Electronic Supplementary Information (ESI): †

Supporting information on:

Low-temperature ZnO nanowire array growth on inkjet-printed patterns of zinc acetate

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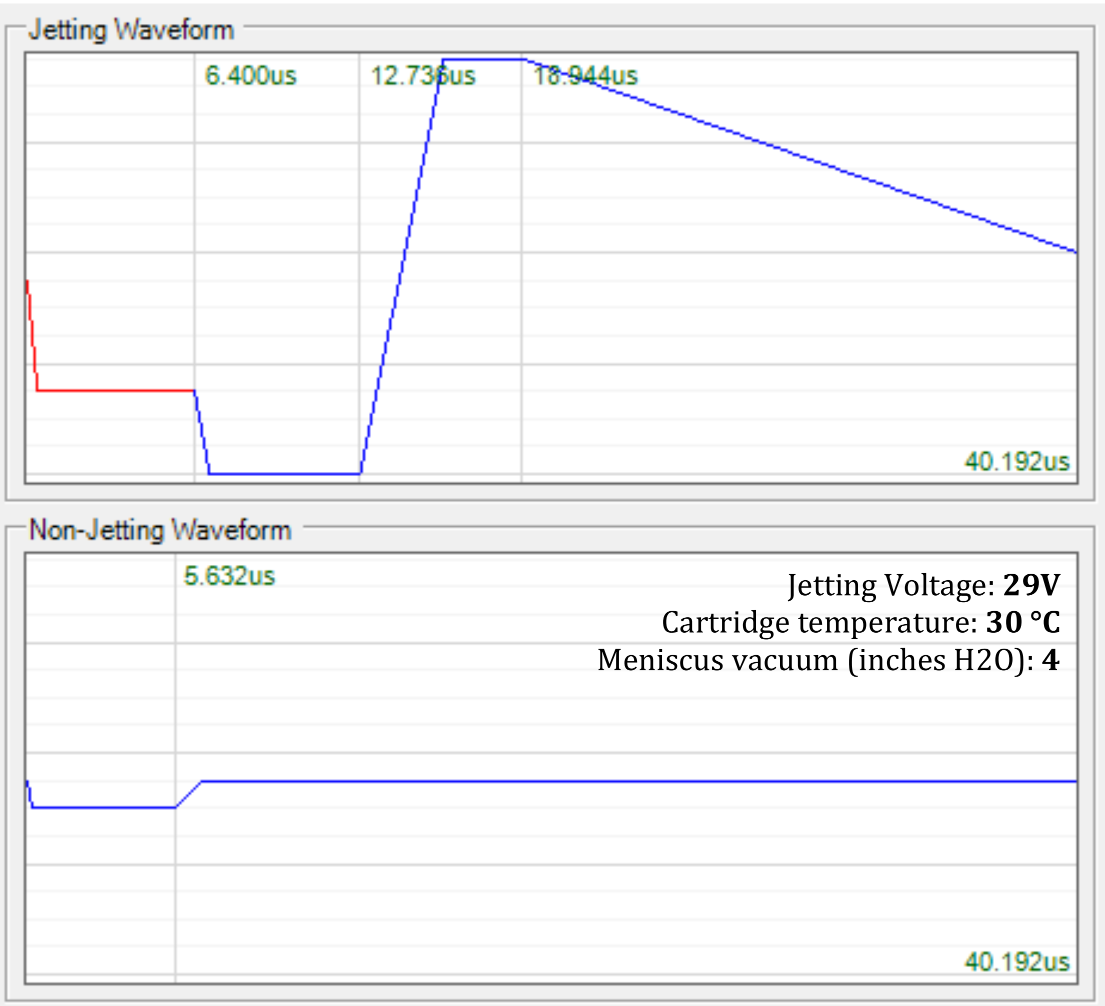

Fig. S1 Plots of jetting and non-jetting waveforms given with additional printing parameters implemented inside.

