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Buried Waveguides using a Quasi-Planar Process

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Introduction

Context:

The selective oxidation of Al-containing III-V semiconductors with high Al content is an established process to confine light and electrical injection in vertical-cavity surface emitting lasers [1-2] which is also used to create edge-emitting lasers [2], whispering-gallery-mode resonators [3-4], photonic crystal waveguides [5-6] and non linear frequency converters [7].

Problem:

The oxidation is a lateral oxidation process performed from the edges of an etched mesa

The associated drawbacks are:

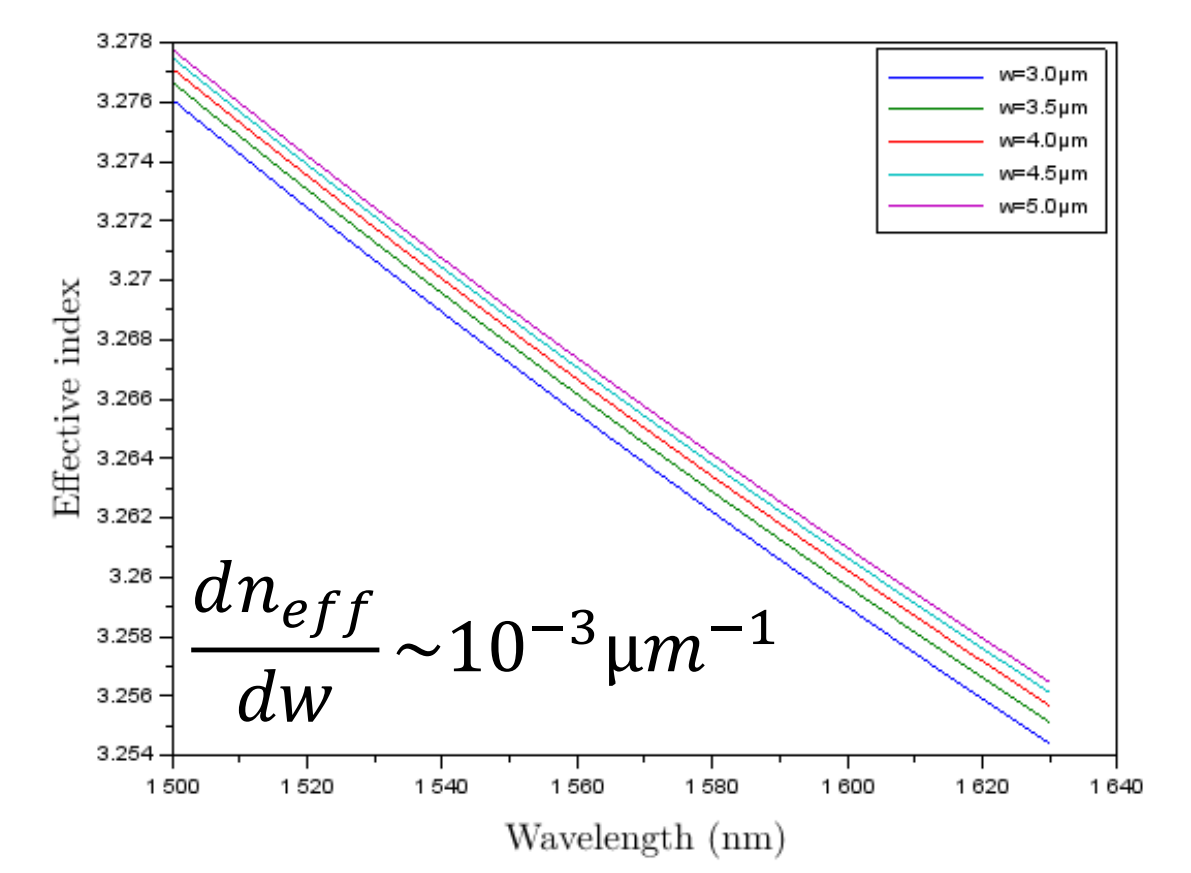
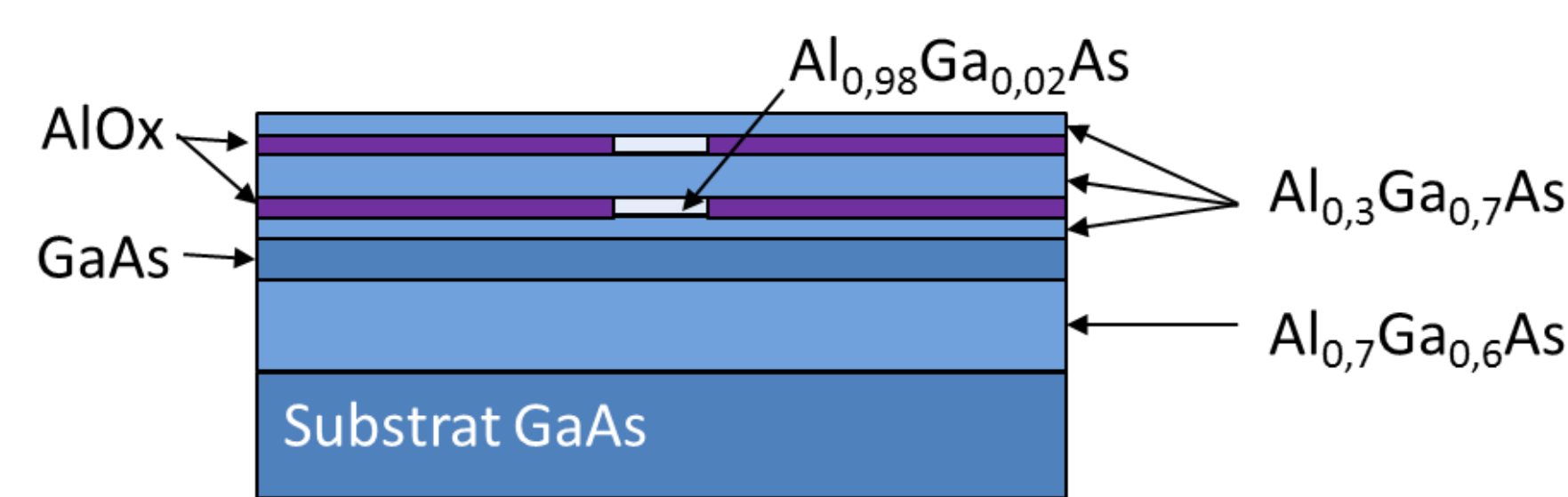
- ✗ Loss of wafer surface planeity
- ✗ Complex subsequent steps of fabrication process

