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A record photovoltaic effect observed in antiferroelectrics

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The photovoltaic effect is the main physical and chemical principle underlying solar cells. It is characterized by the conversion of photons into usable electrical energy. Modern photovoltaic devices have been intensively researched since the early days of the semiconductor transistor revolution in the 1940s, and today, they provide around 13 percent of global renewable electric energy, a figure that will steadily increase to meet the COP21 directives.

A fundamental limit of current photovoltaic devices, all of which are based on semiconductor junctions, is the output voltage, typically limited to ~1.5 volts (roughly equivalent to a AA battery) per junction. This limit is due to intrinsic material properties—basically, the semiconductor bandgap—and is therefore independent of the solar cell area, regardless of whether it is a microscopic dot or a large-area solar panel.

By contrast, there is another family of materials that achieve photovoltages much larger than the bandgap; they are the so-called ferroelectrics, intrinsically polar materials where the photovoltage is originated by the asymmetry of the crystal lattice instead of by a semiconductor interfacial effect. Until now, ferroelectric materials held the record for the highest photoelectric fields ever produced.

Now, a multidisciplinary research team from the Institut Català de Nanociència i Nanotecnologia (ICN2), funded by Severo Ochoa Excellence Program, has reported the largest ever photovoltaic field, reaching values in excess of a million volts per centimetre and beating by a factor of 20 the previous state of the art. Furthermore, they have discovered the effect in a class of antiferroelectric materials in which the photovoltaic effect has not previously been explored. The ICN2 research team behind the discovery includes Dr Amador Pérez-Tomás from ICN2, Prof Mónica Lira-Cantú from CSIC and ICREA research professor Gustau Catalan.

The discovery was in many ways a real surprise, as these materials are antipolar and not polar (hence the name antiferroelectrics) and thus, the researchers did not expect to find stable photovoltaic action. But the authors have proposed an explanation for the observed results. The discovery may have practical application in photovoltaic cells, because even though their photovoltage is very large, their electrical current still remains low, meaning that the electrical power is still below that of standard semiconductor devices. The researchers have nevertheless filed a patent to protect the technology, and are working on the optimization of the device to rapidly advance toward practical applications such as photovoltaic sensors and photocatalysts.

More information: Amador Pérez-Tomás et al. Above-Bandgap Photovoltages in Antiferroelectrics, *Advanced Materials* (2016). DOI: 10.1002/adma.201603176

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