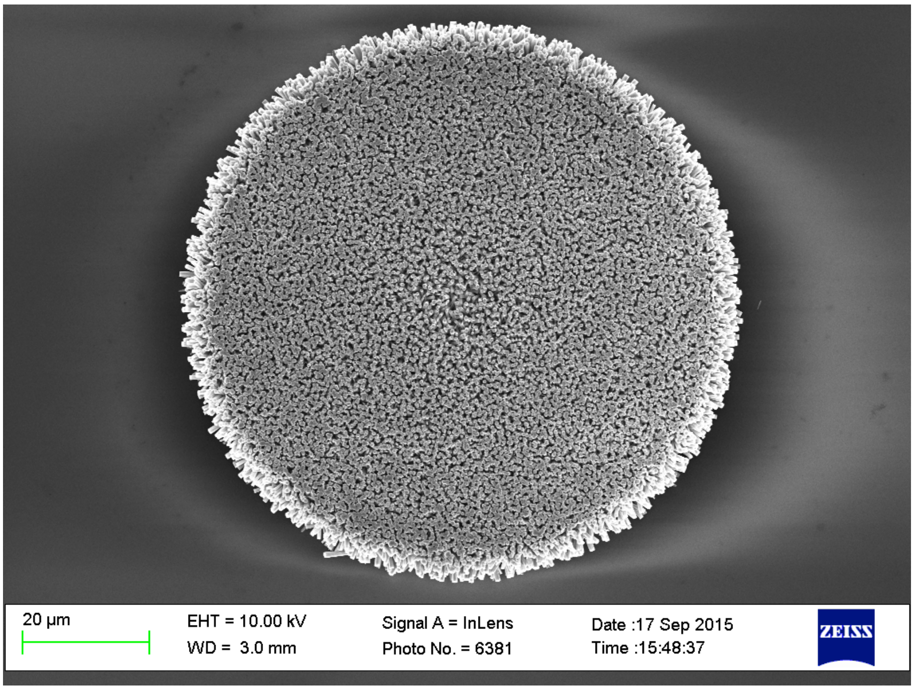

Fig. S2 ZnO nanowires grown on 1-pass printed layer at 60°C.

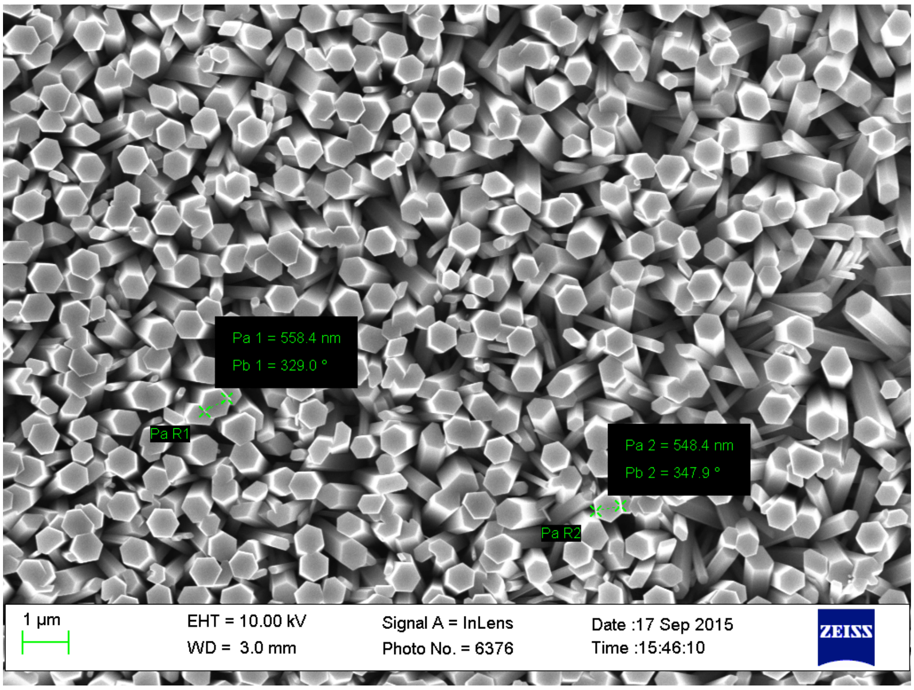

Fig. S3 ZnO nanowires grown on 1-pass printed layer at 60°C.