Contribution:

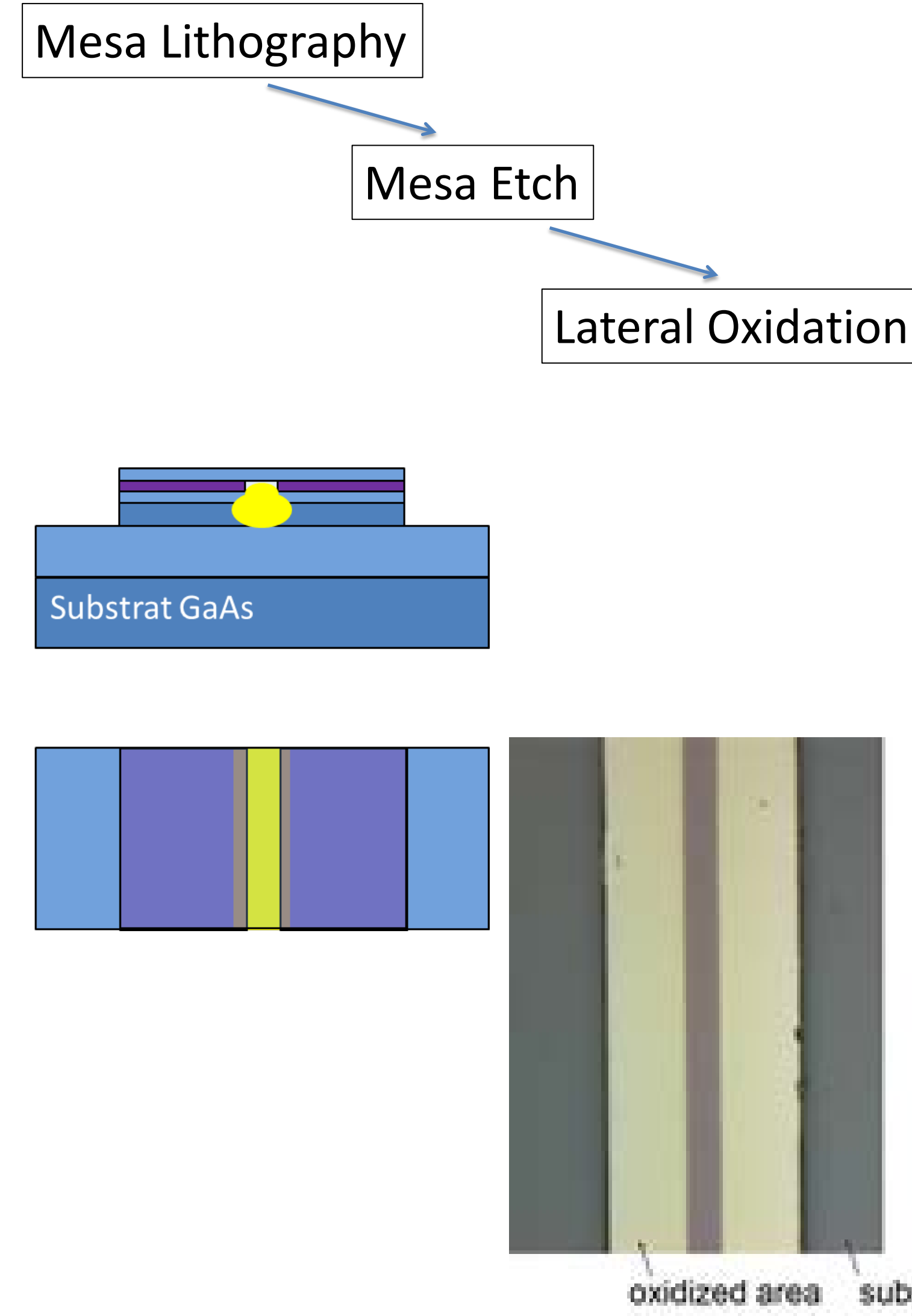
Here, we demonstrate a **modified process where the oxidation is performed via a discrete set of holes** instead of a linear mesa for the fabrication of straight waveguides.

- [1]: J.M. Dallesasse et al., *J. Appl. Phys.* **113**, 051101 (2013).
 [2]: J. M. Dallesasse et al., *Proceedings of the IEEE*, **101** (10), 2234 (2013).
 [3]: E. Peter et al., *Appl. Phys. Lett.*, **86** (2), 021103-1 (2005)
 [4]: S. Calvez et al., *IEEE Photon. Technol. Lett.*, **27**, 982-985, (2015).
 [5]: Y. Tanaka et al., *Japan. J. Appl. Phys. – Part 1*, **42**, 7331 (2003).
 [6]: Welna et al., *Photonics and Nanostructures*, **11**, 139 (2013).
 [7]: M. Savanier et al., *Applied Physics Letters*, **103**, 261105, (2013).

