

ABSTRACT

In this work, long thread like ZnO nanowires with faster growth rate is synthesized on silicon substrate by limited volume heating system in presence of ammonium hydroxide (NH₄OH) solution. Hydrothermal synthesis of ZnO nanowires were carried out using zinc nitrate and hexamethylenetetramine (HMTA) precursors for different process duration. The morphological and structural study of ZnO nanowires were investigated by scanning electron microscopy (SEM), x-ray diffraction (XRD) and high resolution transmission electron microscopy (HRTEM) techniques. EDS mapping was used to investigate the elemental analysis of the material. ZnO nanowires with long thread like morphology spread throughout the substrate have been observed. The average length of the ZnO nanowires is found to be around 21 μm with a growth rate of 2.8 μm/hour for a growth period of 7.5 hours. XRD pattern of ZnO nanowires clearly reveal that the ZnO nanowires are primarily grown along the c-axis direction. TEM images further confirm the formation of ZnO nanowires and HRTEM image depicts that nanowires have good crystalline properties. EDS mapping shows the uniform distribution Zn and O element throughout the nanowire.

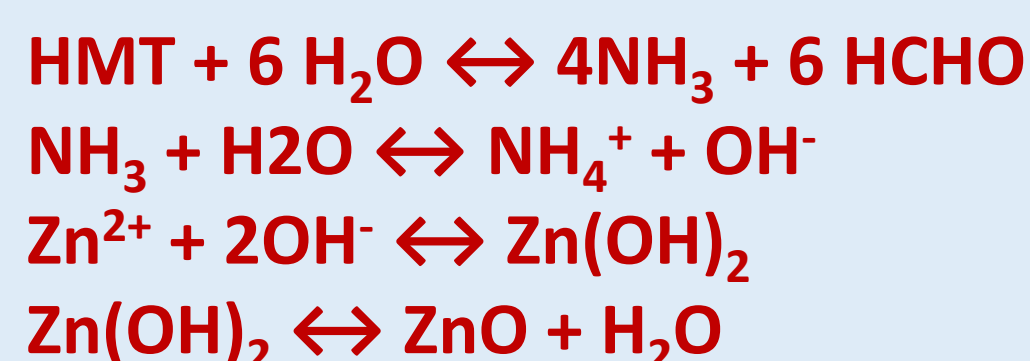
Keywords: Ultralong, Nanowires, ZnO, Ammonia,

INTRODUCTION

➤ ZnO nanostructures has drawn tremendous consideration due to its versatile properties like wide bandgap.

➤ Longer length and higher specific area of the nanowires (NWs) provide a pathway for the rapid and lossless transport of charge carrier and photon.

