Etching Rate Studies for Quantum Cascade Laser Mesa Formations

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Substrate & Superlattices:

Our study was performed using samples of several different InP-substrate QCL designs.

QCL design variations included varying the stack height of the InGaAs / InAlAs superlattice, changing the cladding material / overall thickness, and also BH laser stripe width.

In each case, the ***SiO_2 (top) overlay thickness is ~2500Å****.*

For designs including InP cladding, the ***InP is 3μm thick****.*

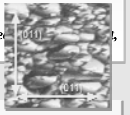
Why this research was conducted:

The value of the Quantum Cascade Laser (QCL) as a vital tool for chemical sensing is becoming increasingly evident. There is a need to develop repeatable manufacturing practices for the creation of quality, reliable QCLs. Our research focuses on the chemical wet-etching & processing of InGaAs/InAlAs buried heterostructure laser mesa formations - with the primary goal of characterizing etching rates in relationship to specific QCL designs.

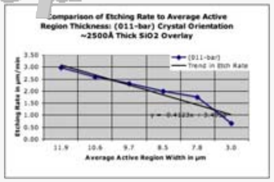
Applications Note:

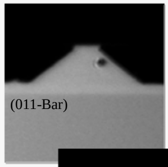
When approaching the photolithography process used to create QCL laser stripes, it is important to know the crystal orientation of the wafer. For InP wafers, we (a) apply a small drop of HCl to the back surface of the wafer and (b) let sit for 3 minutes - then (c) rinse and (d) inspect the etched region under the microscope.

Crystal directions should be[...]t, as seen in this graphic. »

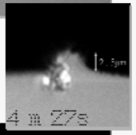


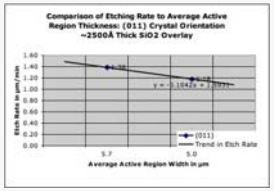
Etching Mesas with SiO_2 overlay:

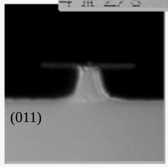



(011-Bar)

We found that the SiO_2 overlay will disappear at a certain etch time - in this case it was ~4m 30s »

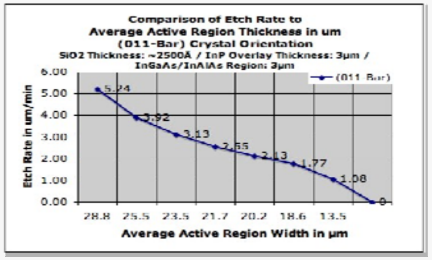





(011)

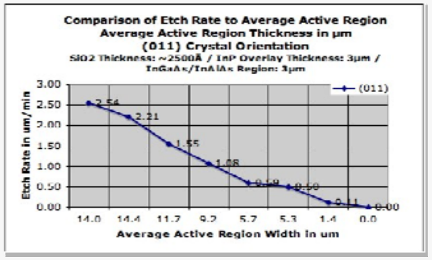
Etching Mesas: SiO_2/InP Overlay:

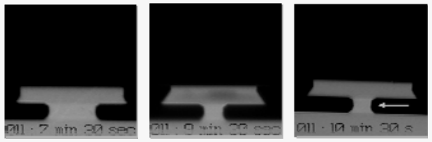
(011-bar): SiO_2: ~2500Å Thick | InP: 3μm Thick
InGaAs/InAlAs Active Region: **3μm** Thick



Etching Mesas: SiO_2/InP Overlay:

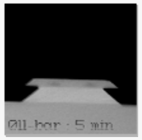
(011): SiO_2: ~2500Å Thick | InP: 3μm Thick
InGaAs/InAlAs Active Region: **3μm** Thick

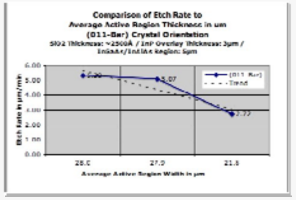


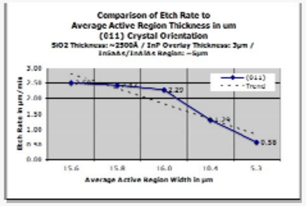


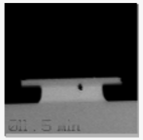
Etching Mesas: SiO_2/InP Overlay:

(011): SiO_2: ~2500Å Thick | InP: 3μm Thick
InGaAs/InAlAs Active Region: **5μm** Thick

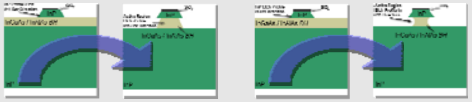








Etching Illustrated:



Carefully timed etching of BH region is carried out using a **H_2SO_4-based acid solution**. Etching profile for stripes along the (011-bar) orientation consistently follow the 111 plane - while those along the (011) direction exhibit noticeable conformities to several different crystal planes.

References:

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Conclusion & Acknowledgements:

In summary, we report new data regarding etching rates and physical profiles for MOCVD-generated QCL superlattices on InP substrate. With the goal of creating repeatable practices for the production of quality Quantum Cascade Lasers, we have compared various designs to establish etching settings. We have also studied etch-rate deceleration and possible causes, as well as information on the role of material overlay in the etching process.

NOTE:
Etching rate appears to decelerate as a function of the relationships of (1) QCL active region height (2) overall stripe width & (3) overlay material /thickness.

In addition, our research provides evidence that creating QCL laser mesas along the (011) crystal direction may allow for a more uniform side-wall profile, largely attributable to the etching process tunneling & deceleration effect. We look forward to future research into the role of SiO_2 and InP overlays, with the goal of determining the role of the inter-material "slipping coefficients" in the etching process and resultant QCL mesa profile.

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