

# MBE-grown Ge nanowires: The co-effect of atomic hydrogen and catalyst spreading

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Molecular Beam Epitaxy is a convenient method for the growth of semiconductor nanowires via VLS (vapour-liquid-solid) process. It allows not only superior control over the deposition parameters (e.g. sample temperature, deposition rates, materials' purity and UHV conditions), but also to introduce different gases during the deposition. This allows us to disentangle the impact of different processes on the nanowire growth (such as diffusion and surface passivation), in contrast to chemical methods of nanowire growth.

In this poster, we present and compare the VLS growth of germanium nanowires from gold catalyst nanoparticles I) under UHV conditions, II) in the presence of atomic hydrogen. The synergic effect of atomic hydrogen passivation and catalyst spreading is described.

Germanium nanowires grown in UHV adopt  $\langle 110 \rangle$  growth direction exclusively, irrespective of substrate orientation. On the contrary, when atomic hydrogen is present, the nanowires grow preferentially along  $\langle 111 \rangle$  direction. Furthermore, the overall morphology is changed (see Fig.1).

The explanation is as follows: With atomic hydrogen passivating the nanowires' sidewalls, the out-diffusion of Au atoms from the catalyst is suppressed, thus there is no preferred sidewall orientation. Therefore, the catalyst droplet adopts the optimal growth geometry leading to  $\langle 111 \rangle$  growth direction. However, in ultra-high vacuum,  $\{111\}$  sidewalls are energetically preferred due to Au decoration. Therefore, the catalyst droplet is constrained and the growth proceeds in  $\langle 110 \rangle$  direction with a different morphology.

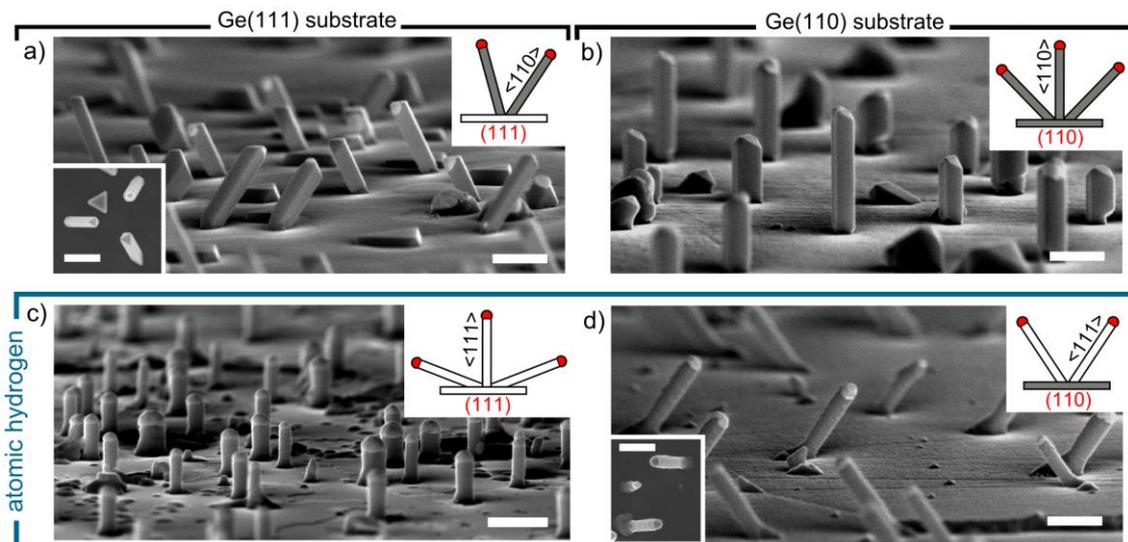


Fig. 1: a,b) The Ge nanowires grown in ultra-high vacuum (UHV) adopt  $\langle 110 \rangle$  growth direction irrespective of substrate orientation. Some of the Au catalyst droplets are lost. c,d) When atomic hydrogen is introduced ( $2 \cdot 10^{-3}$  Pa), the nanowires grow preferentially along  $\langle 111 \rangle$  direction and the overall morphology is changed. Published in [1].

[1] M. Kolíbal et al., Nano Letters **16**, 4880 (2016).

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