

## **TAPERED HEAD FACETS OF ZINC OXIDE NANORODS**

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### **ABSTRACT**

Tapered head facets of ZnO nanorods are unique morphologies that offer potential applications in photoconductivity, chemical sensing, UV photodetection and optoelectronic display. Enhanced photoresponse could be due to large concentrations of intrinsic structural defects such as oxygen vacancies and zinc interstitials that are detected from visible PL emission. From our CFCOM gas synthesis technique, we have grown ZnO nanorods with tapered head facets at a rapid rate of 100nm/s in just 15s whereby the quenching stage could be crucial in retaining the tapered heads. Unstable tapered facets such as planes of  $\{20\bar{2}5\}$ ,  $\{10\bar{1}3\}$ ,  $\{10\bar{1}4\}$  and  $\{10\bar{1}5\}$  could be a contributing factor in the rapid growth rate of CFCOM ZnO rods due to their faster growth rates and high surface energies. Simulations of ZnO heads that we report can be used as a guideline for identification of tapered tips of ZnO nanostructures.

### **INTRODUCTION**

Due to sharp tips, tapered head of ZnO nanorods find promising applications in electron field emission by providing adequate brightness for flat panel display [1]. Thin nanorods with narrow tapered heads normally possess high levels of structural defects and surface recombination due to large surface-to-volume ratio [2]. Green-yellow emission is commonly attributed to these intrinsic structural defects that consist of singly-ionized and doubly-ionised oxygen vacancies while red emission, also known as metallic emission, is due to impurities especially interstitials of zinc [3,4]. High levels of oxygen vacancies at ZnO tapered head can greatly enhance photoconductivity response making ZnO rods excellent candidate for gas nanosensors [5].

It is known that unstable crystal planes of ZnO are normally the ones with high-order indexes such as  $\{10\bar{1}4\}$ ,  $\{20\bar{2}3\}$  and  $\{10\bar{1}4\}$ ; and unstable crystal planes are expected to have faster growth rates and lower crystallinity if compared to that of stable crystal planes including  $\{10\bar{1}0\}$  and  $(10\bar{1}1)$  [6]. With the exception of  $\pm(0001)$  plane facets, stable crystal facets have low growth rates and they readily appear in gas phase synthesis such as vapor-solid and vapor-liquid-solid processes [7]. ZnO is a II-VI compound semiconductor possessing a hexagonal wurtzite structure (space group  $P6_3mc$ ) with lattice constants  $a=0.32495\text{nm}$  and  $c=0.52069\text{nm}$ . It has a wide direct bandgap of 3.37eV and a large exciton binding energy of 60meV making ZnO an excellent material for LEDs and UV lasing [1-4]. ZnO readily grows to form one-dimensional nanostructures with fast growth directions,  $\langle 01\bar{1}0 \rangle$ ,  $\langle 2\bar{1}\bar{1}0 \rangle$  and  $\pm[0001]$ , whereby the first two growth directions tend to produce nonpolar surfaces with lower energy than that of the  $\pm(0001)$  polar facets [8].