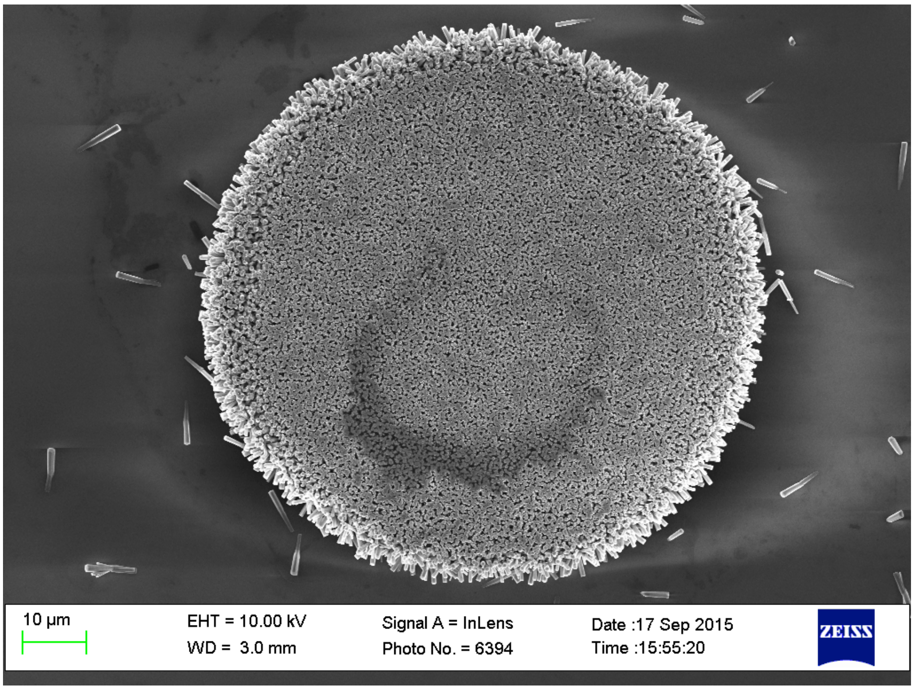

Fig. S4 ZnO nanowires grown on 3-pass printed layer at 60°C

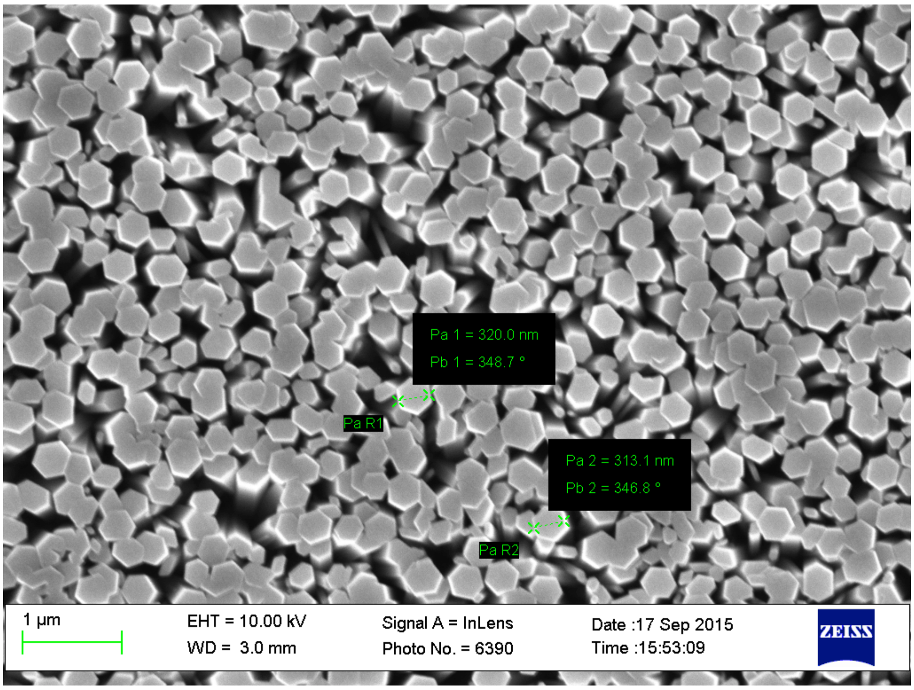

Fig. S5 ZnO nanowires grown on 3-pass printed layer at 60°C.

