Photoluminescence Properties of Hydrothermally Grown Microcrystalline Zinc Oxide with Controllable Morphologies Used for Antibacterial Assays

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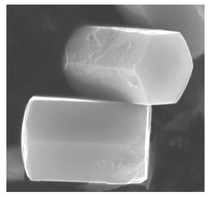
Abstract

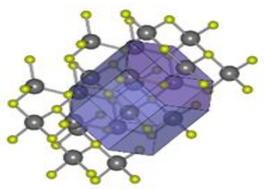
Nano- and microscale zinc oxide (ZnO) have demonstrated potential for applications in electronic, pharmacological and chemical industries among others. At these scales, surface properties dominate, rendering surface defects highly influential. Consequently, understanding of defect- related phenomena are crucial to achieving impactful figures of merit. Many optoelectronic properties of ZnO relevant for applications have been linked to defect-related visible luminescence. Its fundamental origins are still being debated, with attributions to oxygen vacancies, zinc vacancies, oxygen antisites, donor-acceptor pairs, etc. In our studies, we contribute to this discussion by probing the relationship between crystal morphology and this luminescence. We conducted optoelectronic studies to characterize hydrothermally-grown microscale ZnO samples with controlled morphology and their relation to the intensity of the green luminescence aa a means to help elucidate the nature of the visible emission. We report on the observed changes in the photoluminescence spectra indicative of the relationship between surface defects, morphology, and electronic structure of ZnO.

Introduction

- Fundamental mechanisms driving antibacterial action for ZnO is still unknown.
- Antimicrobial behavior of ZnO is initiated by interactions of surfaces

Zinc Oxide Crystal Structure

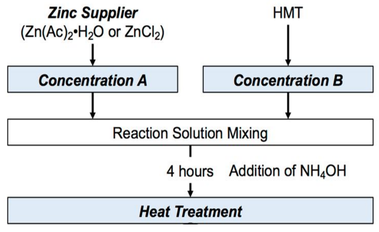




- ZnO has Hexagonal structure composed of alternating layers of Zn^{2+} and O^{2-} ions
- Structure yields net charge at hexagonal (polar) faces and neutral charge on rectangular (non-polar) sides
- Nature of these crystallographic faces (neutral, negative, positive) could be very different.

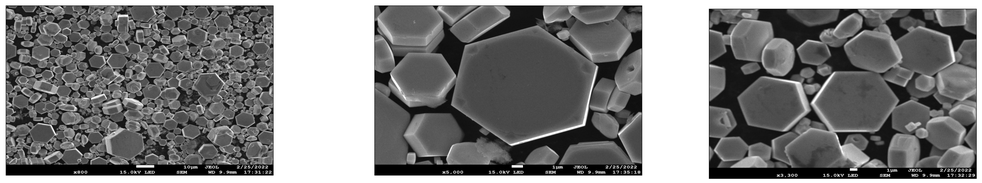
Controlling growth of ZnO structures

- Hydrothermal chemical method allows us to grow specific ZnO micro-crystals
- Allows us to control the ZnO surfaces interacting with bacteria

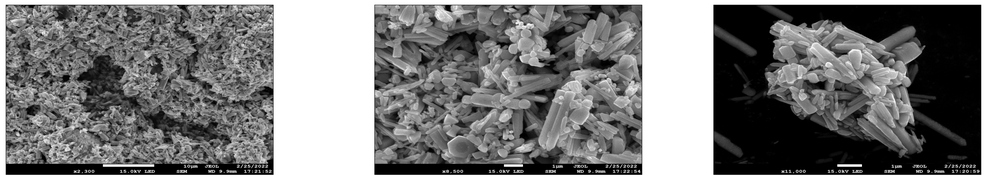


Morphologies of ZnO crystals

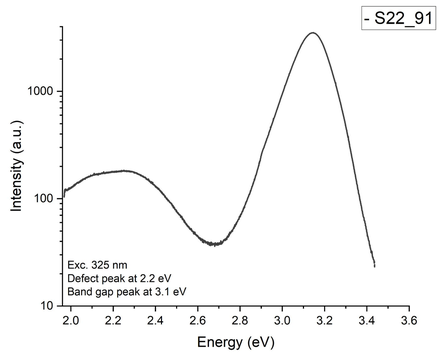
- Different concentrations of zinc acetate and HMTA, and varying time interval of heat treatment.
  - S22_33 Polar Plates

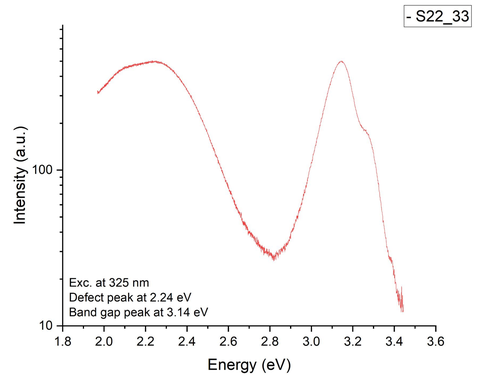


  - S22_91b Non-Polar Rods

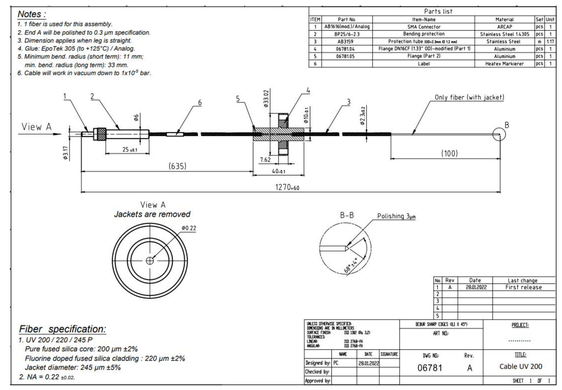


Photoluminescence





FIber for Cathodoluminescence



Conclusions

- Due to polar plates electrostatic nature defects more prone to be on the surface while rod-like structures have more defects in the bulk.
- Initial Photoluminescence studies showed that the green luminescence affected by the nature of the morphology of the zinc oxide particles.
- Polar Plates seem to have greater intensity of green luminescence while rods have a smaller intensity of green luminescence.
- No conclusion has been made between which type of defect or whether its a bulk or a surface property
- Further studies need be conducted using CL so a clear distinction between surface and bulk defects can be drawn.

Future Directions

- Map chamber with a phosphor for installation of the CL Fiber and installation of the fiber.
- Conduct CL experiments and correlate penetration depth of the electron beam and defect intensity.
- Investigate near surface optoelectronic phenomena with surface photovoltage experiments and Auger spectroscopy.