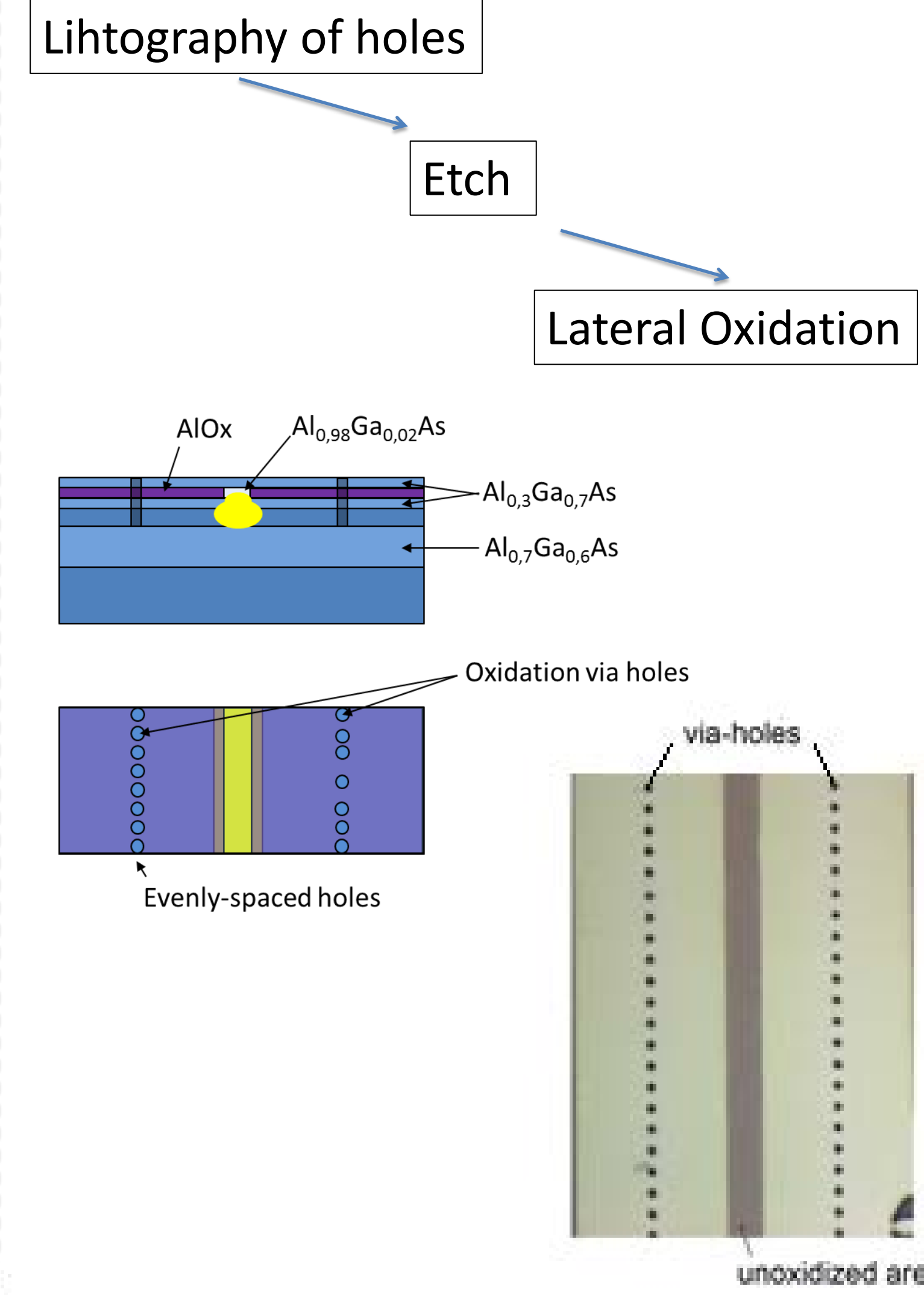
Design - Fabrication



Standard Process



Quasi-Planar Process

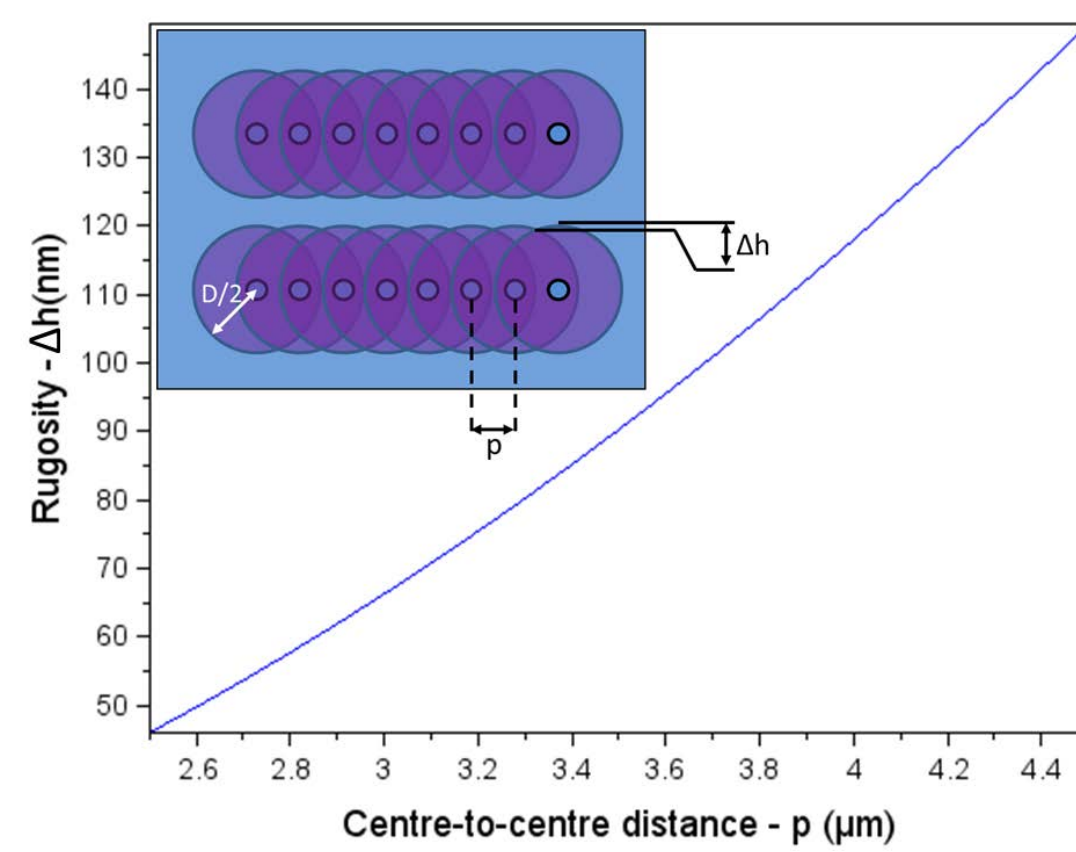


