

Energy harvesting and sensing application of semiconductor nanowires

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The semiconductor nanowire is a versatile and essential nanostructure with significant advantages, such as an enhanced quantum size effect, a large surface-to-volume ratio, and flexibility under external stress without permanent damage. Due to these unique properties, nanowires have gained considerable interest for various applications, including light-emitting devices, sensors, and energy harvesting. In this talk, we present our research results on energy harvesting and sensing applications based on GaN and ZnO nanowires.

One of the promising methods for energy harvesting is photoelectrochemical (PEC) water splitting, which is regarded as the most attractive way to generate "green hydrogen." ZnO has been identified as one of the most promising candidates for PEC water splitting due to its straddling band alignment with the water redox level. However, its performance is limited by its poor visible-light absorption capability, as it has a wide bandgap and is susceptible to photocorrosion in an aqueous medium. Therefore, we have studied the sequential fabrication of a three-dimensional hierarchical structure consisting of high-quality ZnO nanowires on patterned silicon nanowires using metal organic chemical vapor deposition for PEC water splitting. This approach has greatly enhanced the photocurrent density due to the augmented surface area.

For sensing applications of GaN nanowires, we proposed state-of-the-art slowly-adapting (SA) and rapidly-adapting (RA) mechanoreceptors based on n-type and semi-insulating GaN nanowire arrays, respectively. The SA- and RA-mechanoreceptors have demonstrated distinguished features, such as grasping objects and detecting the surface textures of different objects, after being affixed to an index fingertip. We also proposed an electronic skin comprising SA- and RA-mechanoreceptors, which can simultaneously mimic static and dynamic pressure signals using piezoelectric sensing principles. Furthermore, the mechanoreceptors can detect various stimuli of different pressures with low and high frequencies. We analyzed the response and reset times of the GaN NW-based SA-mechanoreceptors, and the results indicated that the response speed is rapid enough for practical e-skin applications.