Electronic Supplementary Information (ESI)

Localized growth and in situ integration of nanowires for device applications

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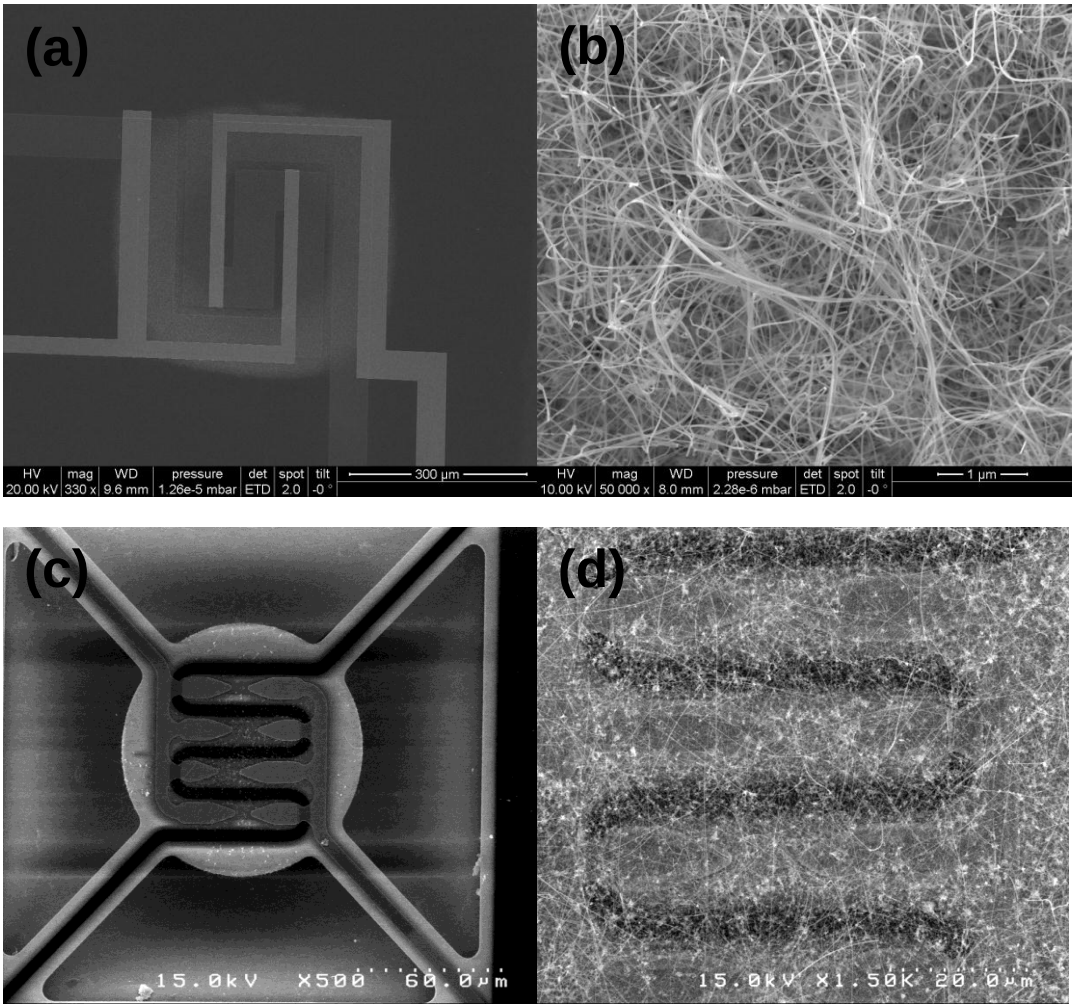

Fig. S1 (a) Site-selective growth of Ge NWs using micro-membranes and (b) SEM image of the homogeneous Ge nanowire coating. (c) and (d) show similar deposits on free-standing micro-hotplates at ~400 °C with low coverage in the centre and ~450 °C higher magnification of dense nanowire bundles at higher temperature, respectively.

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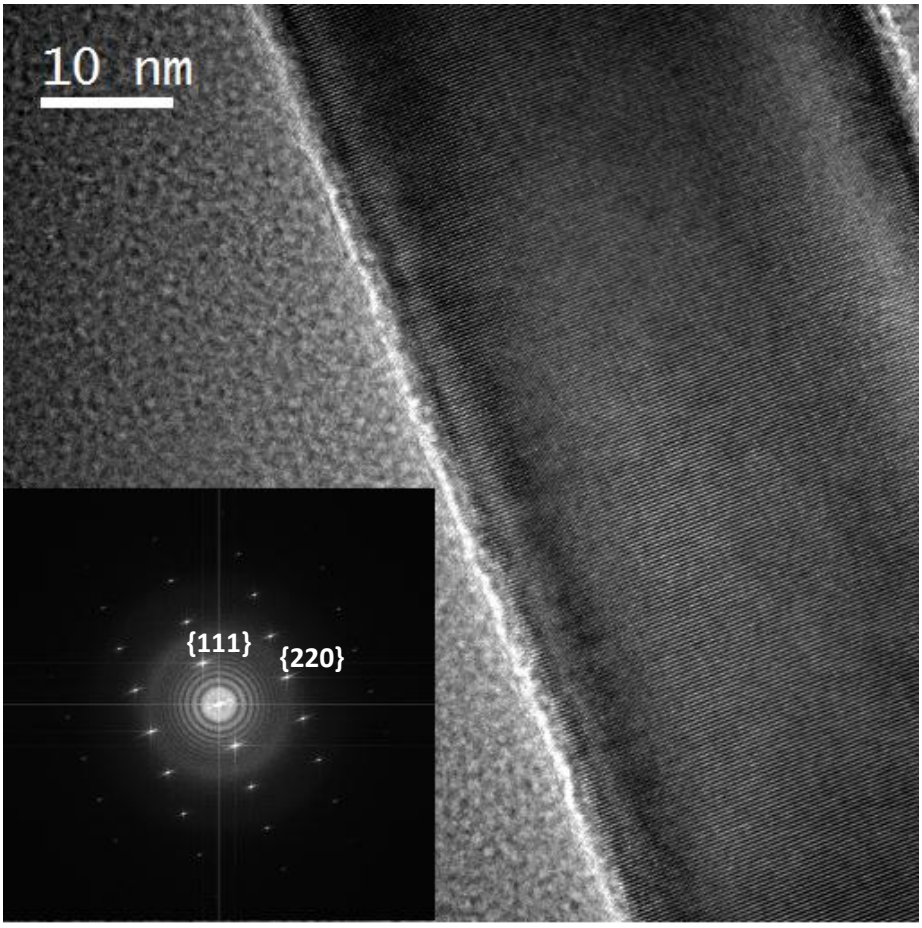

