Oxidation of III-V semiconductors and applications

S. Calvez[1,*], N. Monvoisin[1], E. Hemsley[1], A. Monmayrant[1], H. Camon[1] et G. Almuneau[1]

1. LAAS-CNRS, Université de Toulouse, CNRS, 7 avenue du colonel Roche, F-31400 Toulouse, France

The wet oxidation of aluminum-containing III-V semiconductors is an established technological process that induces, at depth into III-V semiconductor heterostructures, a localized reduction in electrical conductivity and in optical refractive index. The associated engineering of the electrical path and/or the optical confinements have been used to facilitate the fabrication of edge-emitting lasers [1], vertical-cavity surface-emitting lasers (VCSELs) [2] and other photonic devices [1,3].

In this paper, we will review recent experimental investigations and model developments that we have carried out to measure, describe and analyse in detail this lateral oxidation process. In particular, we will present the implementation of a hyperspectral in-situ monitoring technique based on a spectrally-shaped illumination to obtain resolution-limited images of the optical apertures [4]. We will exploit this capability to draw out how the intrinsic anisotropy [5] and the geometry of the etched mesa from which the oxidation proceeds [6] affect and control the resulting shape of the produced oxide apertures. Finally, we will also present a method to artificially engineer the oxidation anisotropy to create aperture profiles that would not be fabricated otherwise [7], thereby opening new application opportunities for this technological process.

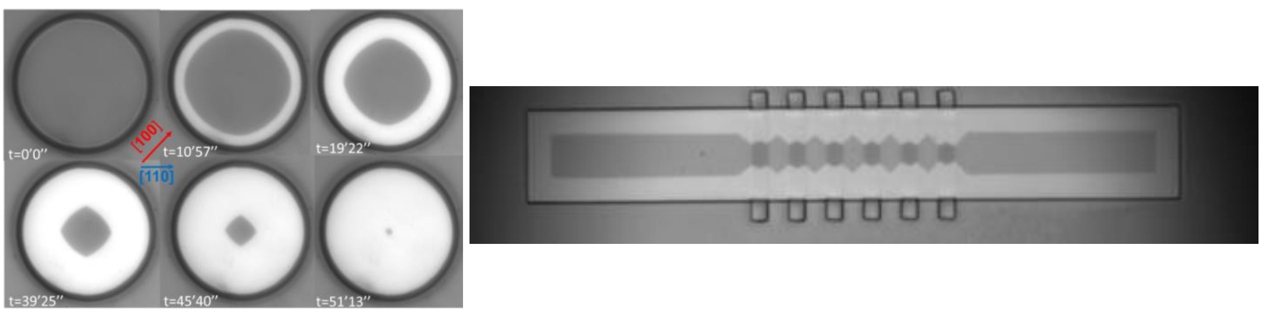

Fig. 1. Examples of oxidation aperture contours (white-to-grey central boundary) (left) resulting from an intrinsic anisotropy deformation [5] and (right) induced by an artificial anisotropy [7].

----

1. J. M. Dallesasse and N. Holonyak, "Oxidation of Al-bearing III-V materials: A review of key progress," J. Appl. Phys. **113**, 051101 (2013).
2. D. L. Huffaker, D. G. Deppe, K. Kumar, and T. J. Rogers, "Native-oxide defined ring contact for low threshold vertical-cavity lasers," Appl. Phys. Lett. **65**, 97–99 (1994).
3. S. Calvez, G. Lafleur, A. Larrue, P.-F. Calmon, A. Arnoult, G. Almuneau, and O. Gauthier-Lafaye, "Vertically Coupled Microdisk Resonators Using AlGaAs/AlOx Technology," IEEE Photonics Technol. Lett. **27**, 982–985 (2015).
4. N. Monvoisin, E. Hemsley, G. Almuneau, S. Calvez, and A. Monmayrant, "Spectrally-shaped illumination for improved optical monitoring of lateral III-V-semiconductor oxidation," Submitt. Opt. Express (2022).
5. S. Calvez, G. Lafleur, A. Arnoult, A. Monmayrant, H. Camon, and G. Almuneau, "Modelling anisotropic lateral oxidation from circular mesas," Opt. Mater. Express **8**, 1762–1773 (2018).
6. S. Calvez, A. Arnoult, A. Monmayrant, H. Camon, and G. Almuneau, "Anisotropic lateral oxidation of Al-III–V semiconductors: inverse problem and circular aperture fabrication," Semicond. Sci. Technol. **34**, 015014 (2019).
7. S. Calvez, A. Arnoult, and G. Almuneau, "Engineering the anisotropy of AlAs wet oxidation using silicon implantation," Opt. Mater. Express **11**, 3600 (2021).