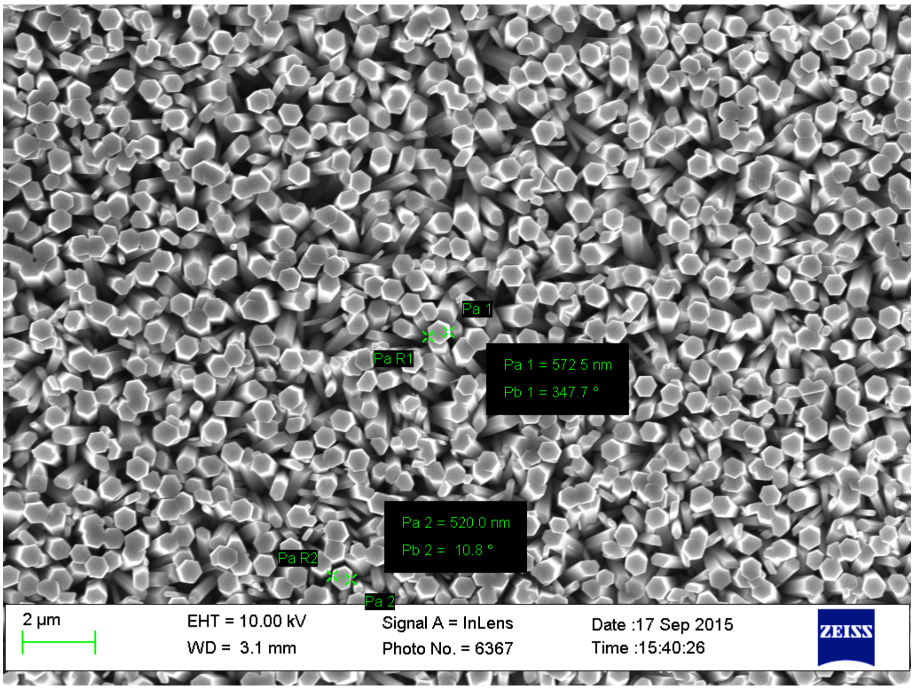

Fig. S6 ZnO nanowires grown on 3-pass printed layer at 50°C. Higher magnification.

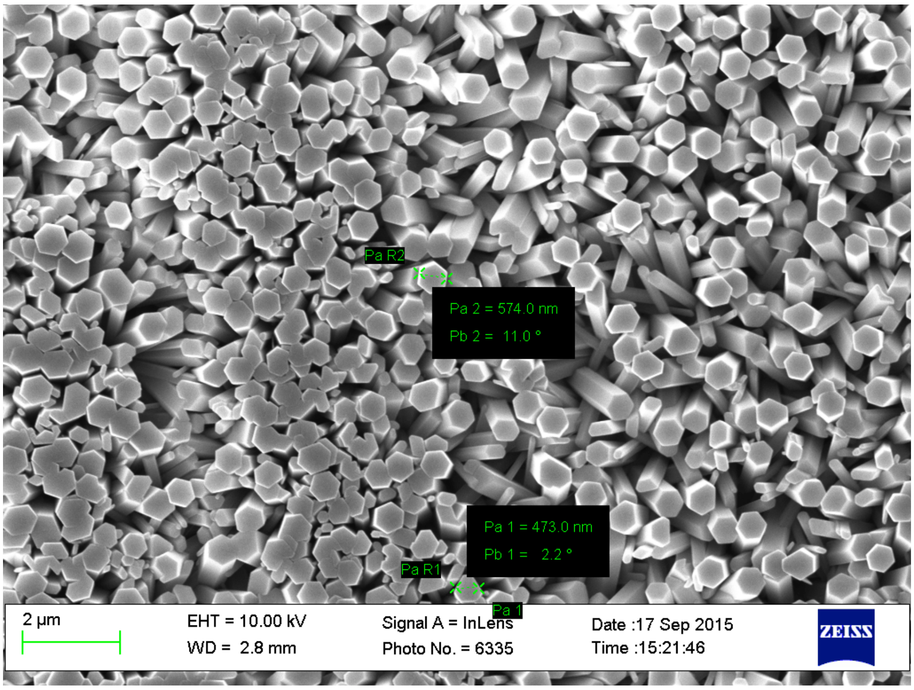

Fig. S7 ZnO nanowires grown on 3-pass printed layer at 40°C. Higher magnification.