Characterisation

Oxydation front

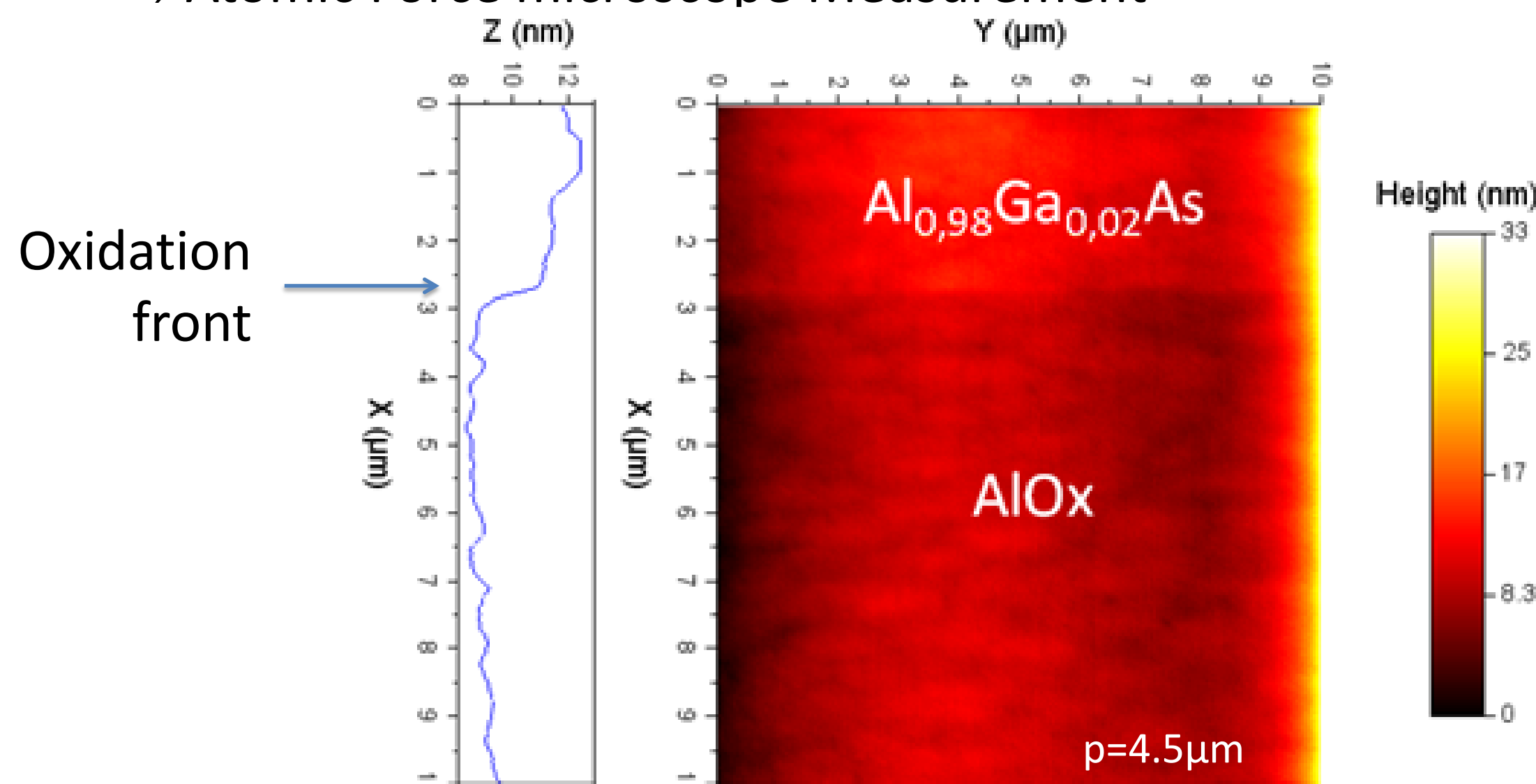
“Simple” Analysis

- Isotropic Oxidation
- Circular Holes
