**Design of nano-layer for beyond 10% efficient green kesterite solar cells**

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The quality of hetero-interface plays a critical role in the performance of heterojunction solar cells. In the development of pure sulphide kesterite heterojunction solar cells, made from green (earth-abundant and non-toxic) constituent of copper, zinc, tin and sulphur, interface recombination induced non-radiative recombination has been one of the key issues limiting the device performance, particularly the open circuit voltage. At the back contact, kesterite can react with Mo back contact, resulting in the decomposition of kesterite and formation of MoS2. At the heterojunction interface, due to the lattice mismatch, the growth of buffer layer (such as CdS, ZnCdS and SnZnO) on the underlying kesterite Cu2ZnSnS4 may generate lattice mismatch-induced crystalline interface defects, leading to significant non-radiative recombination.

Nano-sized layers are designed to improve these interface problems. By introducing Al2O3 nanolayer prior to the growth of kesterite precursor, the traditional kesterite growth mechanism is modified where the Al2O3, on one hand, allows the diffusion of S forming a thin MoS2 layer, thereby preventing the direct contact between kesterite and Mo, and on the other hand breaks into discontinuous openings facilitating carrier transport [1]. As a consequence, the short circuit current and fill factor are greatly improved. By modifying the surface of kesterite, self-grown (either discontinuous or ultra thin) ZnS nanolayer can be formed prior to the buffer layer materials (in both ZnCdS and ZnSnO buffer cases), which, due to the favourable lattice match with kesterite, significantly reduces the formation of interface defects and thereby associated interface recombination [2][3]. The self-grown nano-layer at heterojunction interface can also be obtained by post-annealing, facilitating the formation of new phase and thereby optimise the band alignment [4]. Passivation of interfacial defects is an alternative way of decreasing interface recombination. By introducing less than 1 nm thick ALD-Al2O3 layer, the quality of heterojunction interface can be modified and well passivated, resulting in the beyond 10% efficiency green plus kesterite solar cells [5].

**References**

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