Impact of dopants change on planar GaAs nanowires growth

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Semiconductor III-V nanowires (NWs) are widely considered as promising active component for novel opto- and nanoelectronic devices. Control over the doping and NW assembling at the nanoscale during the growth of the nanostructures is one of the key challenges of the device fabrication. Usually, these processes are considered separately.

Here we would like to discuss about the influence of dopants on growth of planar NWs via Vapor-Liquid-Solid mechanism (VLS). In the present study we investigate the dopants impact on the shape and growth direction of planar NWs. We focused on the following aspects of planar nanowire growth: in-plane rotation of NW marked R in Figure 1 and NW detachment marked D in Figure 1.

We propose a theoretical model based on the nucleation limited mode of NW growth. Our main results can be formulated in the following way: NW rotation and detachment are caused by the change of the catalyst droplet surface energy and volume. An unwanted change of NW dopant level growth direction should be compensated by variation of NW growth rate and V/III ratio.

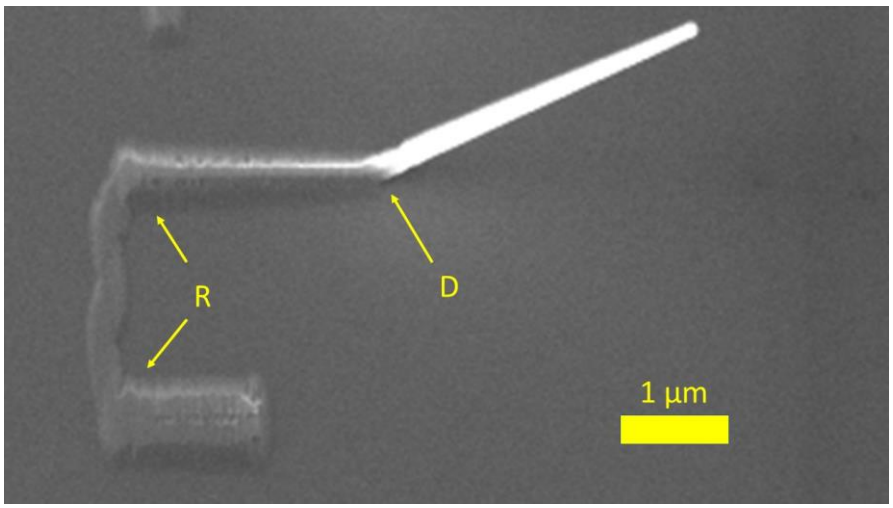

Fig. 1. Change of nanowire growth direction caused by the change of doping level: in-plane rotation is marked with R and nanowire detachment is marked with D.

Results of theoretical modeling were compared with the growth of planar GaAs NWs on doped n- and p-GaAs (100) substrates by MOVPE with Zn and Sn doping. Doping of the NWs leads to the noted above switching of the growth mode from planar to (111) direction and rotation on the substrate and also to the oscillations of the NW diameter. The theoretical analysis supported by EDX chemical measurement shows that such instabilities are due to high As concentration in the NW droplet. Studying the doping distribution by C-AFM shows that misorientation of the substrate's surface appears in the 3D doping distribution. The dopants are likely to be incorporated into polar facets. Thus, the non-polar top (001) NW facet is less doped for the NWs grown on misoriented substrates than the top facet of the NWs grown on singular surfaces.