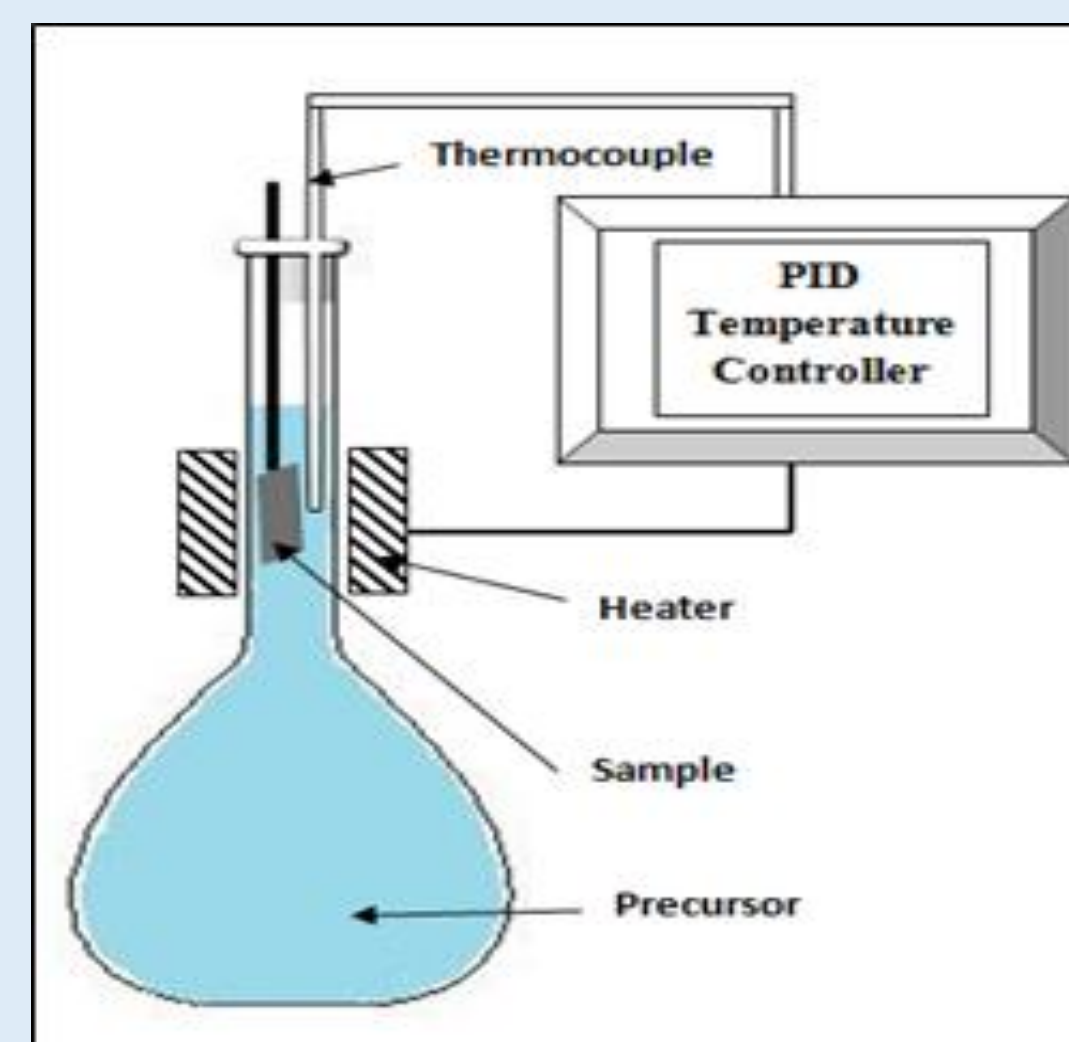
➤ The key way to achieve high specific surface area and aspect ratio of ZnO NWs is to increase the length of NWs.