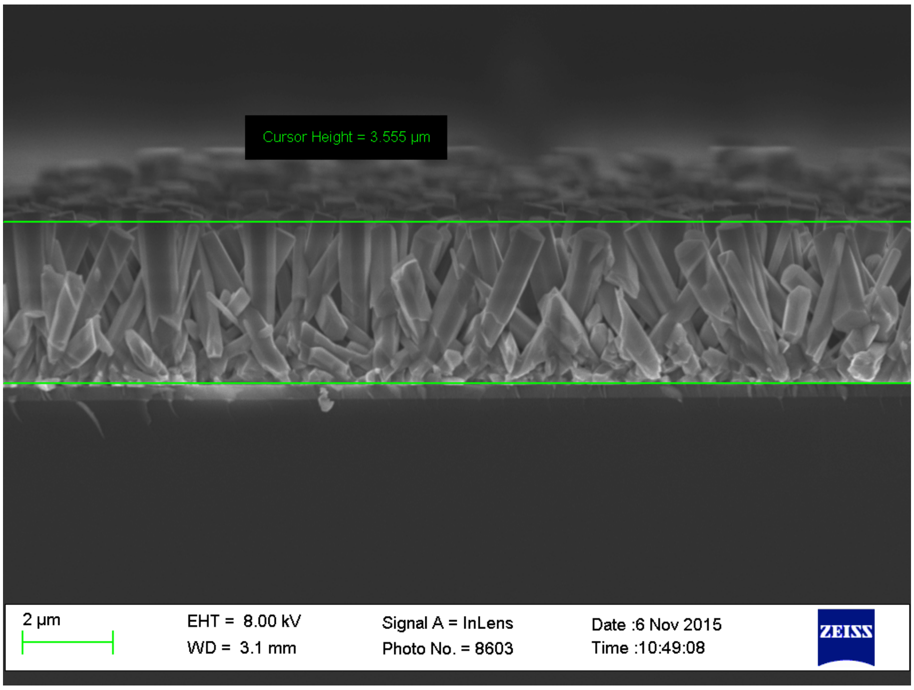

Fig. S8 Cross-sectional view of ZnO nanowires grown on 1-pass printed layer at 60C. Notice the scale.

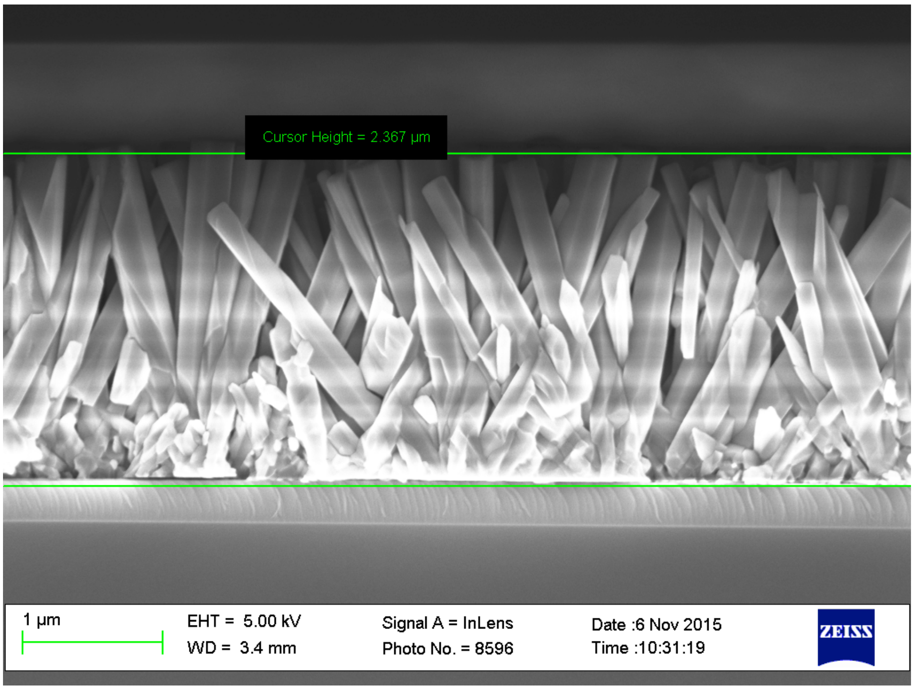

Fig. S9 Cross-sectional view of ZnO nanowires grown on 3-pass printed layer at 60C. Notice the scale.

