Supporting Information

Strain distribution in single, suspended germanium nanowires studied by nano-focused X-rays

1. Details on sample fabrication

![Diagram of sample processing steps](image)

Figure 1: Sketch of the sample processing steps. (a) Beginning with photo-lithographic patterned mesa-cantilever structures, (b) oxidisation step, (c) gap-window oxide removal, (d) Au droplet formation on mesa side facet, (e) Ge wires were synthesized in vapour-liquid-solid (VLS) growth mode using low pressure chemical vapour deposition, (f) final-step with focused ion beam cut-off of the cantilever and resulting cantilever relaxation.

The sample fabrication is identical to that described in Ref. [1], and sketched in Fig. 2.

First, the device layer is patterned by photo-lithography into several mesa with small gaps in between them (Fig. 2(a)). The sidewalls next to these gaps have \{111\} orientation, to allow for NW growth perpendicular to those facets in a later step.
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However, prior to the NW synthesis the cantilevers were pre-bent by oxidizing the whole sample. The free standing cantilever end is very close to a side facet of an additional neighbouring support (“mesa3” in Fig. 2), so that the forming oxide layer pushes the cantilever to the left, i.e., the gap between “mesa2” and the cantilever is decreased.

The next processing step (Fig. 2(c)) was the removal of the oxide around the “mesa2”-cantilever gap at the desired position of the NW. Within this window, gold colloids with a diameter of 30 nm are deposited from an aqueous solution using dielectrophoresis, and attach themselves to the \{111\} oriented sidewalls of the mesa and/or cantilever. Thereafter, the Ge wires were synthesized in vapour-liquid-solid (VLS) growth mode using low pressure chemical vapour deposition (LPCVD) (Fig. 2(d)). The intention is letting the NWs grow epitaxially from the mesa sidewall towards the cantilever’s sidewall, which happens in some but by far not all cases. It is important to select those NWs which grow in the intended way across the mesa-cantilever gap using SEM after NW growth. The NWs can grow in more arbitrary, \textit{i.e.} not epitaxial, directions, as can be seen Fig. 1(c) in the main text. Also, due to a certain density of misfit-dislocations at the NW-bottom/mesa-sidewall interface the NW’s crystal orientation do not necessarily have to match the mesa’s crystal orientation. Even for the selected NWs, small (few degree) misorientations have been found by the XRD analysis. Nevertheless, in several cases NWs indeed do bridge the mesa/cantilever gap and actually also attaches to the opposite side in a very rigid manner [2]. The final processing step shown in Fig. 2(e) is to cut the cantilever end using focused ion beam milling, so that the cantilever can snap back to its original position, which strains the suspended nanowire. How much strain exactly is created in the NW in that way depends on the NW length (essentially given by the mesa-cantilever-gap width, since the cantilever pre-bending amounts only to few 10 nm), and the cantilever stiffness, determined by its geometric dimensions, which in our case are in the range of 1.9 µm width and 2.4 µm thickness of the Si device layer.

2. TEM investigation

TEM imaging was performed after the Raman and XRD experiments on the sample with NW1 and NW2. The goal was to image a single suspended NW in its as-grown state, between mesa and cantilever, in order to visualise an unaltered structure that can be compared to the present state during the previous performed experiments. This challenging task was however not successful for the presented NW1 and NW2 but on another NW grown on the same sample array. Fig. 1 a) shows a single NW attached at it’s growth starting point on the Si mesa. Note that this particular wire has a clear visible growth defect, a kink, at about 200nm from the mesa. Fig. 1 b)

References

Figure 2: (a) TEM cross-section showing Si mesa structure and Ge NW. A white rectangle illustrates the zoomed region around the growth starting point of a NW’s. (b) shows Si [111] side facet of mesa with an epitaxial Ge layer and a NW grown on top covered by an oxide layer. Moreover a crystalline NW core and an partial amorphous shell of oxide are visible.