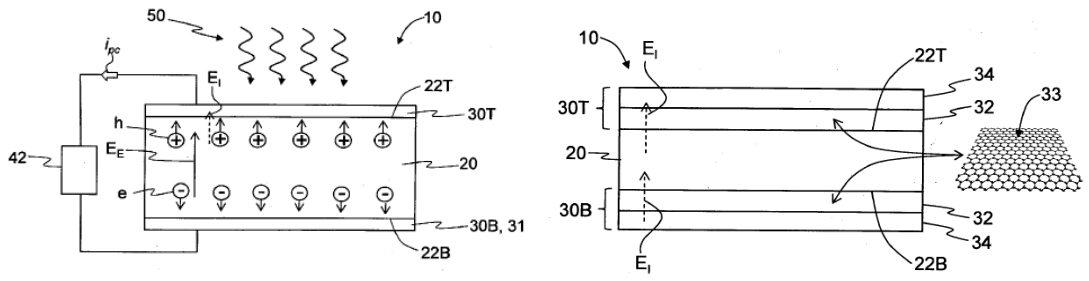
NUS National University of Singapore | Centre for Advanced 2D Materials

JOINT DEVELOPMENT OPPORTUNITY

Photovoltaic cell based on graphene ferroelectric interface and the method of fabrication thereof



The main working parts of a photovoltaic cell (*left*) showing irradiating light (50) on the top graphene-ferroelectric electrode (30). Both top and bottom electrodes form a sandwich with an active layer (20). On the right, graphene layer (32) and polarized ferroelectric layer (34) form the top and bottom electrodes. Graphene in different forms (33) are included in layer 32. When light is absorbed by the active layer, it results in electrons and holes moving as charge carriers towards opposite electrodes as a photocurrent I_{pc} in a circuit. Voltage source (42) supplies a temporary external electric field that polarizes the ferroelectric layer.

TECHNOLOGY BACKGROUND

Photovoltaic cells or solar cells convert light into electricity. A material inside them absorbs light and in doing so, generates charge carriers in the form of electrons and holes.

Most photovoltaic cells contain a semiconductor material such as silicon. Such devices are efficient but also expensive. On the other hand, organic photopolymer solar cells are comparatively cheaper and has the added advantage of flexibility. While not strictly a semiconductor, these cells contain matrixes that perform similar functions. A common problem faced by all of the above devices is reduced conversion efficiency due to recombination of electrons and holes that contributes to less electricity produced.

Different aspects of the invention all involve a device with an active layer (that is either silicon, organic semiconducting polymer, dye-sensitized molecules, gallium arsenide, cadmium telluride or copper indium

gallium selenide) that generates charge carriers when irradiated with light. Top and bottom electrodes are attached to the respective surfaces of the active layer. The top electrode comprises a first graphene layer and a first polarized ferroelectric layer (that contains a polymer). The bottom electrode would then be a metal or a second graphene-polarized ferroelectric layer.

Application Areas

- Transparent electrodes of photovoltaic solar cells
- Electrochromic windows that switches from full opacity to full transparency and vice versa

Benefits Offered

- Interdiffusion of atoms and molecules that reduces photovoltaic cell efficiency are prevented by the graphene layer.
- Cell efficiency is improved by 10% to 20% through doping of the graphene layer by the polarized ferroelectric layer.
- Unlike conventional organic photovoltaic cells, no external electric field is needed to be sustained as one is generated internally by the graphene-ferroelectric electrodes after an initial voltage is applied.
- Graphene-ferroelectric electrodes generate much lower series resistance than ITO transparent electrodes in conventional cells.
- The effect of charge-carrier recombination is minimised by the internal electric field generated, which accelerates the charge carriers to their respective electrodes, thus increasing cell efficiency.
- A polarized ferroelectric layer is substantially transparent to near-UV and mid-UV wavelengths unlike the opacity of ITO at the same wavelengths.
- The possibility of a flexible photovoltaic cell is realistic given that a flexible active layer is used.

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