- ⇒ Oxidation Front = Overlapping circles
- ⇒ **Corrugated oxidation fronts**



Experimental Observations

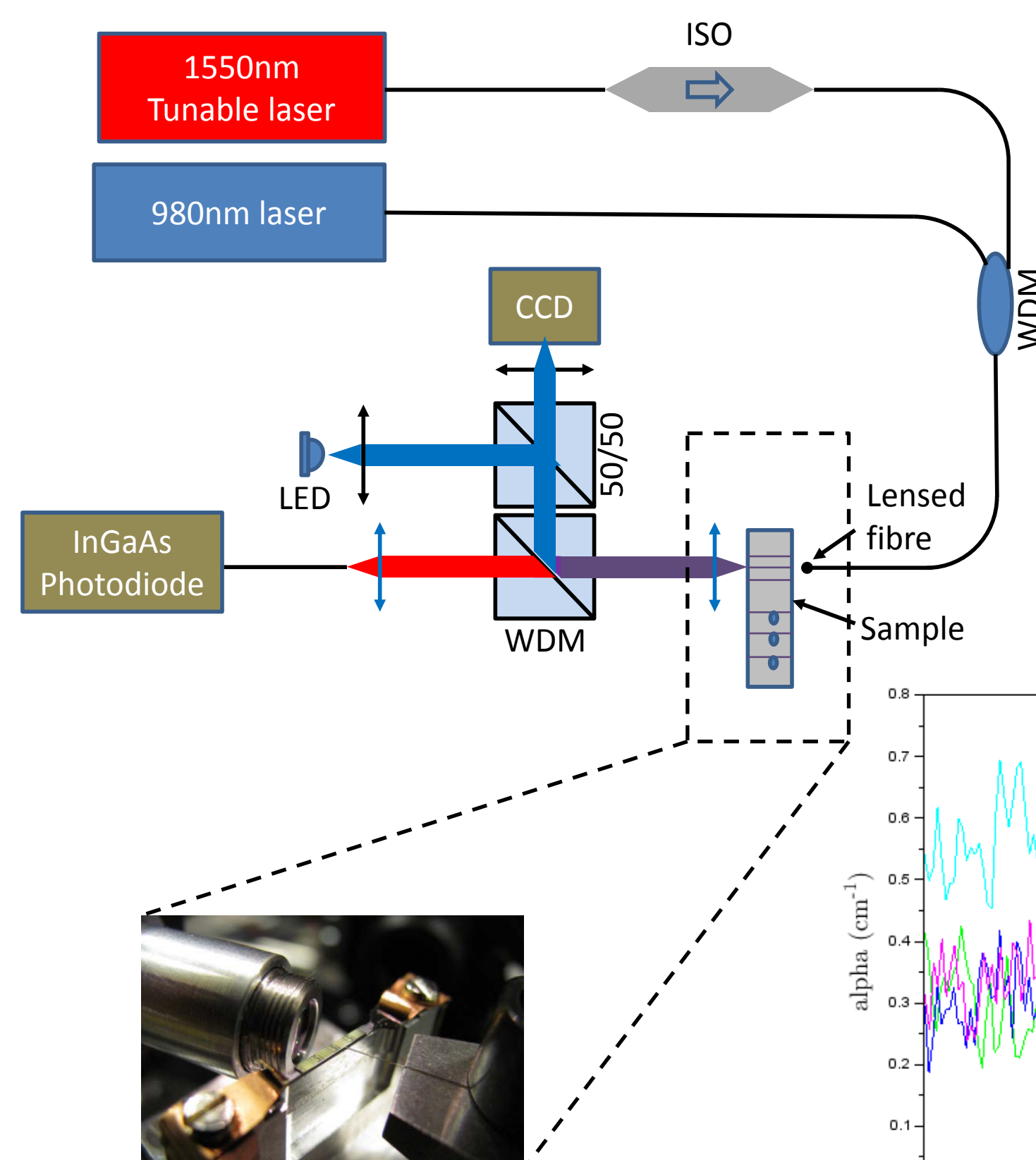
- 10% Volume reduction induced by oxydation
- ⇒ Change of thickness at boundary between oxidized and unoxidized regions
- ⇒ Atomic Force microscope Measurement



