On-Chip Photonics Integrated Cathodes

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Introduction

- Photonics waveguides under a thin film of a high quantum efficiency semiconductor cathode can cause the photons to be efficiently absorbed very close to the surface resulting in high quantum efficiency (QE), low emittance and quick response time simultaneously, thus providing higher brightness electron beams [1].
- This can potentially result in a new method for spatio-temporal shaping of electron beams with unprecedented resolution and enable having correlations in the sub- μm spatial and sub-femtosecond temporal profiles.

Light Coupling Techniques

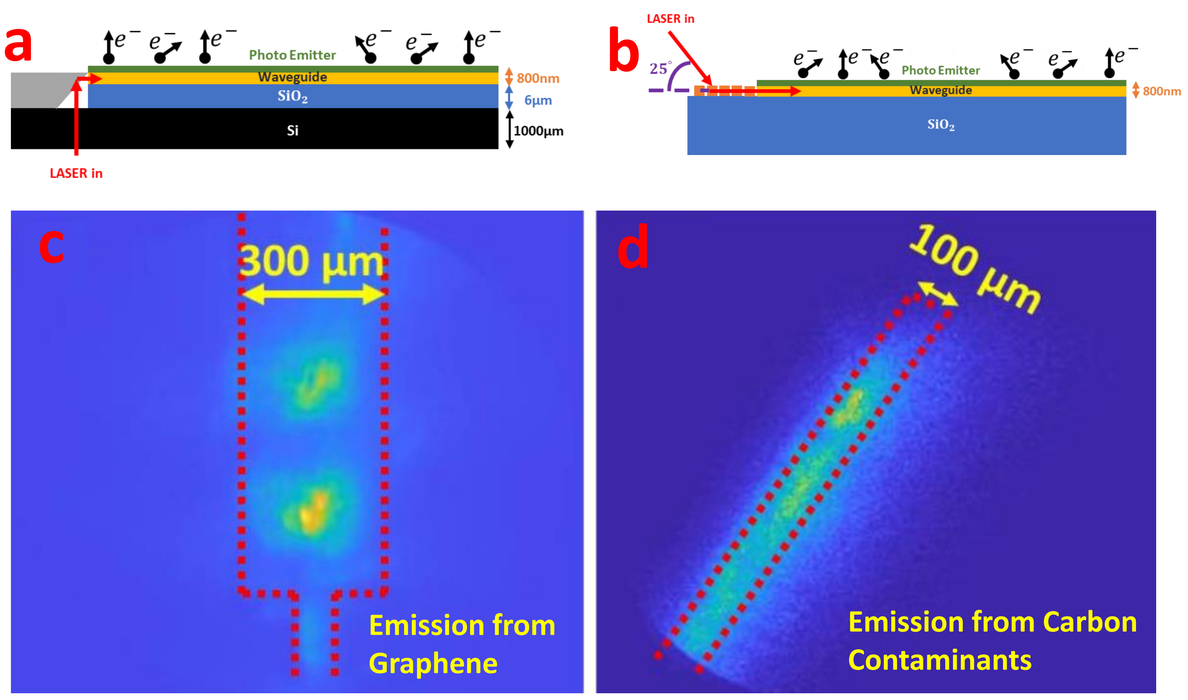

Figure 1: (a) Light coupling into the waveguide using Si etched mirror, (b) Light coupling into the waveguide using a grating coupler, (c) Confined non-linear emission from tapered waveguide with graphene using mirror-based scheme, (d) Confined non-linear emission from straight waveguide using grating scheme

