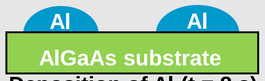
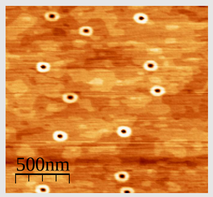
Quantum Dots by self-assembled Droplet Etching

In situ maskless etching



Deposition of Al (t = 8 s)
Droplet formation in Vollmer-Weber Mode

Annealing (t = 180 s)
Hole etching and wall formation



Droplet etching: new degree of freedom for the design of heterostructures by integrating top-down processes into Molecular Beam Epitaxy (MBE) growth

Droplets: Ga, Al, GaAl, In, and InGa

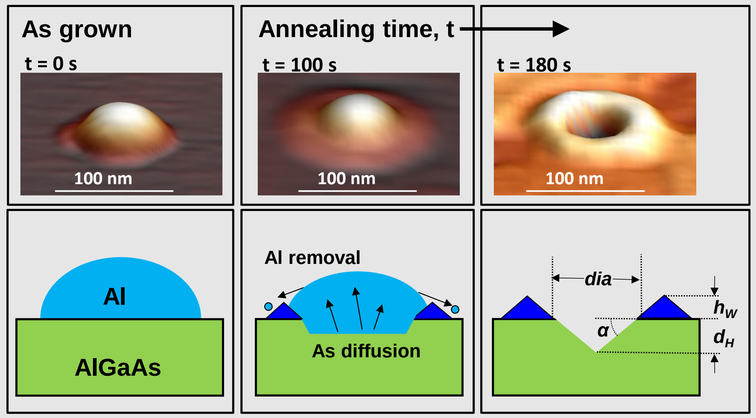
Substrates: GaAs, AlAs, and AlGaAs

Walls: (crystallized from droplet material)

⇨ AlAs, AlGaAs (opt. inactive) or InGaAs (quantum rings)

Novel nanostructures by hole filling:
- Quantum dots, quantum dot molecules
- Nanopillars

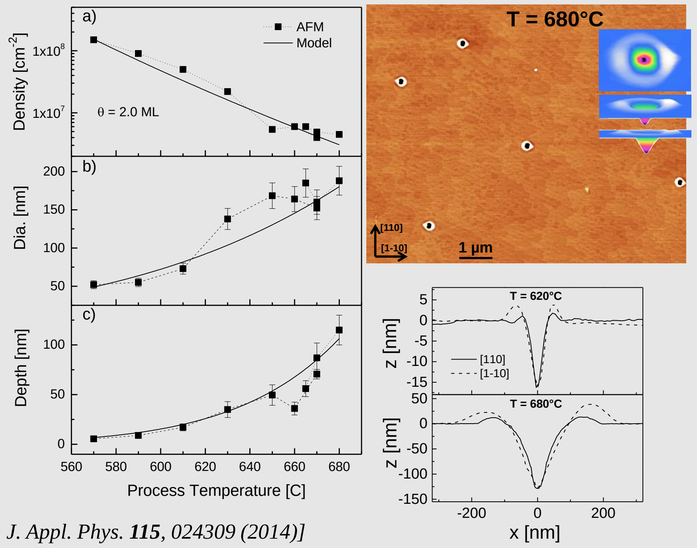
Mechanism of local droplet etching



AFM: *[Appl. Phys. Lett. **95**, 173110 (2009)]*

Model: *[Phys. Rev. B. **83**, 165302 (2011), Nanoscale Res. Lett. **10**, 67 (2015)]*

Control on nanohole morphology

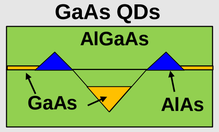


*J. Appl. Phys. **115**, 024309 (2014)]*

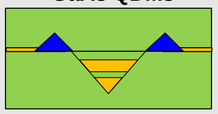
Quantum dots (QD) and quantum dot molecules (QDM) by hole filling

- **Uniform GaAs QDs by nanohole filling**
  *[Appl. Phys. Lett. **94** (2009)]*
- **QD shape approx. inverted cone**
  *[A. Nemcics et al., J. Crystal Growth **335** (2011)]*
- **PL emission adjustable by hole filling level: 700 - 800 nm**
  *[Appl. Phys. Lett. **94** (2009), APL **101** (2012)]*
- **White-light emitter by modified process**
  *[Nanoscale Res. Lett. **5** (2010)]*
- **QD density tunable: $1x10^6$ - $5x10^8$ cm^{-2}**
  *[Appl. Phys. Lett. **101**, (2012)]*
- **Sharp excitonic lines from single dots**
  *[Nanoscale Res. Lett. **5** (2010)]*
- **QD molecules (QDM) by multiple filling**
  *[Nanotechnology **25**, 215602(2014)]*

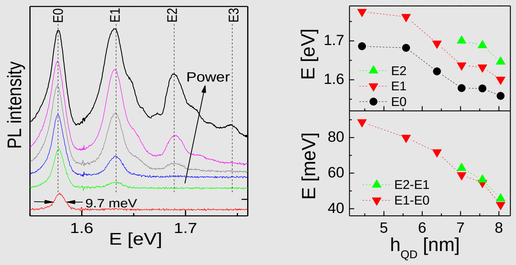
GaAs QDs



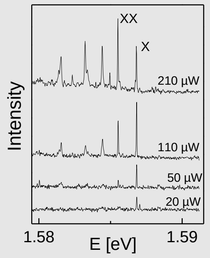
GaAs QDMs



Photoluminescence emission from uniform QD ensemble



Photoluminescence emission from single QD



Photoluminescence emission from single QDM under vertical gate voltage