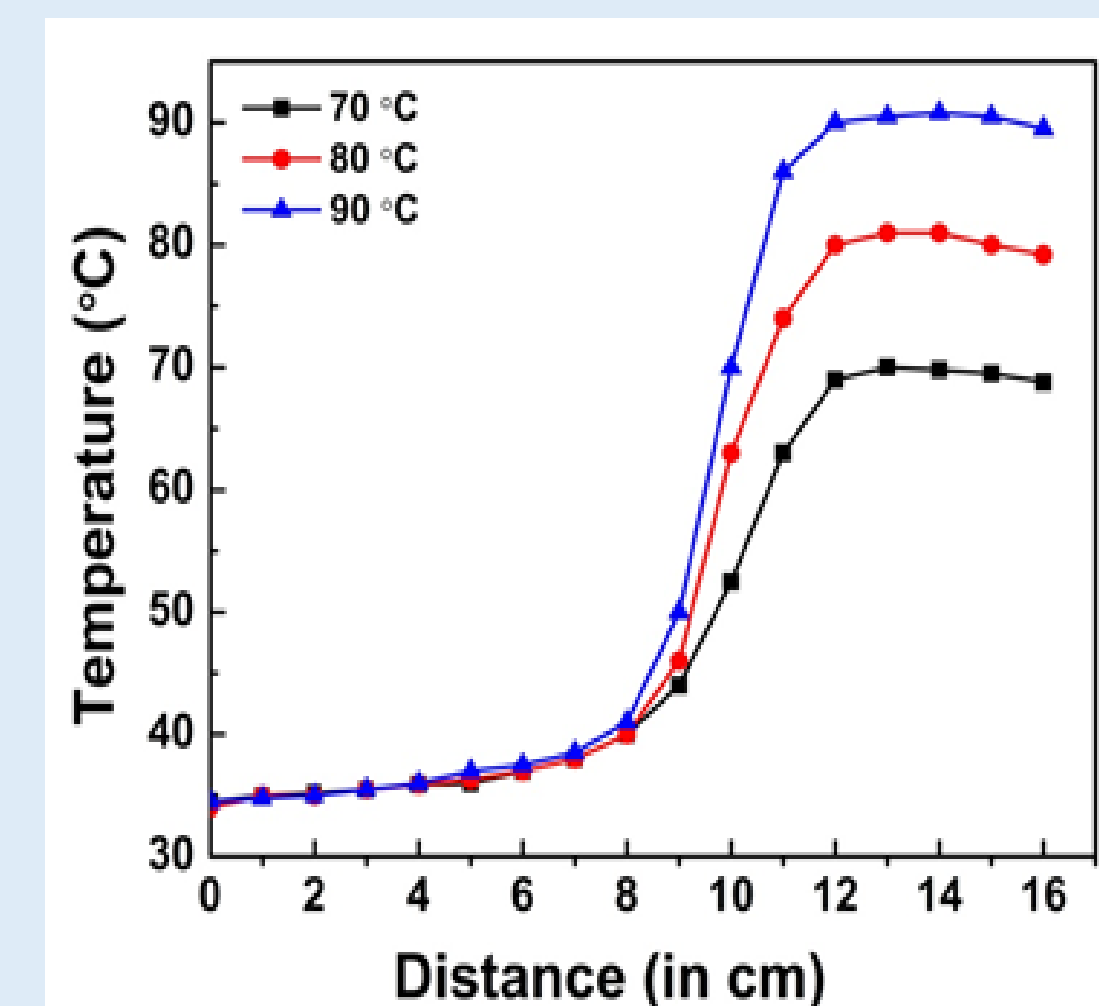
➤ The synthesis of ZnO nanostructures by hydrothermal method is mostly adopted due to its simplicity, low cost and low process temperature. But, in this method homogeneous nucleation occurs due to the rapid depletion of reactants and as a result, growth rate of ZnO NWs slows down.

➤ Addition of ammonia can suppress the homogeneous nucleation of ZnO by forming complexes with zinc ions and enhance the growth rate of ZnO NWs.

