Supporting Information.

Contacting ZnO individual crystal facets by direct write lithography.

Nikolay Petkov[1], János Volk[2], Róbert Erdélyi[2], István Endre Lukács[2], Takahiro Nagata[3], Chris Sturm[4] and M. Grundmann[4].*

1. Tyndall National Institute, Lee Maltings and Cork Institute of Technology, Rosa Avenue, Cork, Ireland.

2. MTA EK Institute of Technical Physics and Materials Science, Konkoly Thege M. út 29-33, 1121 Budapest, Hungary,

3. International Center for Materials Nanoarchitectonics, National Institute for Materials Science, 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan

4. Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig, Germany.

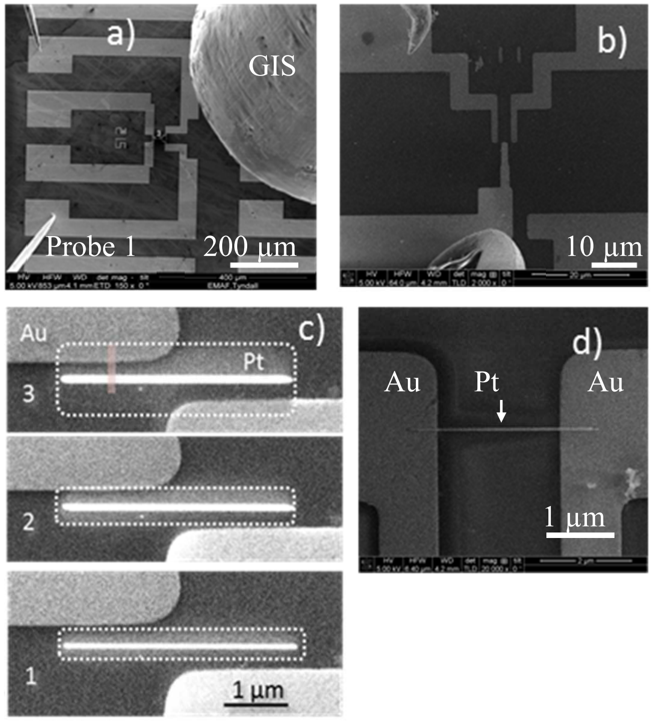


Figure S1. a) Overview SEM image of the Au test electrodes on SiO_2/Si substrate together with the electrical probes and gas-injector nozzle used for in-situ EBID/electrical testing experiments, b) SEM image of the device having the Au fingers, c) series of SEM images of step-wise EBID deposition at 5 kV, corresponding to the current *vs* nominal thickness plot for steps 1 to 3 shown in Figure 1 a) from the manuscript and d) cross-line, directly linking two Au electrodes separated by 3 μm.

The identification of the boundaries of "halo" deposits is very challenging by using top-down SEM; hence in many reports the "halo" contribution has been consistently overlooked. The challenge in imaging the range of the EBID "halo" is due to the fact that the thickness/density of Pt crystals constituting the EBID "halo" normally degrease monotonically as the range from the central Pt-line is increasing. More over the Pt crystals are surrounded by amorphous carbon matrix. Hence no sharp edge/boundary of the "halo" region exists. As contrast formation in SEM is mainly due to the difference in secondary electrons (SE) emission from surfaces/edges having different inclination to the incident beam, the absences of sharp edges at the boundaries of the "halo" deposits makes it very difficult for imaging by SEM. Previously AFM measurements have been used to estimate the boundaries of the "halo" deposits. Here we've used cross-sectional TEM imaging to observe the "halo" deposits, which are in contact to pre-made (with known distance) Au electrodes. To the best of our knowledge cross-sectional TEM images of the "halo" deposits have not been presented before.

