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# Synthesis and Characterization of ZnO Nanostructures with Macroscopic Gel-like Morphology

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As an important II-VI semiconductor material, zinc oxide (ZnO) and its nanostructures have attracted great attention in the last decade because of its potential applications in various fields, such as sensing, photocatalysis, field emission, and disease diagnostics and treatment [1]. Due to non-symmetric wurtzite structure, ZnO nanostructures possess various morphologies such as nanowires, nanobelts, nanoring, nanohelixes, nanotetrapods, etc., which have been synthesized by using various physical or chemical methods [1]. Most macroscopic morphologies of ZnO nanomaterials, synthesized by physical vapor deposition method, however, look like white-wool morphology or the variations of it. We report here the synthesis of gel-like ZnO films.

The ZnO nanostructures were synthesized in a high temperature tube furnace by a standard thermal evaporation-condensation process. The experimental setup was similar to those reported in literature [2]. We used a mixture of oxygen and argon as the carrier gas. The morphology of as-grown nanostructures was examined in a high-resolution field emission SEM (JEOL JEM-6320F).

Figure 1 is an optical digital image of as-grown ZnO white gel-like materials. The gel-film is very soft and lightweight and can be easily torn. These structures sometimes look like a film and sometimes look like a paste. They usually grew in the lower temperature zone of the tube furnace with temperatures ranging from about 400ºC to 500ºC. Large-scale synthesis of such structures is possible. Figure 2 shows a SEM image of the as-grown gel, revealing the presence of nanowires and some multipods. Detailed examination of many SEM images showed that almost all the nanowires are connected with each other; some multipods were also observed as shown in the image. Figure 3 is a high magnification SEM image of a typical nanowire showing the morphology of the nanowire and the regularity of the change of its diameter. Detailed measurements of the diameters of the nanowires showed that there was a bimodal distribution of nanowire diameters with their average sizes of 53 nm and 125 nm, respectively. The clusters usually connect the nearby nanowires together tightly, which is central for the macroscopic gel-like morphology. The pressure during the growth of as-grown nanomaterials is also a key factor. The growth mechanism of gel-like morphology as well as the detailed synthesis-structure relationships will be discussed [3].

## References

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[3] This research was supported by the University of Missouri-St. Louis.

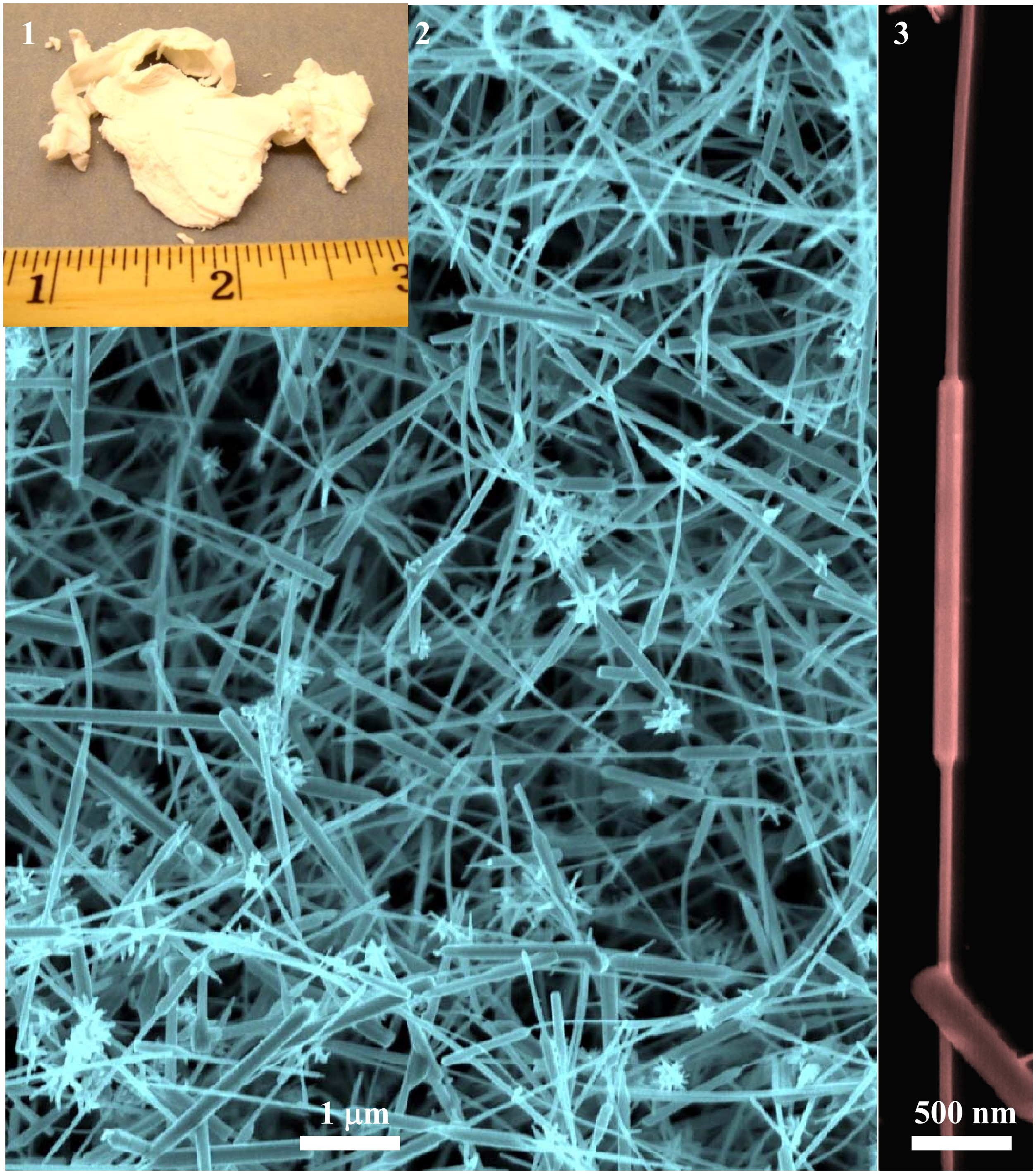


FIG. 1. Optical digital image of as-grown nanomaterials showing the macroscopic soft gel-like morphology.
FIG. 2. SEM image of as-grown ZnO soft gel revealing the interlacing and networked ZnO nanowires as well as some nanomultipods.
FIG. 3. SEM image of a typical nanowire within the ZnO gel-like structure showing the bimodal distribution of the nanowire diameters and the joint of different nanowires.

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