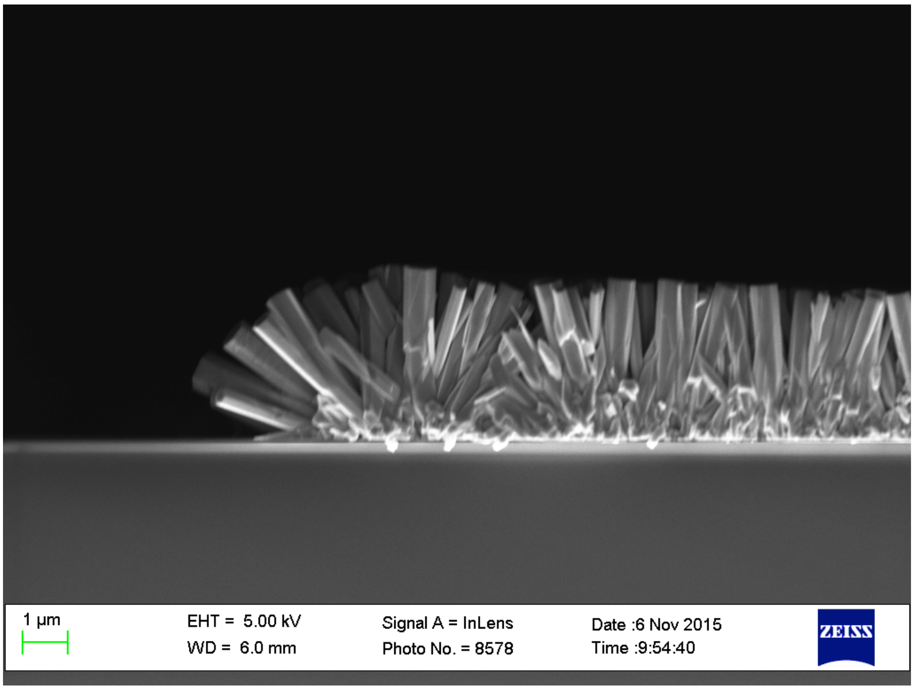

Fig. S10 Urchin-like orientation of ZnO nanowires at the edge of a pattern.

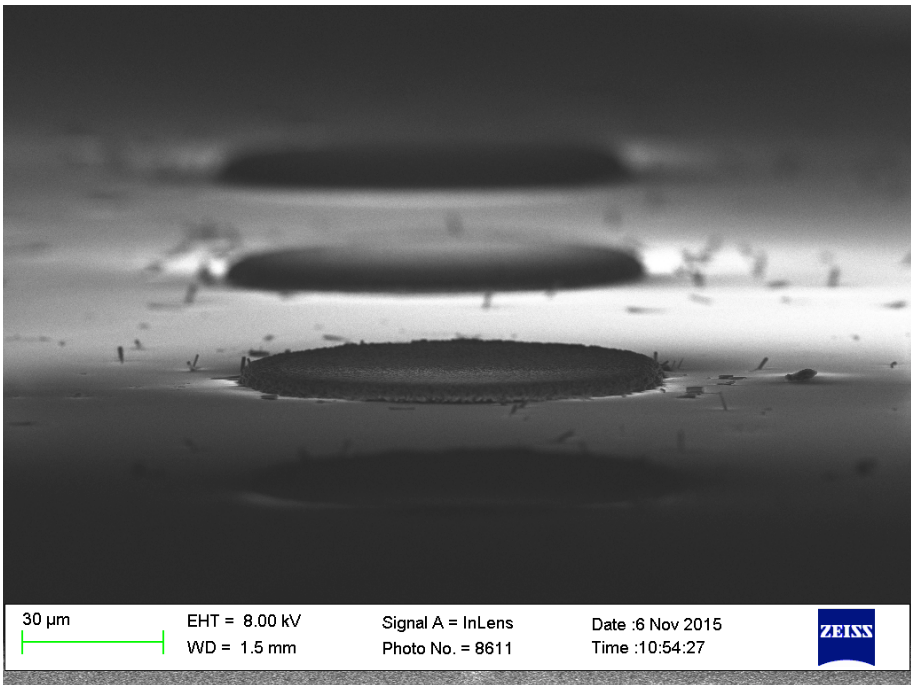

Fig. S11 SEM image of ZnO nanowire patterns from an angle.