EXPERIMENTAL DETAILS

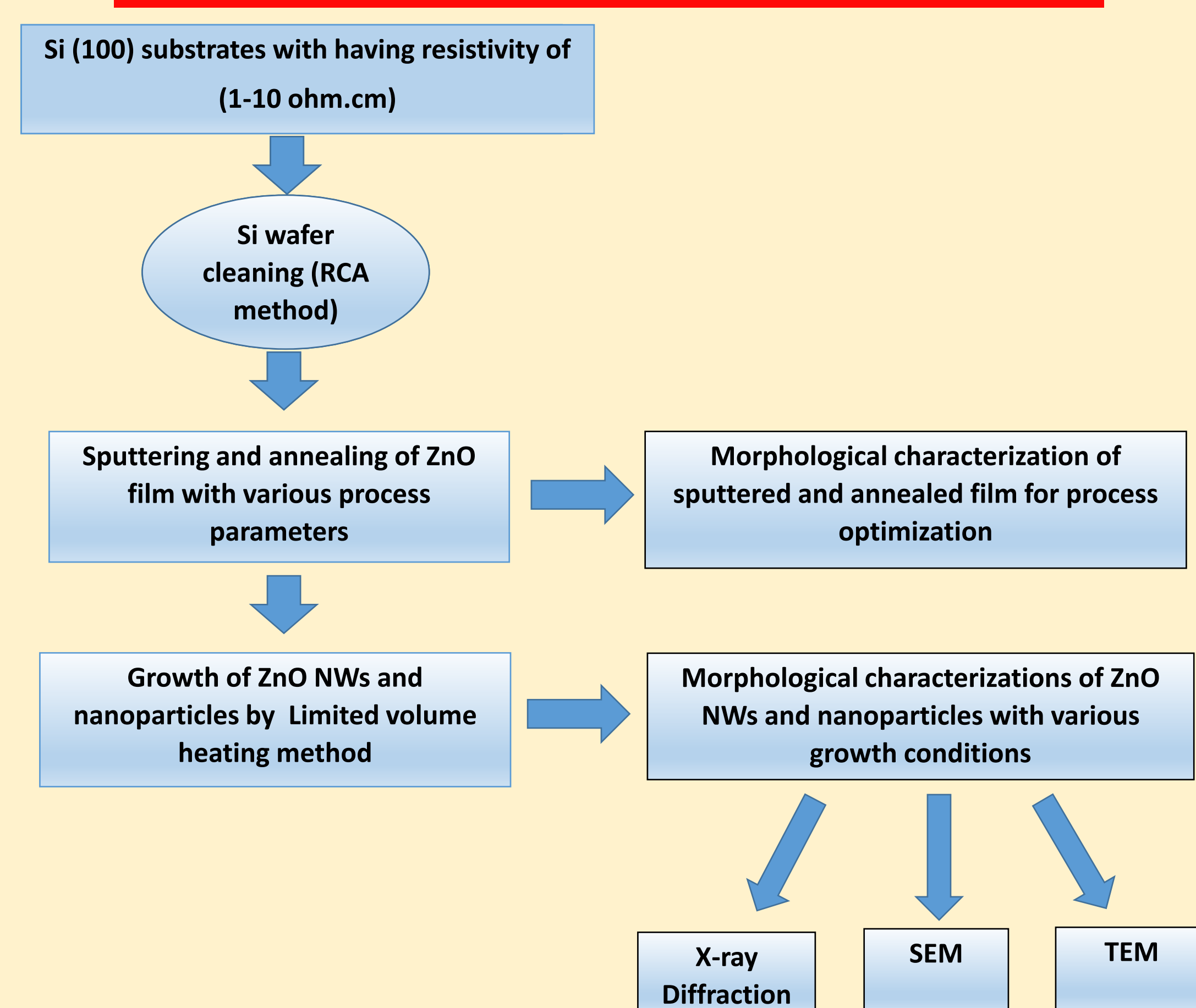


The schematic layout of the limited volume heating system for the growth of ZnO nanowires.