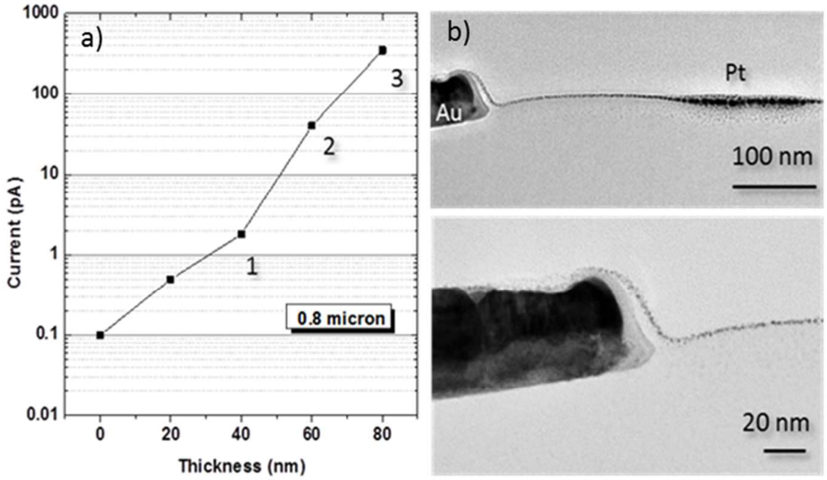


Figure S2. a) Current vs nominal thickness plot for an IBID deposited Pt line in parallel to 0.8 μm separated Au electrodes, and b) corresponding cross-sectional TEM images of the Pt line and the "halo" deposits in contact to one of the Au electrodes

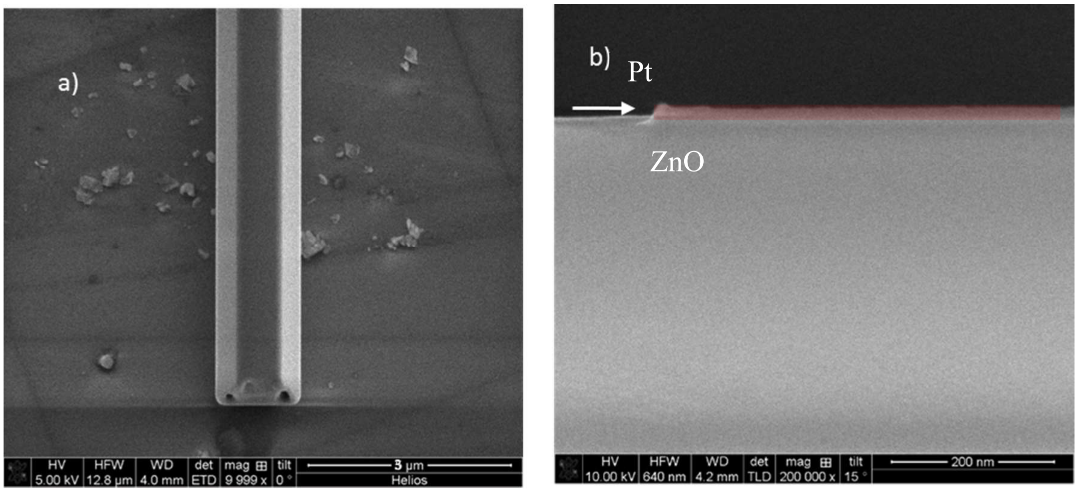


Figure S3. a) Top-down SEM image of a 710 nm in diameter, well-faceted ZnO wire on a SiO_2/Si substrate used to write Pt EBID lines on the side-wall facets and additional extension lines to contact pads for electrical testing, and b) high-resolution SEM image of one of the sidewall facets after developing a Pt-line on top (marked in red).

