Mn doped GaAs and GaSb/GaAs nanowires grown in the MBE system at BL 41

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Growth of nanowires by molecular beam epitaxy (MBE):

- *usually the growth of nanowires (NWs) is catalyzed by gold nanodroplets created at the substrate (GaAs, Si or other) either by direct deposition (from aerosol or from liquid solution containing gold nanoparticles) or by annealing of predeposited ultrathin gold film (3 – 10 Å)*

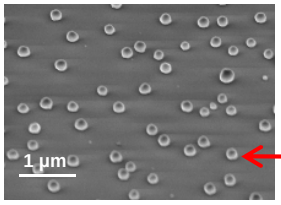
- *in our case the NW growth occurs without any external catalyst Ga nanodroplets formed at Si surface exposed to Ga flux catalyze the NW growth*

GaMnAs/GaAs hierarchical structures:

- *doping of GaAs NWs with Mn at high temperature growth doesn't work (Mn segregates inside the Ga droplet)*

⇓

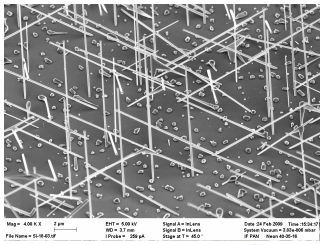
- *We tried to grow GaMnAs shell at low temperatures (250 – 350 °C) around GaAs NWs grown at high temperature (600°C)*



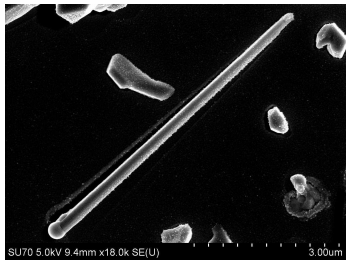
MBE growth of GaAs

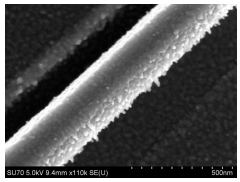
Ga droplets on Si(100)

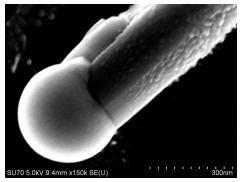
SEM - Si(100) substrate with Ga droplets deposited in the MBE growth chamber



GaAs nanowires 45 ° tilt view

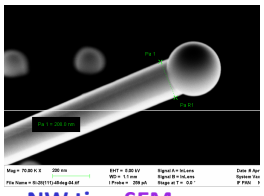




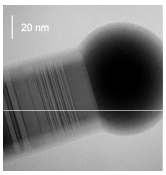


HT GaAs nanowires covered by LT $Ga_{0.93}Mn_{0.07}As$ shell grown at 230 °C

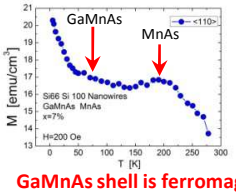
GaAs nanowires side view

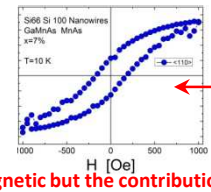


NW tip: SEM



TEM

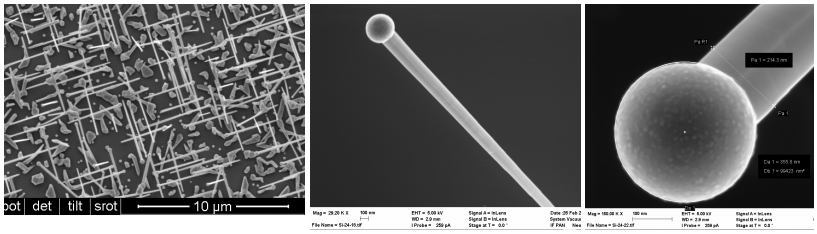




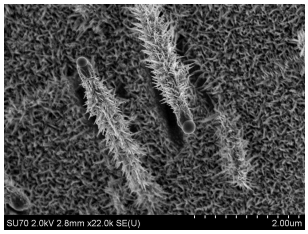
Magnetisation M(T) and M(H)

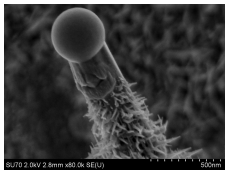
GaMnAs shell is ferromagnetic but the contribution from ferromagnetic MnAs is visible

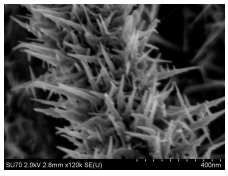
Doping of GaAs NWs with Mn (MBE growth at 600 °C)



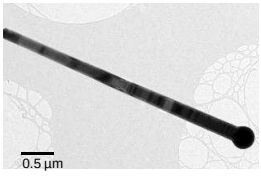
GaAs:Mn nanowires SEM pictures

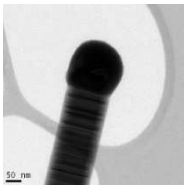


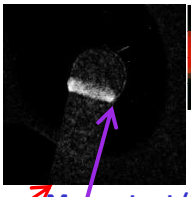


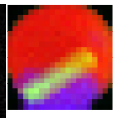


HT GaAs nanowires covered by secondary LT $Ga_{0.93}Mn_{0.07}As$ nanowires grown at 270 °C









HAADF tomography
Tilt range: +65° to -65°
Increment: 2°

200 nm

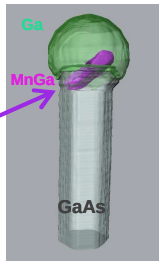
GaAs:Mn nanowires TEM pictures

Mn in the main part of NW – below the detection limit of EDX

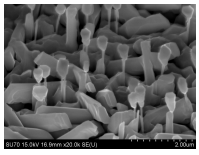
Mn content (EDX)

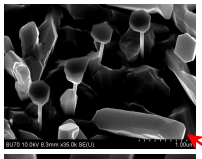
Mn accumulation in the Ga droplet

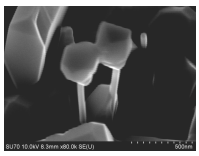
MnGa nanocrystallite inside the Ga droplet

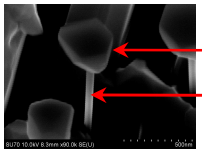


GaSb/GaAs nanowires:









GaSb

GaAs NW

GaAs NWs grown at Si(111) at 600 °C overgrown by GaSb at 560 °C

Conclusions:

different types of nanowires were grown at BL 41 MBE system with self catalysing Ga droplets on Si substrates:

- Mn doped GaAsNWs, core-shell GaMnAs/GaAs, secondary GaMnAs NWs

- small GaSb crystallites on tops of thin GaAs NWs

These new nanostructures are interesting to study using MAX-Lab beamlines