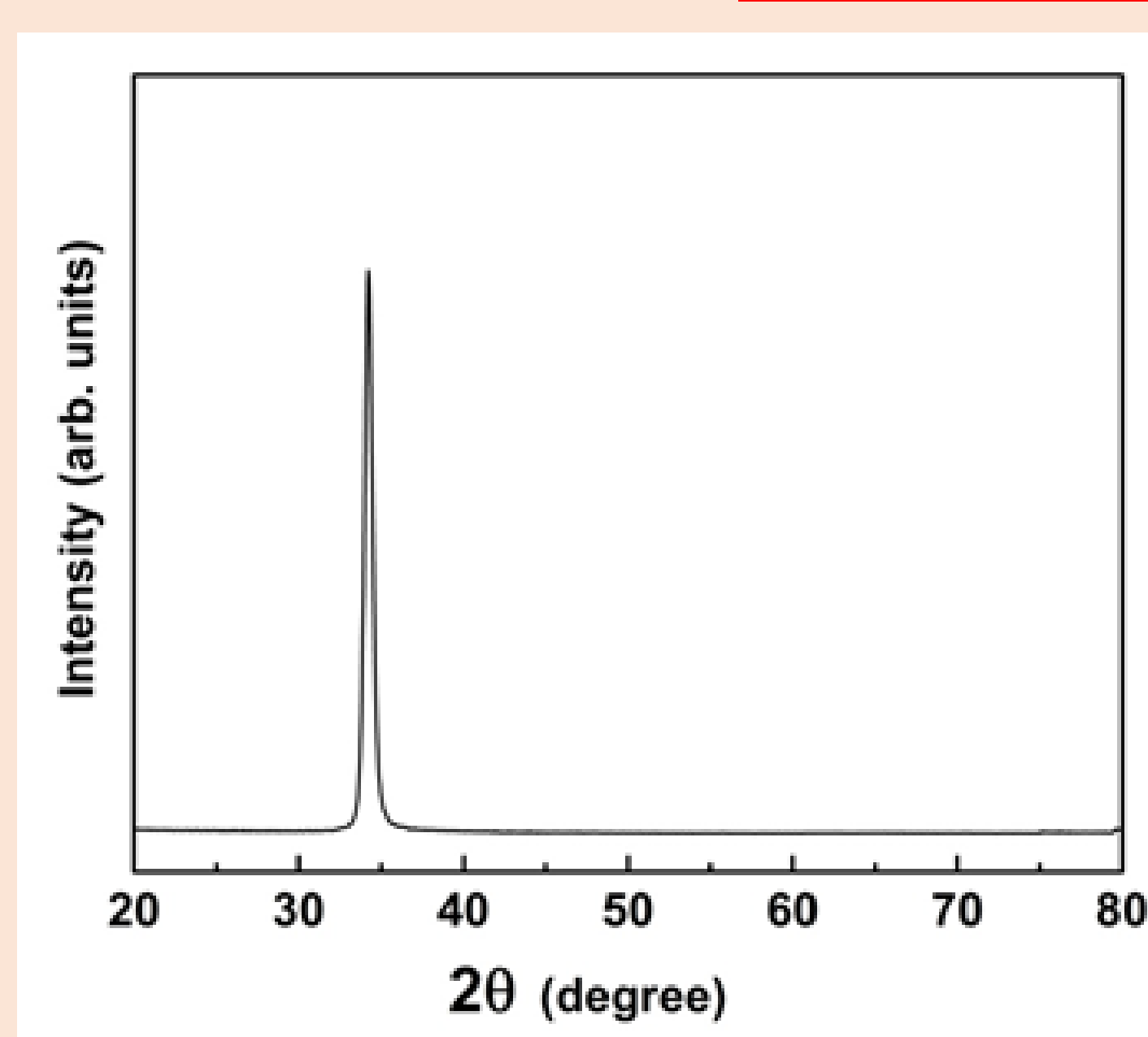


The vertical temperature profile of the limited volume heating system with variation in distance from the bottom of the vessel to the growth region.