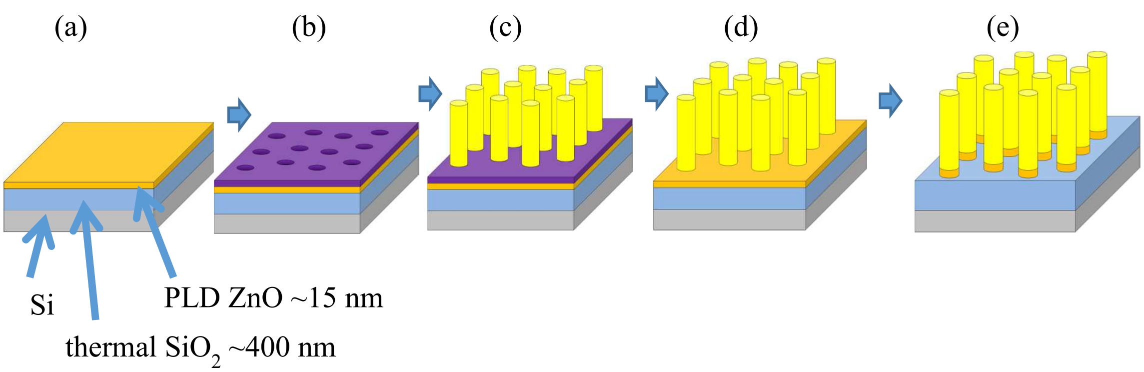
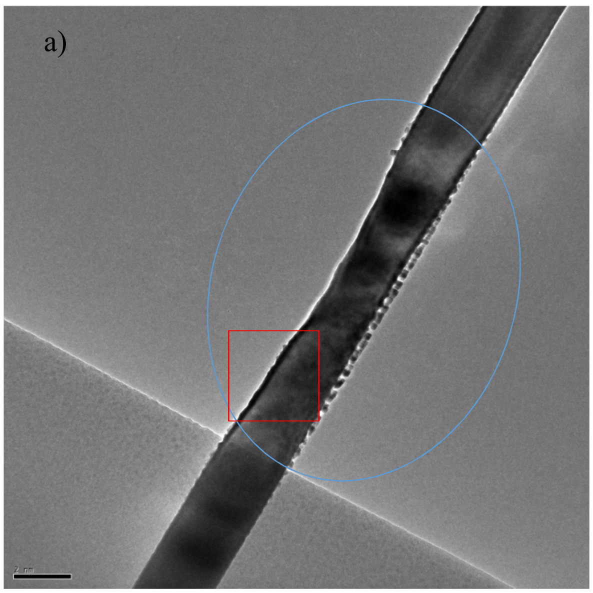


Figure S4. Schematics of the process flow used to grow ZnO pillar arrays used in the study. a) PLD deposition of ZnO seed layer, b) E-beam lithography defined aperture arrays in PMMA , c) ZnO hydrothermal growth, d) PMMA removal and e) Ar-ion etching of the ZnO seed layer to electrically insulate the pillar structures.

Figure S5

We did not observe any measurable (by TEM) structural damage at the Pt/ZnO interface post EBID. Lattice resolution TEM at 200 kV (images shown below) of grown ZnO wires dispersed onto TEM grids showed degradation of the ZnO crystal quality, hence only lower resolution (low dose) imaging was adopted. Notably, image formation under diffraction contrast conditions (in bright or dark field, not at lattice resolution) can be indicative for formation of crystal defects including point defects and extended amorphous regions as we have demonstrated before[1].



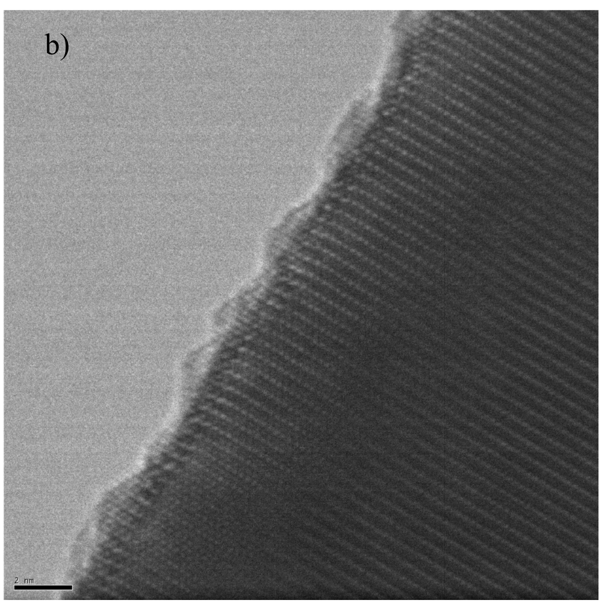


Figure S5. a) Lower resolution TEM image of a grown ZnO wire (80 nm in diameter) after imaging at lattice resolution in the marked area, and b) corresponding lattice resolution image from the area marked in red in S4a.

Reference:

1) Roisin A. Kelly, Bartosz Liedke, Stefan Baldauf, Anushka Gangnaik, Subhajit Biswas, Yordan Georgiev, Justin D. Holmes, Matthias Posselt, and Nikolay Petkov Epitaxial Post-Implant Recrystallization in Germanium Nanowires, *Cryst. Growth Des.* **2015**, *15* (9), 4581–4590