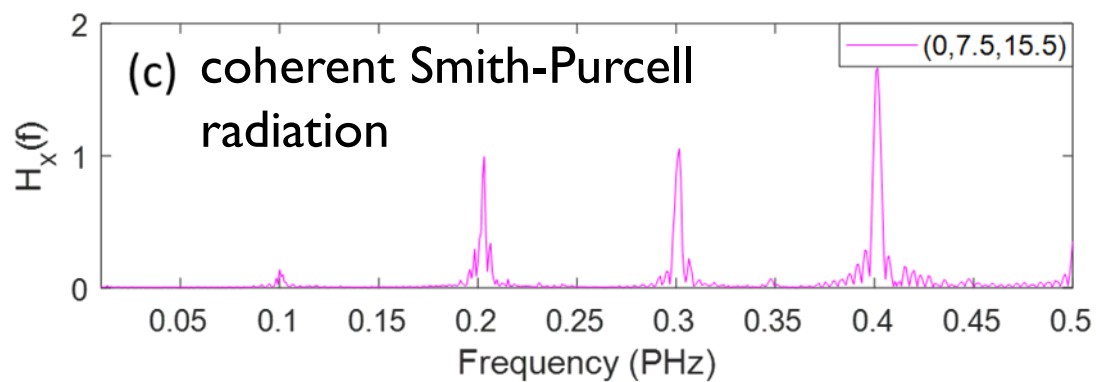
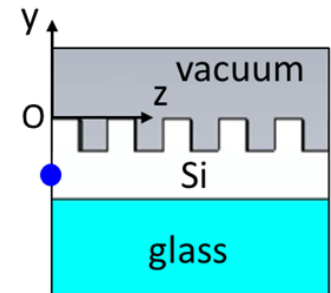
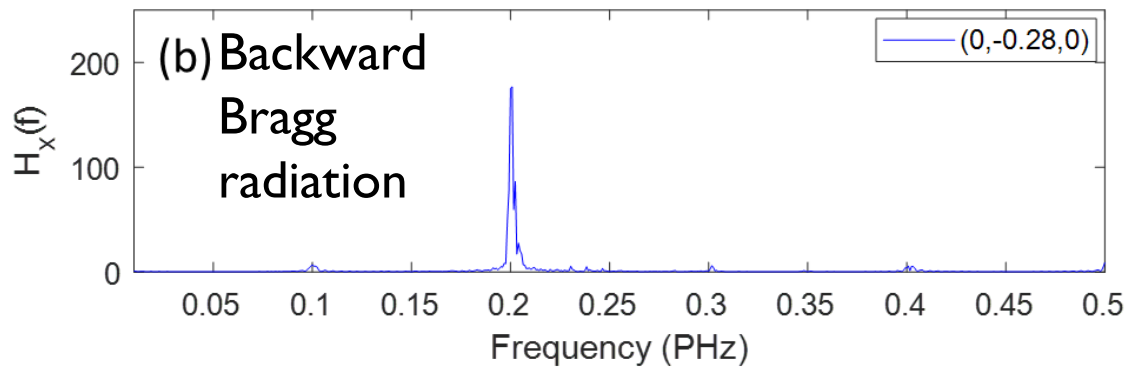
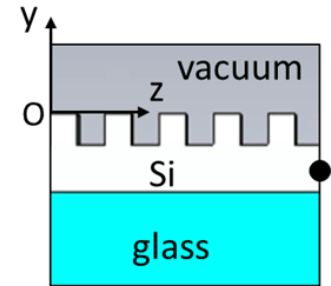
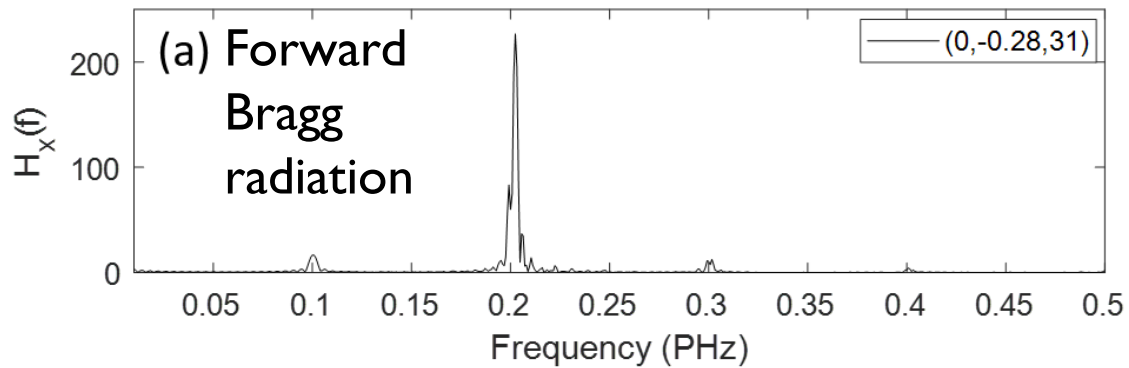