Fig. S2 HRTEM of a ⟨111⟩-oriented Ge nanowire grown on a micro-membrane illustrating the excellent crystal quality of the germanium nanowire , which is also reflected in the sharp FFT (inset).

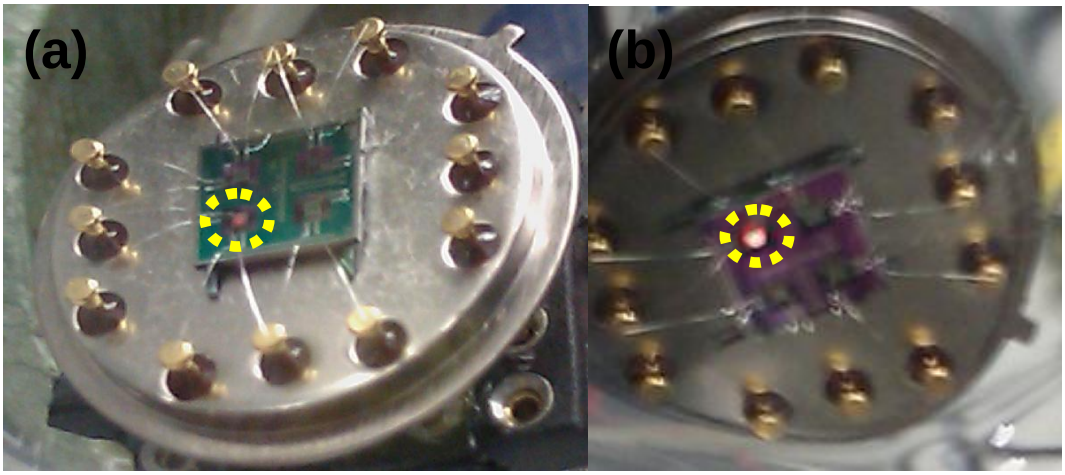

Fig. S3 Photographs of a micro-membranes heated to 700 °C in a glass chamber. The heated area is glowing due to the high temperature and indicated by yellow circles to guide the eye. Distortions in the image are due to the non-planar shape of the glass chamber used to visualize this effect.

Experimental Procedure:

Nanowire growth was achieved using a home-build cold-wall low pressure stainless steel CVD reactor with a volume of 25 ml. Diphenylgermane (50 mg) and $Sn(O^tBu)_4$ (50 mg) were used as molecular sources for the nanowire growth and kept at RT (25 °C) during the process. Substrates were coated with a 1-1.5 nm thick Au layer by sputtering. Nanowire growth was achieved by applying a vacuum of ~$4x10^{-2}$ mbar facilitating the evaporation of the molecular source, heating the respective micro-device to the appropriate temperature (400-420 °C for Ge; 700-750 °C for SnO_2) and subsequent opening of a valve between the precursor reservoir and the growth chamber.. Thermal decomposition of the vaporized precursor species allows the growth of nanowires only at the heated micro-membranes. A similar arrangement for the use of molecular species to grow thin films on inductively heated large substrates was described in a previous paper.[1] The nanowire growth duration was in the range for 2-10 mins depending on the desired length of the nanowires. The growth temperature was empirically determined by using similar pressure and changing the heating current for individual experiments. The deposits were then compared to nanowires grown on bulk substrates inductively heated by a graphite suszeptor (using 25 °C steps) to evaluate the growth temperature.

The heaters were controlled by a Keithley 2602 Source-Measuring Unit connected to a computer operating with Labview software. A constant current operation mode was employed to carry out the heating experiments, while the voltage drop was measured continuously. The electrical power was in the range of 3 mW for the 100x100 μm^2 micro-hotplates heated to 400 °C and of 48 mW for 700 °C in the case of micro-membranes, whose dimensions were 1x1 mm^2, although the heated area was only about 500x500 μm^2.

The morphology of 1D nanostructures on micro-membranes and micro-hotplates was analysed using a FEI Inspect F50 scanning electron microscope (SEM). The nanowires were deposited on lacey carbon and carbon film copper grids for TEM characterisation (Alfa Aesar) using mechanical force. In this study, we used a FEI TECNAI F20 equipped with an EDX detector.

The heating power employed to bring the gas sensor device to a suitable operating temperature of 260 ºC was 48 mW, the same value required for achieving the right growing temperature. This strong difference in temperature is related to the strong heat dissipation when in atmospheric pressure due to convection effects.

References:

1. S. Mathur, S. Barth and H. Shen, *Chem. Vapor Depos.*, 2005, **11**, 11-16.