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Flexible Transparent ZnO:Al/ZnO/$CuAlO_x$:Ca Heterojunction Diodes on Polyethylene Terephthalate Substrates

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Transparent flexible n^+-ZnO:Al (100 nm)/n-ZnO (40 nm)/p-$CuAlO_x$:Ca (100 nm, 200 nm, 300 nm) diodes were fabricated on polyethylene terephthalate substrates at room temperature using a sputtering technique. No additional heat treatment was performed on the fabricated devices. Increase of the diode layer thickness reduced the on-current and leakage-current levels simultaneously, which led the rectification ratio to first increase and then decrease as the p-layer thickness increased. The ultraviolet (UV) response of the diode was also investigated under irradiation at 365 nm. The n^+-ZnO:Al (100 nm)/n-ZnO (40 nm)/p-$CuAlO_x$:Ca (200 nm) diode exhibited photocurrent/leakage current ratio of 1.03×10^3 and responsivity of 0.64 A/W at reverse bias of −6 V when measured in flat status. The corresponding photocurrent/leakage current ratio and responsivity were 7.99×10^2 and 0.65 A/W, respectively, for an outwardly bent diode with 5.5 cm radius of curvature. The increases of current levels under bending are attributed to the decreases of series resistance for the diode under tensile strain.

Key words: Ca-doped $CuAlO_x$, sputtering, oxide electronics, diodes, flexible electronics, large-area electronics

INTRODUCTION

Flexible electronics have received considerable attention due to their versatile applications in E-papers, cell phones, and roll-up portable displays.[1–5] Hydrogenated amorphous silicon is the mainstream industrial technology for large-area electronics; however, its electron mobility is less than 1 $cm^2\ V^{-1}\ s^{-1}$, which limits applications when higher speed is required.[6,7] This has triggered research and development in large-area electronics with higher electron mobility using materials such as nc-Si:H[7–12] and transition metal oxide semiconductors.[2,13–18] Oxide electronics can possess high transparency in the visible light wavelength region. Therefore, it is attractive for those applications that require high transparency such as displays, touch panels, and portable photovoltaic power generators. This invites interest in the development of transparent oxide electronics on clear plastic substrates.[4,15,19,20]

The p–n junction diode is a fundamental electronic component. Owing to the lack of stable p-type ZnO-based materials, delafossite p-type oxides have been used together with ZnO to make transparent heterojunction p–n diodes.[21–28] However, the reported results on p–n diodes involve high-temperature processes on rigid glass substrates. In this paper, we report the performance of room-temperature radio frequency (RF)-sputtered flexible transparent ZnO:Al/ZnO/$CuAlO_x$:Ca heterojunction diodes on clear polyethylene terephthalate (PET) substrates. Ca is introduced into $CuAlO_x$ to reduce the series resistance of the diodes.[29] Heterojunction diodes with various p-layer thicknesses are investigated. UV responsivity is also evaluated.

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