Hybrid GaAs nanowire/halide perovskite optoelectronic devices

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Perovskite solar cells attract much interest in photovoltaic applications nowadays, due to the high photovoltaic performance that they exhibit combined with the relative ease of fabrication. On the other hand, GaAs-based semiconducting devices are the best photovoltaic materials by most metrics, including, high absorption coefficient, direct bandgap, as well as high carrier mobility values [1]. For highly efficient solar cells, the choice of electron and hole transporting materials is of paramount importance to ensure efficient charge extraction with minimum recombination losses. As a norm, highly efficient perovskite solar cells make use of polycrystalline TiO_2 as the Electron Transporting Layer (ETL). Conceptually, considering the superb GaAs semiconducting properties, it is proposed that GaAs can be used as ETL, substituting conventional ETLs, aiming to drastically enhance electron extraction. This device design takes advantage of the discrete property of GaAs to have its conduction band lower in absolute energy than the perovskite conduction band, thus providing a favorable band alignment. In addition, intrinsic GaAs has extremely high electron mobility compared with polycrystalline TiO_2 [1],[2]. In this work, we focused on the fabrication of hybrid GaAs nanowire/perovskite diode devices, specifically choosing GaAs in its nanowire (NW) form to enhance the electrical contact area between the two materials (Figure 1a), intending to study the electrical properties of the device. The device architecture comprises (i) the GaAs NWs grown on an n-doped (111) Si wafer, (ii) an insulating layer (Cyclotene 3022-46 BCB) in between the NWs, preventing short-circuiting of the device, (iii) $CH_3NH_3PbI_3$, (iv) Spiro-OMETAD and (v) Au. The devices exhibited a clear diode response (Figure 1b), which is a promising result towards the fabrication of GaAs nanowire/perovskite photodiode devices, which can be made by substituting the top gold electrode with a transparent conducting oxide material.

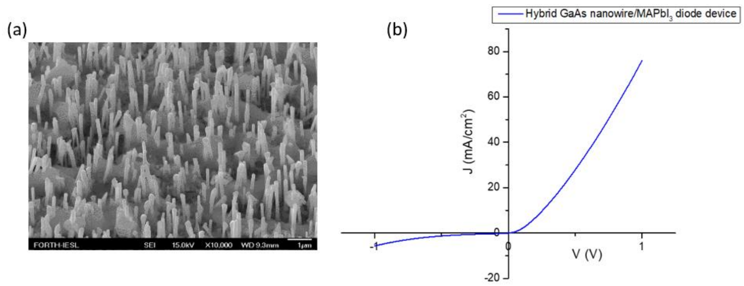

Figure 1: (a) SEM image of $MAPbI_3$ perovskite deposition around nanowires, (b) Current-voltage (I-V) curve of the diode device

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References

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