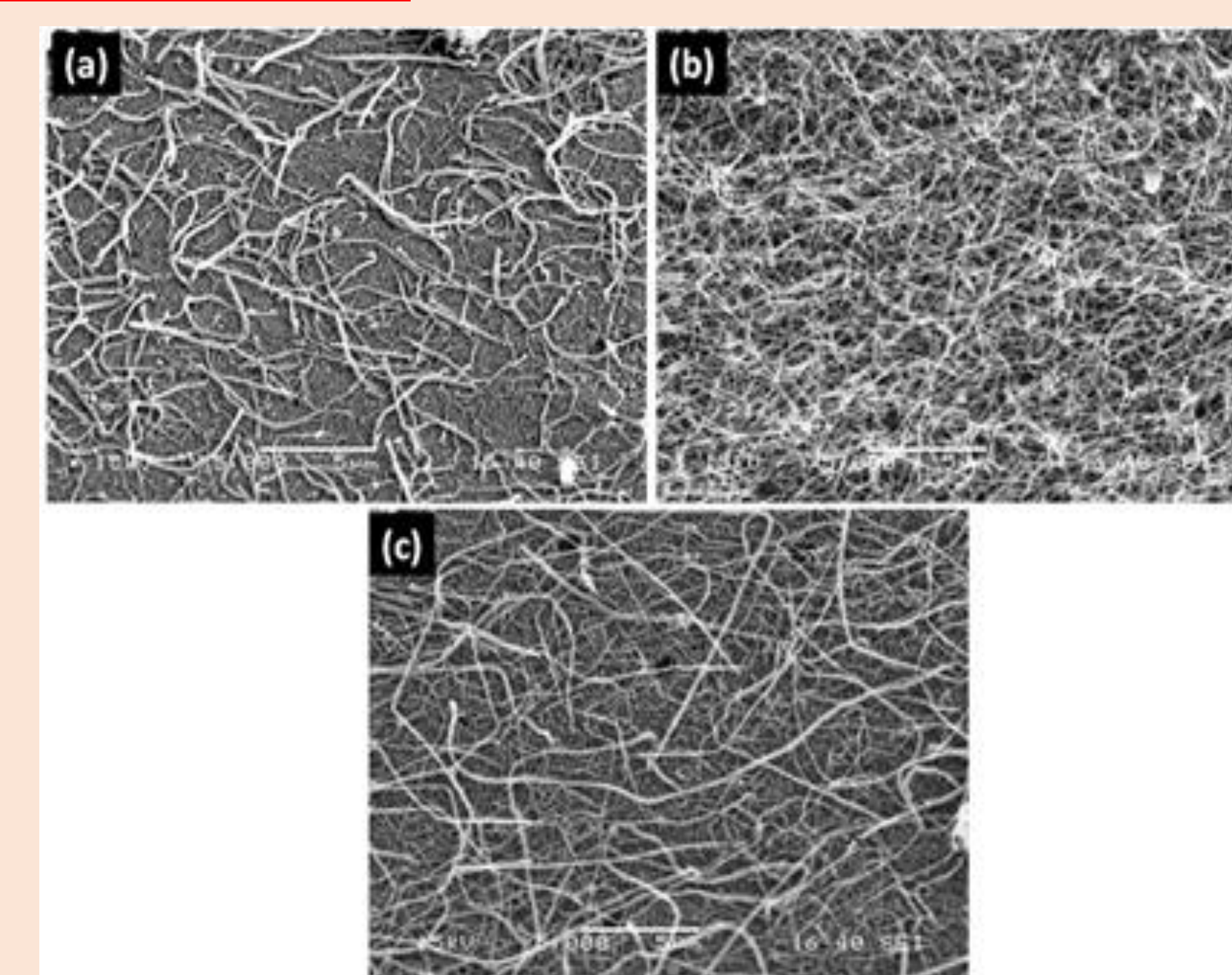
ZnO NANOWIRES GROWTH FLOW CHART



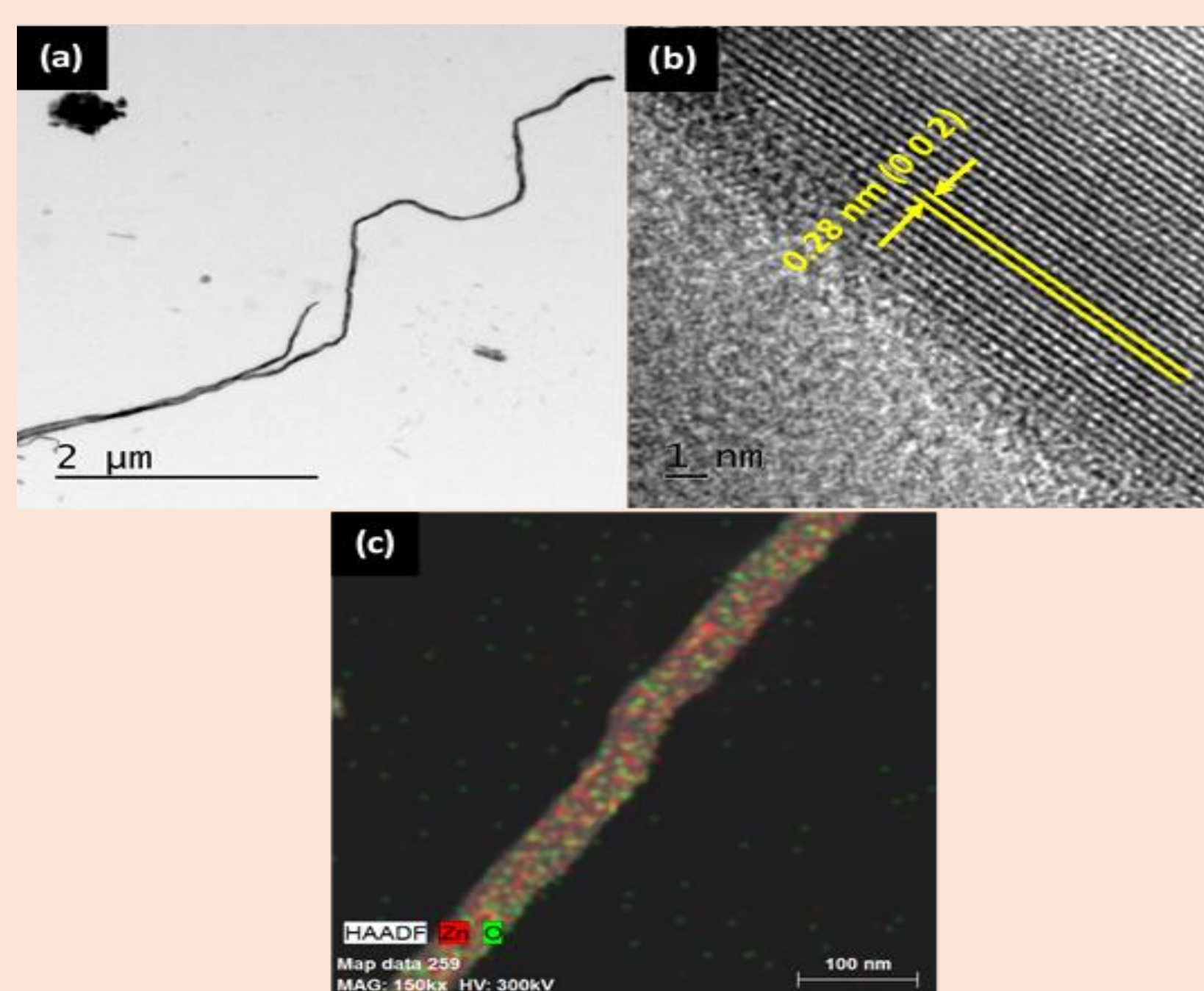
RESULT AND DISCUSSION



X-ray diffraction patterns of ZnO nanowires with concentration of Zn (NO₃)₂ 0.025 M and Hexamethylenetetramine of 0.0125 M grown at 90 °C for 7.5 hr.



