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Bifacial Efficient Solar cell Technology with 4 terminal architecture for Utility scale

The objective of the BEST-4U project is the fabrication of a **photovoltaic cell/module with 4 terminals**, having a **bifacial Si heterojunction cell as bottom cell** and a **wide bandgap semiconductor cell as top cell**. The bifacial bottom cell collects and converts into electrical energy the red and infrared sunlight, passed through the top cell and, on the backside, the albedo light reflected/scattered from the ground. The top cell collects the blue region of the incident solar spectrum. The objective is an efficiency larger than 25% in standard conditions. Several approaches will be studied and compared with this aim, identifying the more promising. A demonstrator of **bifacial photovoltaic field** will be also realised, **optimized for the ground albedo** exploitation with a kWh/kWp productivity larger than 20% compared to the monofacial system.

To obtain the improvement in the efficiency and productivity we propose the concept of 4 terminals photovoltaic modules. **The cells and the 4T modules can be considered as an alternative to the tandem photovoltaic cells,** with some advantages. Indeed, the conventional monolithic tandem cell, with 2 cells connected in series, has the limitation of the lattice parameter matching, as well as the current matching. On the contrary, the 4 terminals structure is not affected by these limitations, and it allows many degrees of freedom.

The BEST-4U Project consortium is coordinated by **ENEL GREEN POWER**. The other partners are **CONSIGLIO NAZIONALE DELLE RICERCHE (CNR)**, **Università di PERUGIA**, **Università di PADOVA, Università di CATANIA, APPLIED MATERIALS ITALIA SRL, Distretto Tecnologico Sicilia Micro e Nano Sistemi S.c.a.r.l, DTS** (with actuators **Università di PALERMO and Italtel S.p.A**.), **Università di MILANO-BICOCCA, Università di TORINO**.

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Best4U is structured in 6 Work Packages. CNR SPIN participated to WP2 "*Top Cells based on Chalcogenides and other inorganic materials*" and in particular it is in charge, jointly with CNR-IMEM, of Task 4 "*Explore Ferro-PV materials*". The CNR-SPIN participation to BEST4U is under the responsibility of Fabio Miletto Granozio, who is also Task 4 leader.

Ferrophotovoltaic (Ferro-PV) materials, sometimes also called photoferrolectric, represent a totally new paradigm in photovoltaics [1]. Here, the separation of the photon-induced electron-hole pairs, rather than taking place as an interface effect occurring in the proximity of a pn junction, occurs as a bulk effect related to the very presence of ferroelectricity. The origins of such bulk photovoltaic ferroelectric effect lie in the complex interaction of light with a solid lacking spatial inversion symmetry [2]. Efficiencies up to about 8% have been demonstrated [3]. In the initial phase of the project, CNR-IMM and CNR-SPIN have decided to explore the photoferroelectrics properties of $BaFe_2O_4$, a material for which the growth in form of epitaxial thin film has been not studied so far. CNR-SPIN will try to deposit high quality *TCO-T*/ BaFe2O4 /*CO-B* structures, where *TCO-T* stands for Transparent Conducting Oxide Top-electrode, and CO- B for Conductive Oxide Back-electrode. Their Ferro-PV properties will be investigated jointly with CNR-IMEM.

[1] Kreisel, J., Alexe, M., Thomas, P.A., 2012. A photoferroelectric material is more than the sum of its parts. Nature Materials 11, 260–260. https://doi.org/10.1038/nmat3282

[2] Paillard, C., Bai, X., Infante, I.C., Guennou, M., Geneste, G., Alexe, M., Kreisel, J., Dkhil, B., 2016. Photovoltaics with Ferroelectrics: Current Status and Beyond. Advanced Materials 28, 5153–5168. https://doi.org/10.1002/adma.201505215

[3] Nechache, R., Harnagea, C., Li, S., Cardenas, L., Huang, W., Chakrabartty, J., Rosei, F., 2015. Bandgap tuning of multiferroic oxide solar cells. Nature Photon 9, 61–67. https://doi.org/10.1038/nphoton.2014.255

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