EPITAXIAL TRANSFER OF GALLIUM ARSENIDE

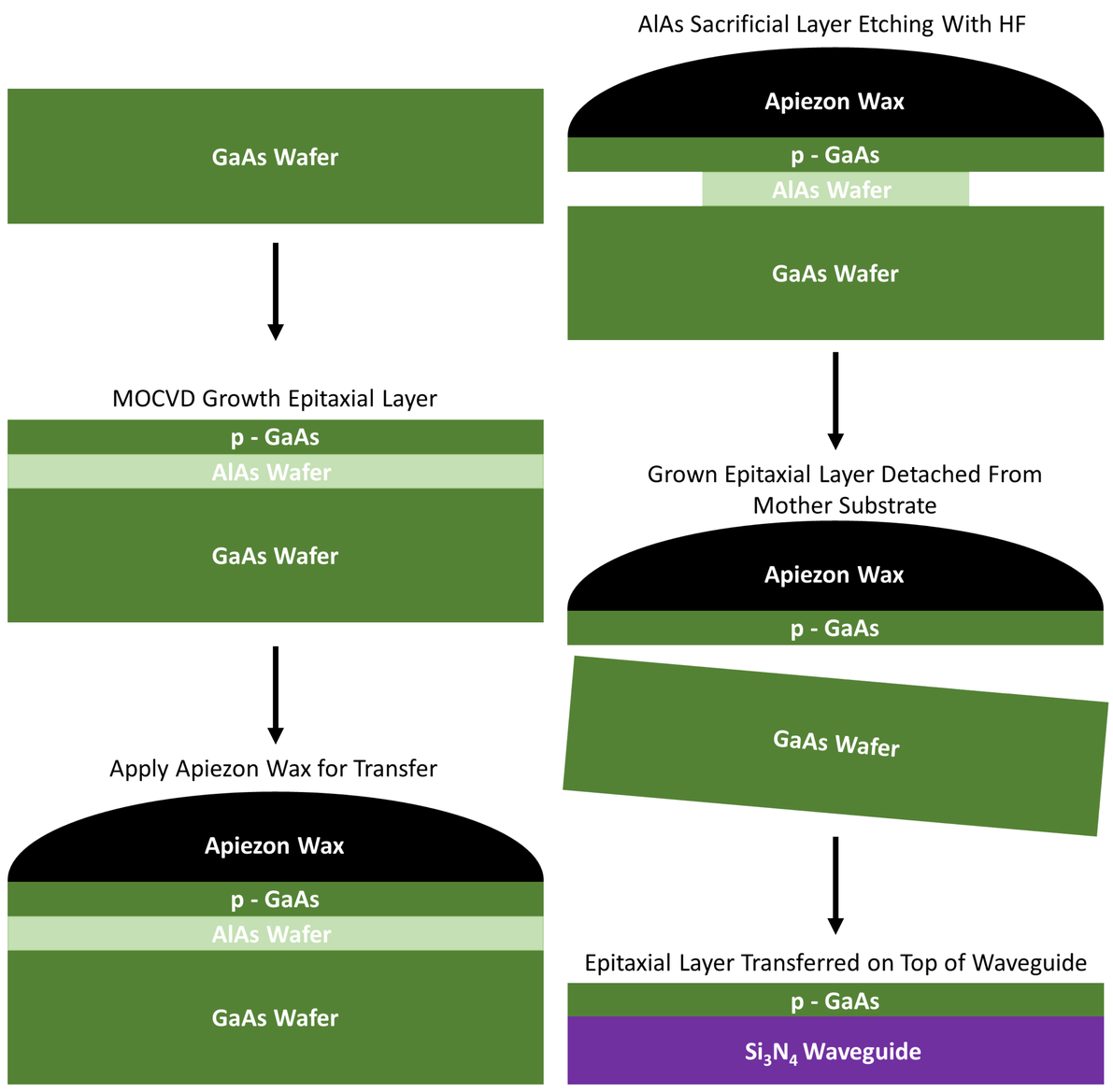

Figure 2: Schematic of GaAs transfer process

DEMONSTRATION OF CONFINED EMISSION USING PEEM

- PEEM produces images of electrons emitted from a surface with a sub-40-nm lateral resolution [2].
- Angle of incidence : 65° w.r.t normal of the sample.
- A 500 kHz repetition rate femtosecond pulsed laser with a pulse length of 150 fs and wavelength 532 nm made incident on grating coupler.
- LASER spot size : 100 μm X 250 μm

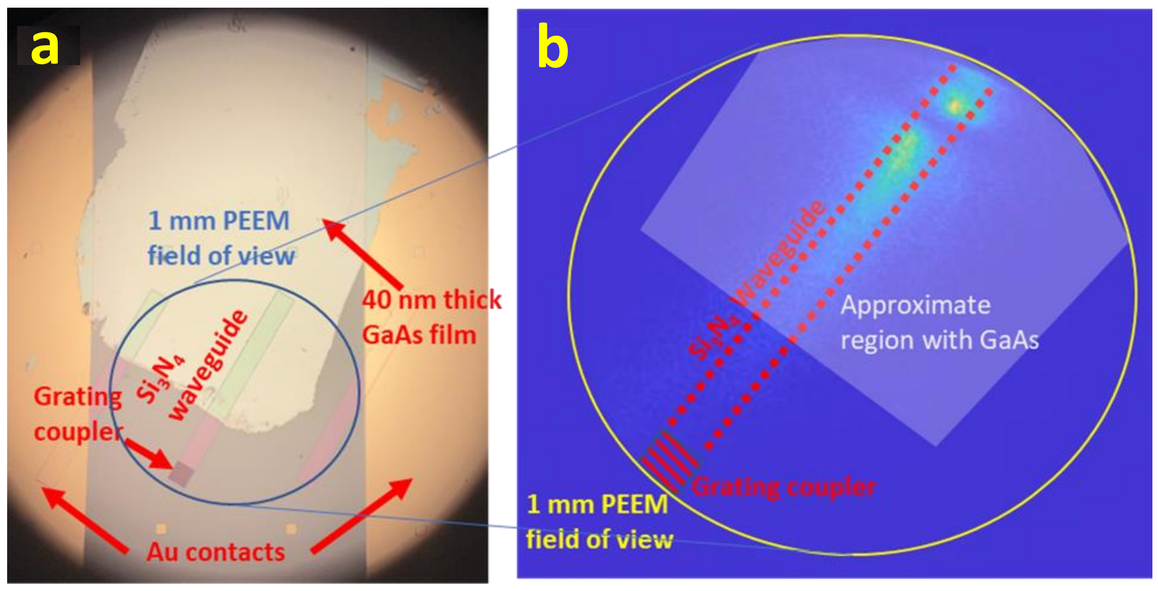

Figure 3: (a) Optical microscope image of 40nm GaAs on waveguide, (b) First PEEM image showing confined linear emission from cesiated GaAs

Future Work

- Optimize growth and transfer process for uniform illumination and better confinement.
- Design technologically advanced brighter photonics integrated photocathodes by simultaneously having high quantum efficiency (QE), low emittance and a quick response time.

Acknowledgements

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References

[1] Blankemeier, L., et al. *Journal of Applied Physics* 126.3 (2019): 033102.

[2] FOCUS-IS-IEF-PEEM, https://www.focus-gmbh.com/peemnanoesca/peem