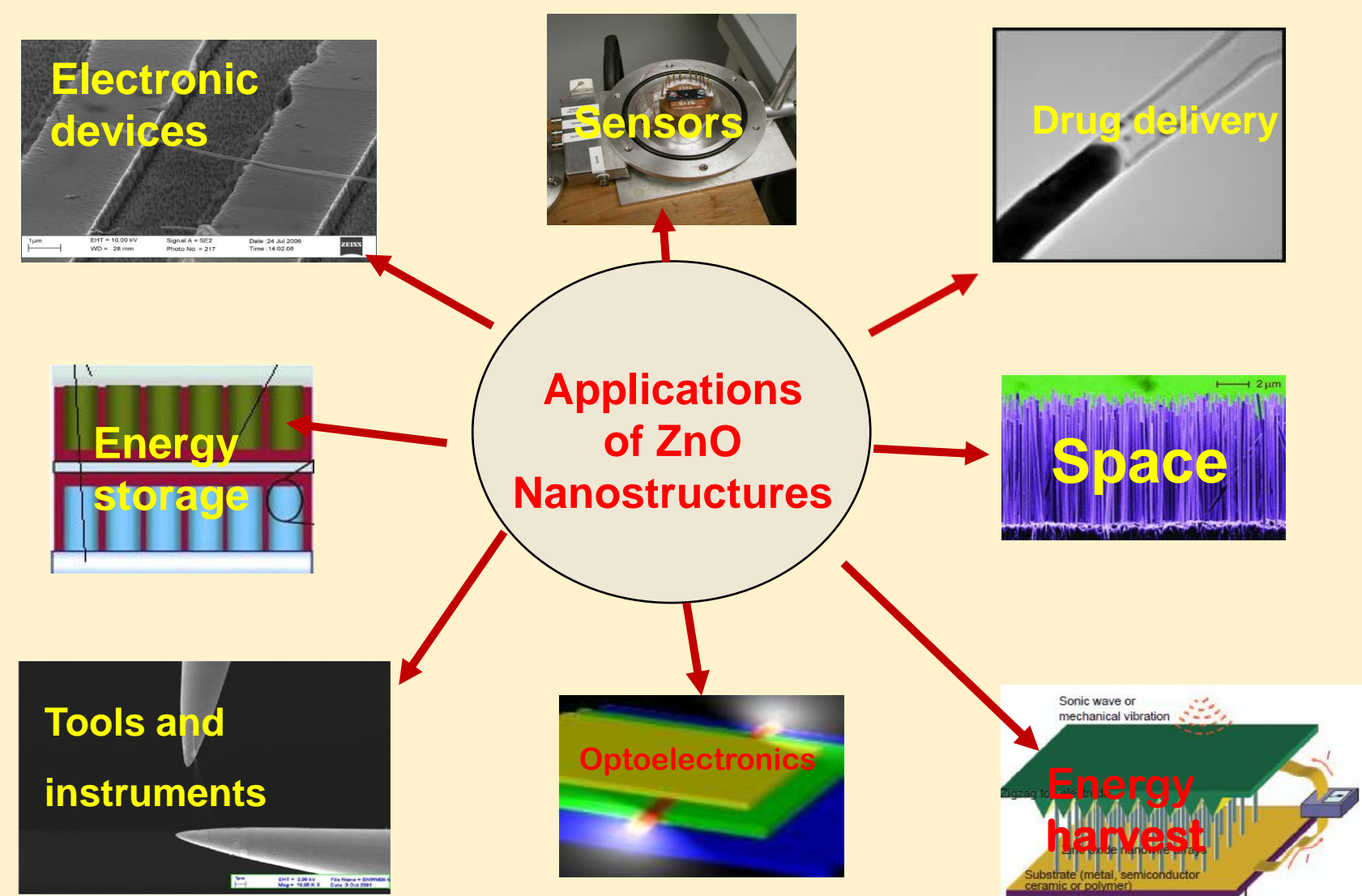
SEM images of ZnO nanowires at concentration of Zn (NO₃)₂ 0.025 M and Hexamethylenetetramine of 0.0125 M grown at 90 °C for (a) 2.5 hr, (b) 5 hr, (c) 7.5 hr. The scale bar represents 5 μm.



(a), (b), (c) TEM, HRTEM image and EDS mapping of single ZnO nanowire with concentration of Zn (NO₃)₂ 0.025 M and Hexamethylenetetramine of 0.0125 M grown at 90 °C for 7.5 hr.

- ☐ A prominent diffraction peak corresponds to (002) plane indicates that the ZnO NWs are preferentially oriented along c-axis and demonstrate single crystalline nature of ZnO NWs
- ☐ From the SEM micrograph of ZnO NWs, it is observed that, the length of ZnO NWs increases and their diameter seems to be almost constant with the growth duration.
- ☐ From the TEM image, the surface of the nanowire is found to be smooth and no impurity is observed on the surface of ZnO NWs.
- ☐ The HRTEM image of single ZnO NW depicts that the NW is structurally uniform.
- ☐ The color mapping of ZnO NWs shows the uniform distribution of Zn & O element throughout the nanowires

APPLICATION



CONCLUSION & FUTURE SCOPE

- ✓ Long thread like ZnO NWs with faster growth rate is synthesized on ZnO/Si substrate by limited volume heating hydrothermal process using ammonium hydroxide solution
- ✓ Ultra long thread like ZnO NW having average length of 21 μm with a higher growth rate of 2.8 μm/hour was obtained.
- ✓ The HRTEM shows the single crystalline structure with inter-planar spacing of 0.28 nm
- ✓ Growth of single nanowire and fabrication of single nanowire based sensor.
- ✓ Surface functionalization with suitable doping.
- ✓ Sensitivity measurement with different electrode spacing

PUBLICATION

1. S.P. Ghosh, K.C. Das, N. Tripathy, K. K. Sahoo, D.H. Kim, T. I Lee, J.M. Myoung, and J.P. Kar, "Limited volume heating method: A simple low cost approach to synthesize additive free long nanowires" J. Mater. Sci. Mater. Electron., 30 (2019) 5065-5073.
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