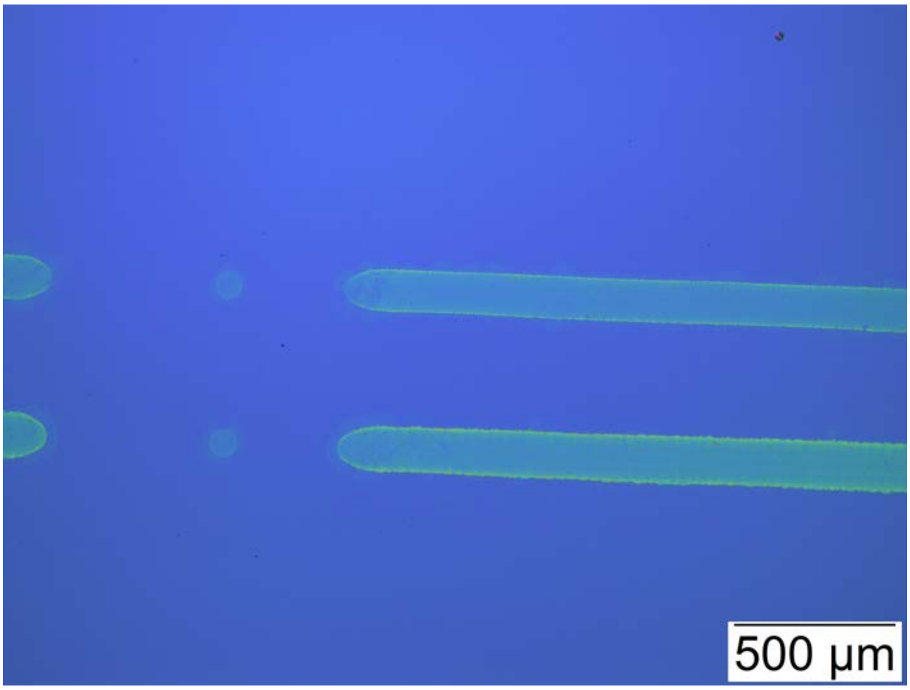

Fig. S12 Optical microscopy picture of printed seed layer with dot spacing at 35μm. It shows that it can successfully form a straight and continuous line.

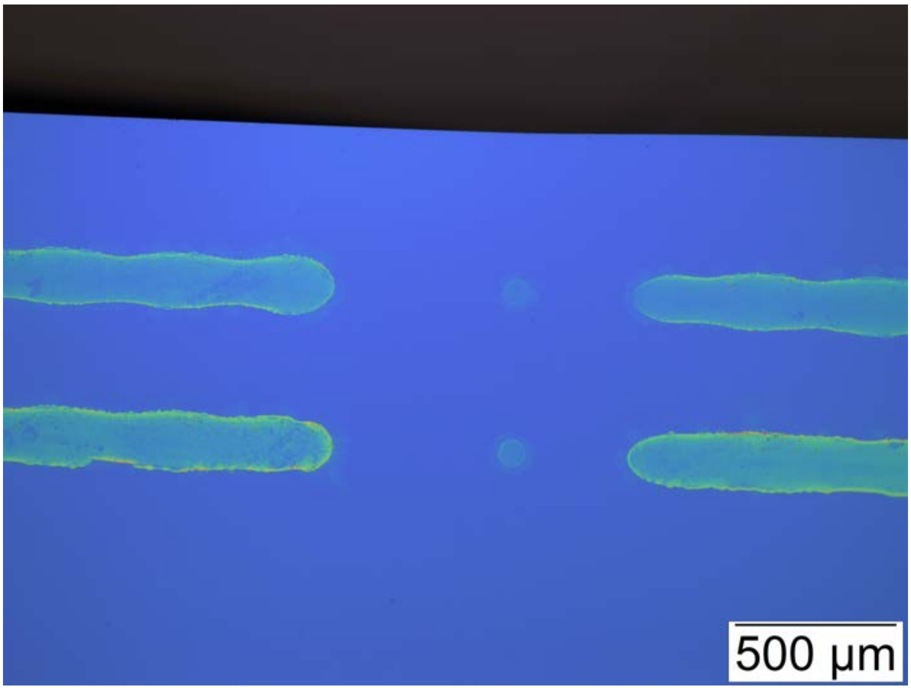

Fig. S13 Optical microscopy picture of printed seed layer with dot spacing at 25μm. It unsuccessfully produces a line formed of bulges instead of straight and continuous line.

