ABSTRACT

Site-selective micron or nanoscale structuring such as surface patterning, nanosized objects, or voids at the length scale comparable to incoming optical illumination have drawn extensive attention due to periodicity-dependent optical properties. The incoming optical waves are multiply scattered, reflected, and diffracted in the periodic structure at the length scale of a fraction of the incoming optical wavelength. This phenomenon engenders several light manipulation schemes such as anti-reflection, photonic bandgap, the enhanced path length of the optic waves, and surface plasmon resonance. The light manipulation in the periodic structures can overcome the bottleneck related to a deficiency of light absorption or light extraction in optoelectronic devices. The light to the electrical signal converting optoelectronic devices such as photodetectors, solar cells, light-activated room temperature gas sensors suffers from insufficient absorption cross-section and the mismatch between diffusion length and photogenerated carrier separation/transfer towards electrodes. The light manipulation in ordered structures might solve the barrier providing enhanced optical path length of the incoming light to enhance absorption. The low light extraction in electrical to light converting devices such as light-emitting diodes (LEDs) might be solved using structures capable of light extraction. However, the development of scalable, inexpensive, ordered structure fabrication and detailed investigation of patterned dependent tunable optoelectronic properties are in the nascent stage. (chapter 1)

In the thesis, periodic nanostructured for improving the performance of the optoelectronic devices were fabricated by low-cost soft lithography technique (chapter 2), colloidal self-assembly-based sacrificial template (chapter 3), polymer thin film instability mediated approach (chapter 4), and nanorods based method (chapter 5). The fabricated periodic nanostructured devices were employed in the fabrication of devices such as photodetectors (chapter 2, chapter 4), light-activated room temperature gas sensors (chapter 3), and light-emitting diodes (LED) (chapter 5). The light management strategies in optoelectronics properties are investigated, and the stability of the devices is also studied.

Keywords: light trapping, soft lithography, ZnO, TiO_2, carbon dot ink, photodetectors, gas sensing, LEDs, stable photodetectors