Fabrication and characterization of zinc oxide nanoneedles for medical/biological applications

Atif Syed[a], Vasileios Koutsos, Enrico Mastropaolo[b]
School of Engineering, The University of Edinburgh, EH9 3JL, Edinburgh, UK
[a]*a.syed@ed.ac.uk ;* [b]*e.mastropaolo@ed.ac.uk*
Monika Warzecha, Dimitrios Lamprou
Inst. of Pharmacy and Biomedical Sciences, University of Strathclyde, G4 0RE, Glasgow, UK

Over the past few years, zinc oxide (ZnO) nanostructures have attracted large interest among the scientific community due to their unique optical and electrical properties. Some recent applications include biosensors[1], nanogenerators[2] and dye-sentisized solar cells[3]. The intrinsic biocompatibility of ZnO makes nanowires promising candidates for nanomedicine applications[4,5]. In particular, for drug delivery applications, the nanostructures should be chemically and morphologically stable at human body temperature (37^oC) for a prolonged period of time. Furthermore, the nanostructures should be resistant to different pH values in order to ensure drug encapsulation or release[6,7]. Although work has been done to explore the use of ZnO nanostructures in drug delivery, more studies are needed in order to investigate their chemical and morphological stability at different conditions (pH and temperature) for a prolonged period of time.

In this paper, vertically-aligned ZnO nanoneedles (NNs) (i.e., nanowires with conical shape) have been prepared using hydrothermal synthesis on 300-nm-thick zinc (Zn) seed layer. The ZnO NNs have been heated at temperature of 50° C for up to 2 weeks and Figure 1 shows x-ray diffraction (XRD) spectra taken for different heating times. When increasing the heating time from 16 to 47 hours, the sharp peak at 35 deg. (ZnO NNs aligned in the c-direction) remains unchanged while the amplitude of the peak at 36.5 deg. (Zn seed and ZnO) increases most likely due to the removal of impurities arisen from the chemical synthesis. Atomic force microscopy (AFM) of ZnO NNs as-synthesized (Fig 2(a)) and heated for 2 weeks (Fig 2(b)) reveals that the shape of the structures is unaffected when exposed at 50° C for prolonged time. Scanning electron micrographs of the ZnO NNs show that the structures have no apparent morphological change when immersed in phosphate-buffered saline for 24 hours (PBS, pH=7.4) (Figure 3). Preliminary results indicate that the average diameter tends to decrease when increasing heating time probably due to the removal of surface impurities during heating.

In this paper, further investigations and discussion on the influence of temperature on diameter, length and chemical properties of ZnO NNs will be presented together with the effect of different pH (from acidic to highly basic). This work creates the foundation for using ZnO nanostructures for drug delivery applications.

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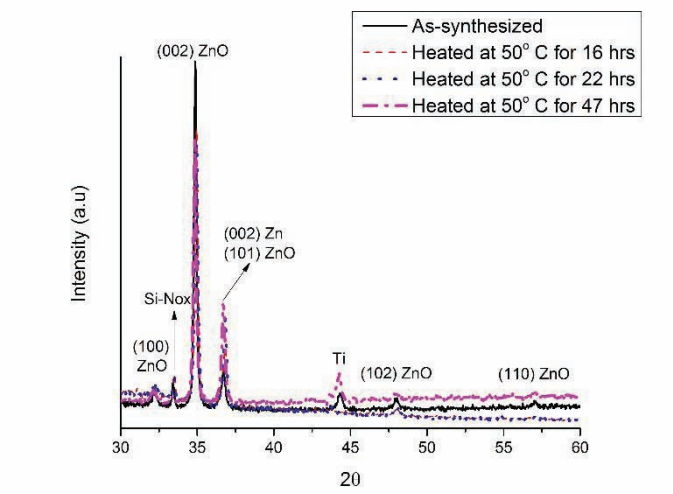

Figure 1: XRD spectra of as-synthesized ZnO NNs and heated at 16, 22 and 47 hours.

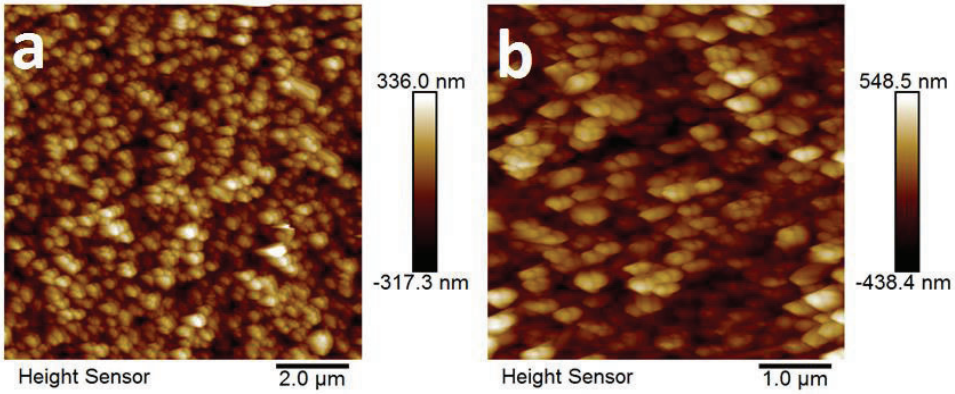

Figure 2: AFM height images of (a) as-synthesized and (b) heated at $50^{o}C$ for 2 weeks ZnO NNs

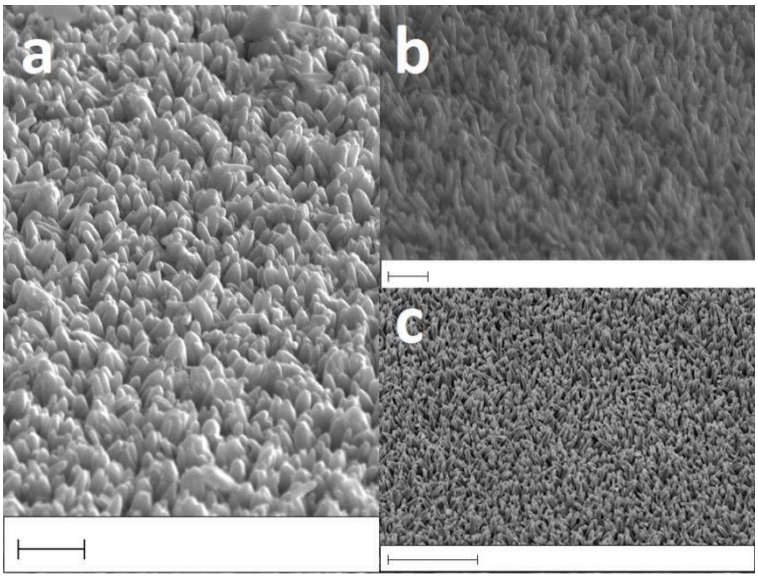

Figure 3: SEM images of (a) as-synthesized, (b) heated at $50^{o}C$ for 2 weeks and (c) immersed in PBS solution for 24 hours ZnO NNs. Scales: (a, b) 1 micron (c) 5 microns