H_x Field Patterns



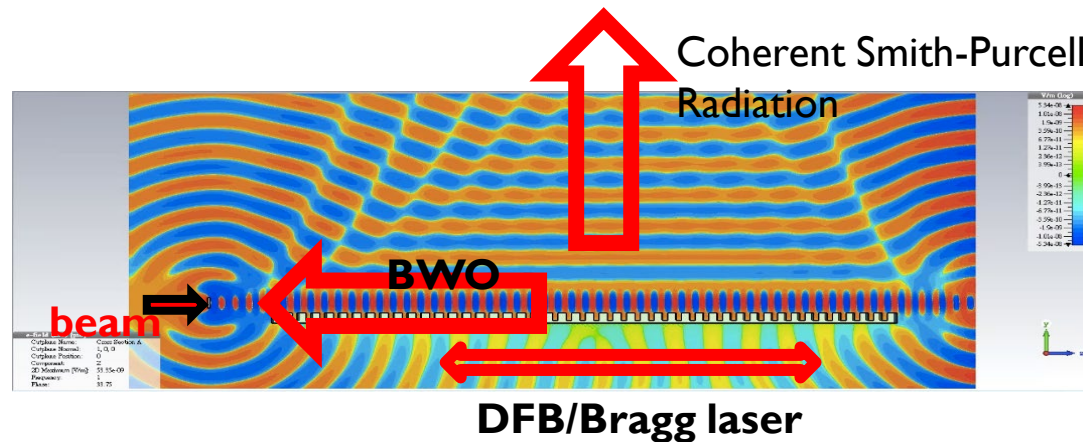
All electrons exiting
the structure

Harmonic Radiation Spectrum

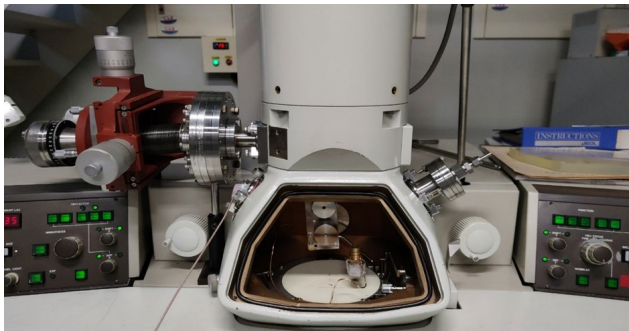


Conclusions

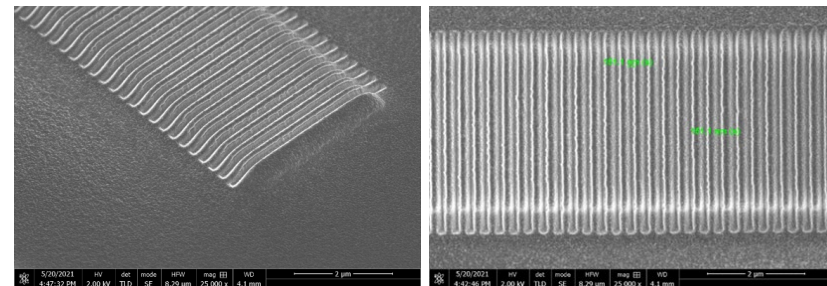
1. Dielectric laser accelerator and photonic FEL can be integrated into a chip-size structure via microfabrication techniques.
2. Single-electron FEL built upon a dielectric-grating waveguide is numerically demonstrated at 0.2 PHz and its harmonics.



3. Experimental tests are on-going by using a TEM beam.



TEM experimental chamber



Fabricated structure on Si (courtesy of Prof. Wei-Chih Wang of NTHU)

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Ming-Wei Lin



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Laboratory : Photon Source and Radiation Application Laboratory

Discipline

Interaction of Radiation with Matter, Engineering Mathematics I, Introduction to Nuclear Engineering, Applied Photonics

Specialty

Ultrafast optics, nonlinear optics, plasma physics and simulations, laser-based particle acceleration, radiation generation/detection