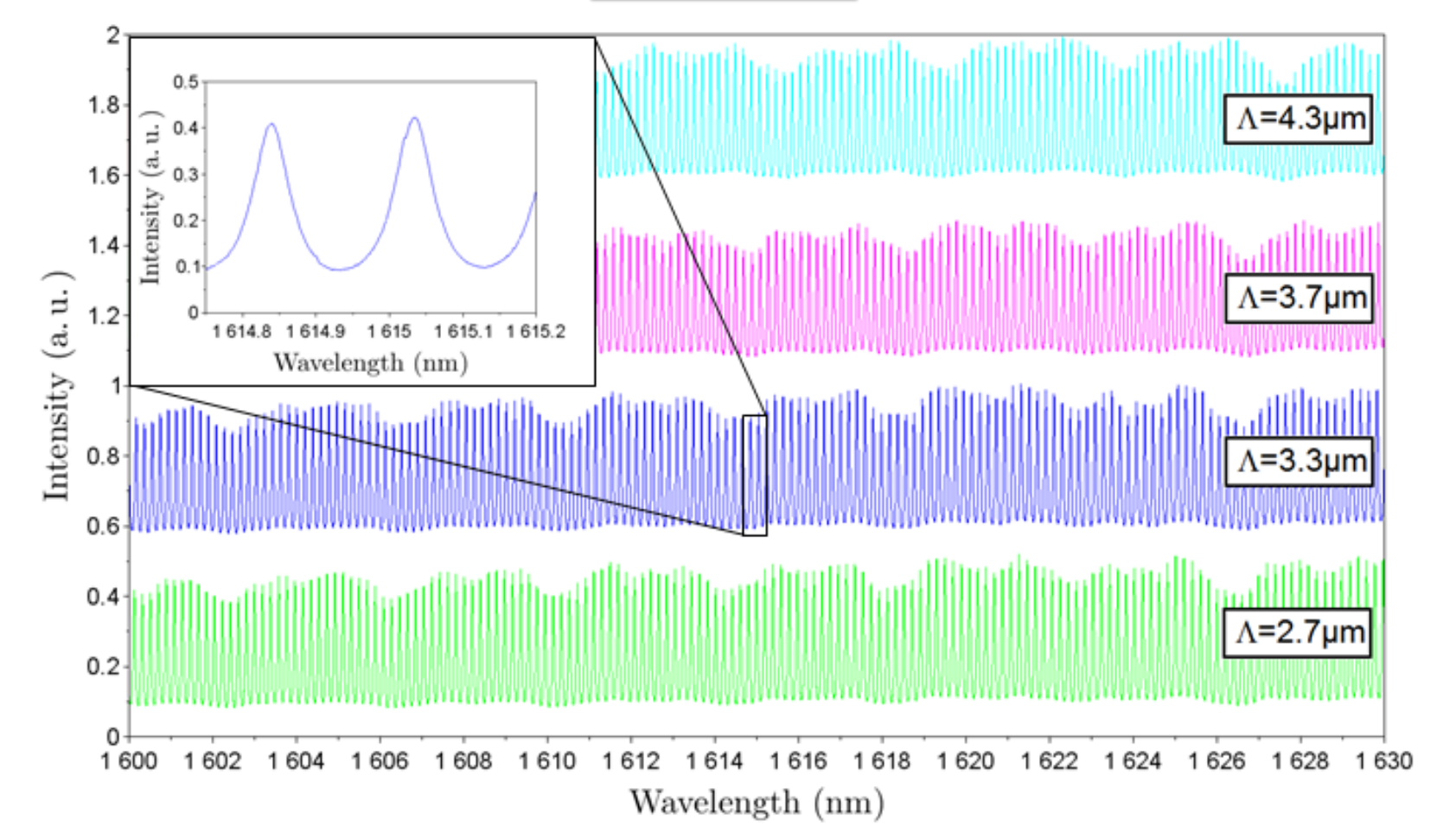
Oxidation fronts are smoothed by diffusion

