A simple Al/SRO/Si Structure with Silicon Nanoparticles as a Photodetector UV and Vis

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Summary

A photodetector that shows a very high photocurrent in the ultraviolet and visible wavelengths has been fabricated. The device consists of a metal-oxide-semiconductor (MOS)-like structure where the dielectric layer is a silicon-rich oxide (SRO) film; its fabrication is completely compatible with silicon technology. SRO thin films with 1 to 12% silicon excess were deposited on silicon wafers by low pressure chemical vapour deposition technique using SiH_4 (silane) and N_2O (nitrous oxide) as reactive gases at 700 ºC. Si nanoparticles (Si-nps) were created after SRO films were thermally annealed at high temperature. Current-voltage (I-V) and capacitance-voltage (C-V) measurements in dark and illumination conditions were done. These characteristics indicate behaviour as an induced PN-like junction, which have a large enhancement in the reverse (RB) biased under UV and Vis illumination. The spectral response of these photodetectors was obtained. Si nanoparticles (Si-nps) and defects within the SRO films permit to obtain interesting photoelectric properties as a high photosensitivity.

Motivations and results

In the past decade various photodetector structures have been developed from pn junction, pin junction, bipolar transistor, avalanched photodiode (APD), and metal-semiconductor-metal MSM structures [1]. In these structures different semiconductor such as III-V and II-VI have been used, depending on the wavelength range to be detected. Nowadays, photodetectors are important components for the optoelectronic integration. Also, the silicon is an important material in the integrated circuit technology, but silicon has an indirect bandgap. Furthermore, this bandgap correspond to an infrared wavelength making it not very useful for UV detection. Most recently, a visible-infrared (VIS-IR), with enhanced ultraviolet (UV), silicon-based photodetector has been made commercially available by Oriel [2]. However, most of the available materials for UV detection are not based on silicon. Since the observation of photoluminescence (PL) of porous silicon by Canham [3], a lot of works has been done to study Si-based materials. Silicon rich oxide (SRO) is one of such materials that have been studied due to its interesting optical and electrical characteristics, which vary with the excess silicon in the films [4]. These characteristics have led towards a variety of applications such as waveguide, non volatile memories, voltage peaks suppressers, detectors and emitting light devices [3, 4, 5, so on]. In this work, the light detection properties of SRO films are shown. The thickness and refractive index of the Silicon Rich Oxide films used in this structure are show in table 1. SRO films exhibits a high sensitivity to UV light as shown in Fig. 1. C-V characteristics showed a PN junction induced at the surface of silicon, as observed in Fig. 2. In this material, UV light couples to the silicon nanoparticles efficiently to produce electron–hole pairs. Response spectral of SRO films is shows in Fig. 3. Therefore, we report a very simple structure working as a photodetector in UV and Vis. This very simple structure requires very few process steps and its fabrication is compatible with CMOS technology.

References

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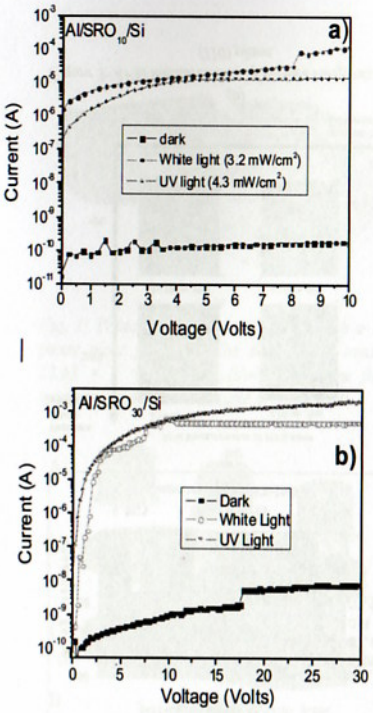

Fig. 1: I-V curve of the Al/SRO/Si MOS-like structure with a) SRO_{10} and b) SRO_{30} under dark and illumination conditions.

Table 1: Refractive index and thickness to SRO samples utilized.

Ro	Refractive index	Thickness (nm)
10	1.77	72
20	1.55	75
30	1.46	59

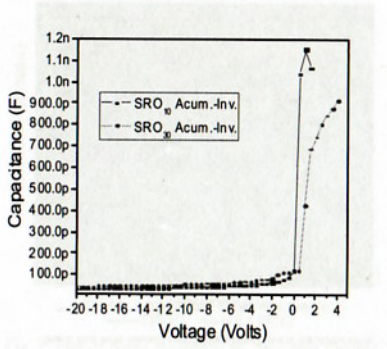

Fig. 2: C-V curve of the Al/SRO/Si MOS-like structure with SRO_{10} and SRO_{30} under dark conditions.

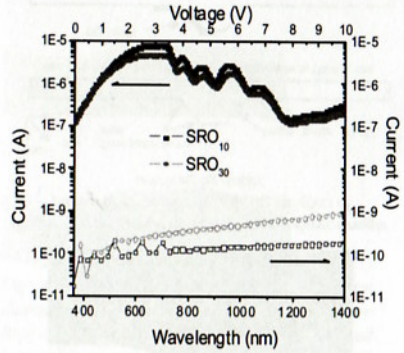

Fig. 3: Spectral response and dark I-V characteristics of the Al/SRO/Si MOS-like structure.