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Electrical properties of germanium alloyed layers as a low-band gap absorber for thin film silicon solar cells

AIST RCPVT, °Adrien Bidiville, Takuya Matsui, Michio Kondo

E-mail: adrien.bidiville@aist.go.jp

As silicon has a low absorption coefficient for infrared, either a thick (thus expensive) absorber layer or an efficient light-trapping scheme is required. We are also pursuing an alternative path by alloying germanium to microcrystalline silicon to increase the light absorption coefficient. Doing so allows the design of thinner bottom cells with a high short-circuit current.

Germanium and silicon are close to each other: both are tetravalent and completely soluble into each other. The addition of germanium decreases the silicon band gap: an alloy with 50% of germanium has a band gap around 0.9 eV. Despite this seemingly good compatibility, solar cells with a high content of germanium or absorber layer thicker than 1 μm have bad performances due to a poor charge collection. It was found that doping the cells with oxygen improves the charge collection of thick cells by increasing the blue light region quantum efficiency to levels similar to thin cells (Fig. 1). In order to understand this phenomenon, we have analysed intrinsic SiGe layers with different levels of oxygen doping and measured their electrical properties (dark- and photo-conductivity, charge mobility and concentration, and their activation energy). We also measured the complete single-junction cell performance with these layers (open-circuit voltage, short-circuit current and EQE curve) as well as the sub-band gap defects by Fourier transform photocurrent spectroscopy. From these measurements, we concluded that oxygen might not passivate dangling bonds, but compensates space charges due to germanium dangling bonds, thus improving the electrical field across the absorber layer and the photo-generated carriers' collection.

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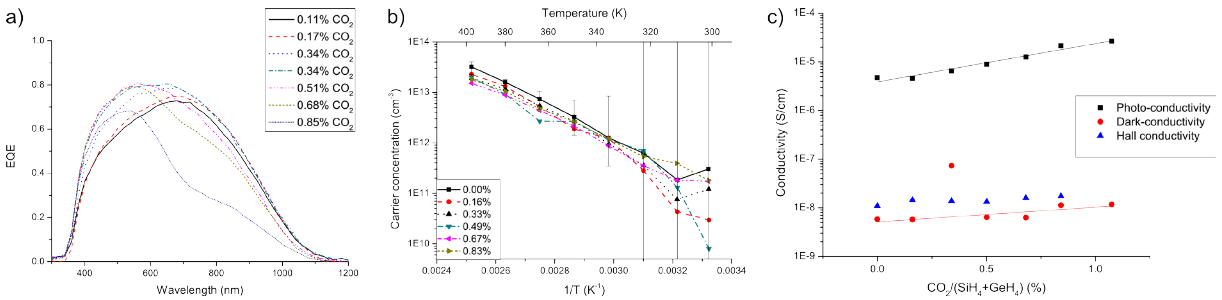

Figure 1: a) EQE of 3 um thick cells doped with various CO2 flows, b) temperature dependence of carrier concentration for different CO2 doping, and c) dark- and photo-conductivity.