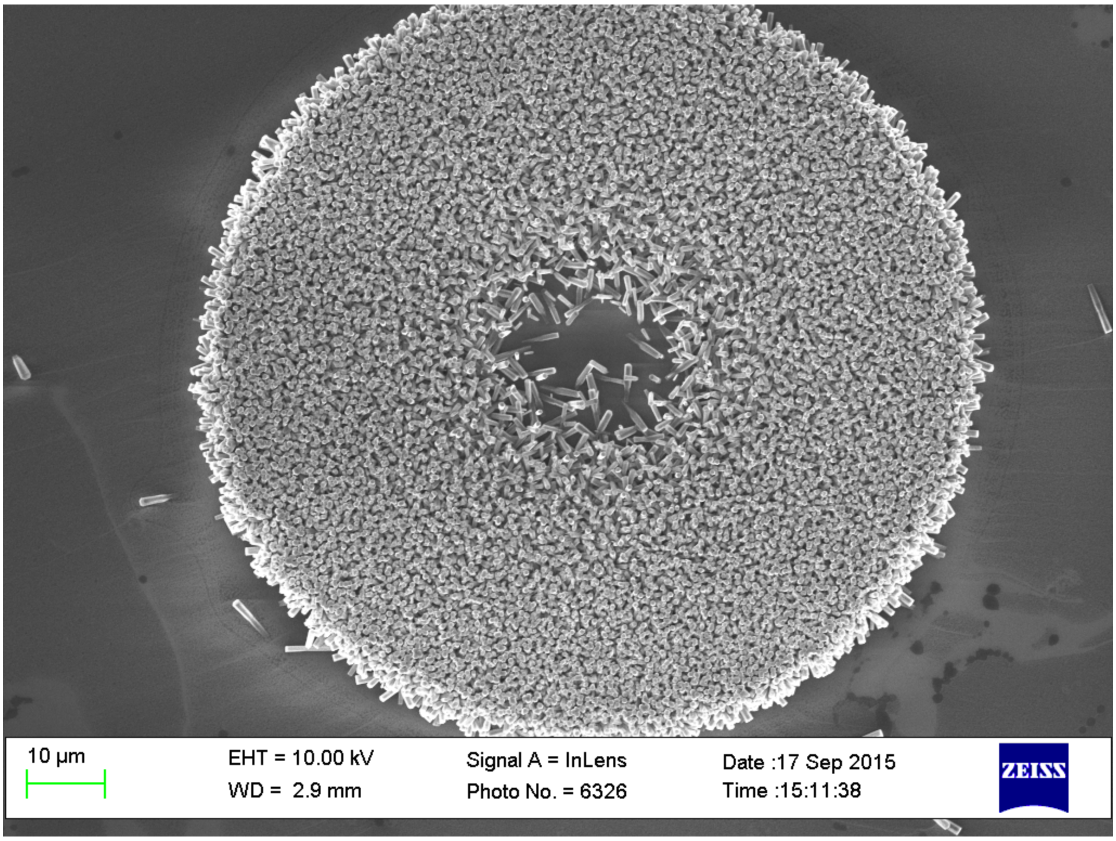

Fig. S 14 ZnO nanowires grown on 1-pass printed layer at 60°C.

Substrate Temperature	Nanowire Diameter (edge)	Nanowire Diameter (center)	Density of Nanowires
40°C (Fig. S14)	1100 nm	580 nm	Low
60°C (Fig. S2)	776 nm	564 nm	High

Table 1 Comparison of density and individual nanowire diameter at substrate temperatures of 40°C and 60°C.

Some insight info on the role of HMTA on growth mechanism:

The contribution of HMTA in the growth of ZnO nanowires plays an essential role but its mechanism was highly debatable among different works. Some have claimed that HMTA does adsorb on certain ZnO crystal faces and thus hinders their growth while allowing the c-axis growth, enhancing in this way the vertical orientation. However, according to the results of our work we have seen that for the same concentration of HMTA we could get nanowires with angular deviations in respect to the normal of the substrate. To our knowledge and understanding, the orientation (verticality) of ZnO nanowires grown in our work, strongly depends on the density of nanowires and their size. We have identified that at higher densities of nanowires, the alignment of them was more vertical than for less-dense nanowires. This must be due to the smaller gap in-between the nanowires that does limit their degree of freedom. They are forced from the very beginning to grow vertical since the faces that are responsible for lateral growth are restricted in contact with nutrient solution. However, the sparse nanowires are allowed to start growing with a small angle of deviation that ends into not so vertical alignment. This is also seen in the work of Z.H. Ibupoto et al..[1]

Interestingly, K. Mcpeak et al.[2] have done an in situ attenuated total reflection furrier transform infrared (ATR-FTIR) spectroscopy study and have shown that HMTA does not adsorb on the faces of ZnO at all. What they had shown though, is that HMTA indeed decomposes slowly in the usual conditions (temperature, solvent, time) and due to this mechanism, there is a steady production of OH^- that is responsible for the low saturation index of ZnO. Therefore, by controlling the concentration of OH^- and the rate of its addition, someone can adjust both density and crystallinity.

References

1 Z. H. Ibupoto, K. Khun, M. Eriksson, M. Alsalhi, M. Atif, A. Ansari and M. Willander, 2013, 3584–3597.
2 K. M. Mcpeak, T. P. Le, N. G. Britton, Z. S. Nickolov, Y. A. Elabd and J. B. Baxter, 2011, 3672–3677.