Vacuum Thermal Evaporation (VTE)-deposited lead-free copper halide-based solar-blind UV photodetector

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Abstract:

The growing need of miniaturized and reliable UV detection systems especially for portable and space applications has driven the development of semiconductor-based UV photodetectors. While UV photodetectors using wide bandgap semiconductors such as silicon carbide (SiC), diamond, and gallium nitride (GaN) or AlGaN alloys are quite attractive for solar-blind imaging or sensing applications, UV photodetector technologies based on the wide bandgap semiconductors are not matured yet for real-world applications. On the other hand, Si-based photodiodes are fully commercialized with a variety of applications. In the UV range, however, the penetration depth of UV light in Si is typically only a few nanometers and thus absorption occurs before the UV photon reaches the detection region in the Si-based photodetectors. As a result, traditional Si-based photodetectors show poor performance in UV regions.

In this study, we investigated an innovative alternative route to realize high-performance and cost effective Si-based UV photodetector using an efficient UV-to-visible down-conversion layer. A high-performance solar-blind UV photodetector is fabricated by integrating a zero-dimensional lead-free copper halide semiconductor film as a down-conversion layer onto a commercially available inexpensive silicon photodiode. Zero-dimensional copper halide semiconductor films deposited via a vacuum thermal evaporation (VTE) film deposition process exhibit a large Stokes shift of 231 nm and strong greenish emission at the peak emission wavelength of 516 nm. The films also show a nearly 100% photoluminescence quantum yield (PLQY) with strong absorption in solar-blind UV wavelengths. The optimized solar-blind UV detector shows outstanding device performance including excellent UV-to-visible rejection ratio of 1022 for R280/R400, indicating the detector's strong ability to reject visible light while efficiently detecting solar-blind UV radiation.