Waveguide characterisation

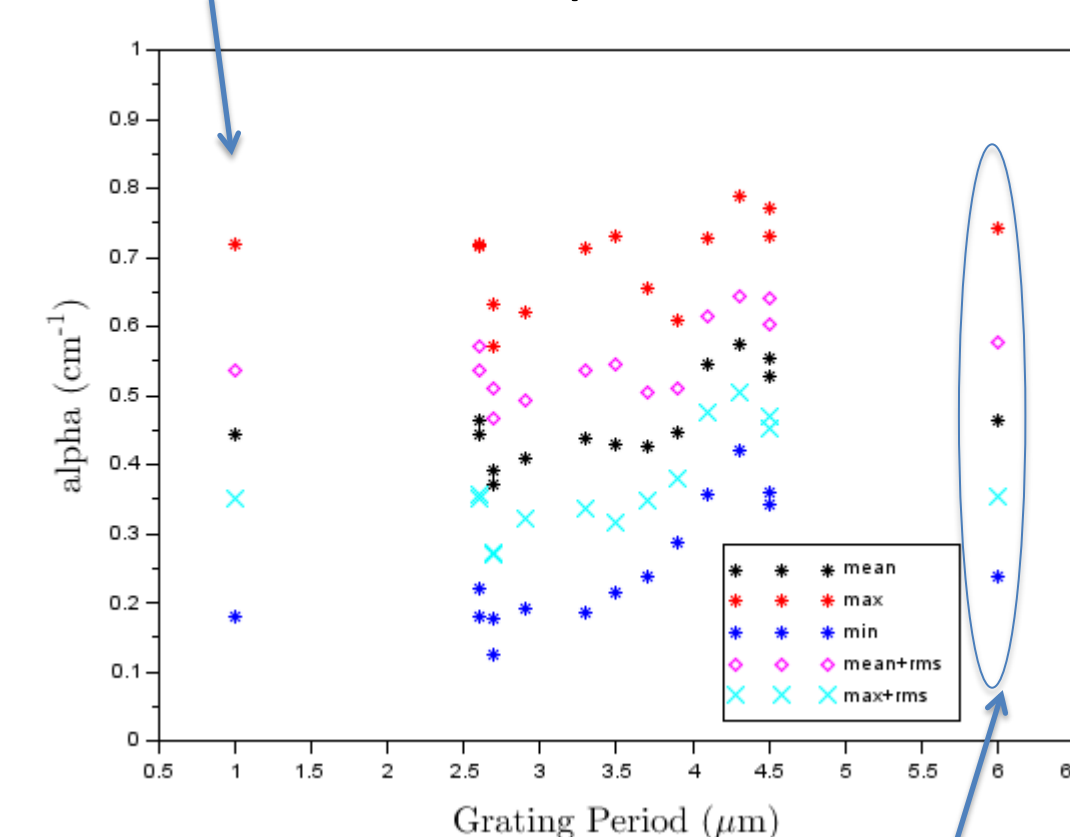
Setup



Results



Conventional process



Irregularly-spaced holes

Conclusions

- ✓ Validated via-hole Al-III-V-semiconductor oxidation process
- ✓ Made straight oxide-confined waveguides with smooth fronts using conventional and quasi-planar processes
- ✓ Both processes lead to similar waveguide losses ($\sim 0.45 \text{ cm}^{-1}$)