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Turning the microscope upside down to measure the piezoelectricity of materials at the nanoscale

- **ICMAB-CSIC researchers are able, for the first time, to measure the very small amounts of charge generated in piezoelectric materials with an inverse use of the atomic force microscope (AFM)**
- **The technique, published in *Nature Communications*, has been implemented by incorporating a new device to the microscope that allows measuring electric currents one billion times smaller than the ones circulating in an LED**

Bellaterra, October 24, 2017 - Imagine a material that generates electric charges when a force is applied to it. This is what happens in the so-called piezoelectric materials, discovered in 1880 by the Curie brothers. Now, more than 100 years later, a group of researchers from ICMAB-CSIC in collaboration with CNRS (France) has been able to detect and measure electrical charges in piezoelectric materials when tiny forces are applied to them with an atomic force microscope (AFM).

AFM is one of the most prosperous and versatile techniques in material characterization, since it is not only possible to see the materials, but to study their electrical, magnetic or thermal properties, depending on how it is used. This versatility has made AFM a far-reaching technique with a promising future for the characterization of materials, which already assumes an industry by itself, that reports more than $ 400 million in profits annually.

"In this work we use an AFM in the opposite way as the usual" describes Andrés Gómez. "Usually a voltage is applied with the tip of the microscope, and the deformation of the material is detected indirectly, only being able to study the piezoelectric response in a qualitative way. Now we do the reverse: with the tip we apply a force to the material, and then we measure the current that it generates. This technique, called "Direct Piezoelectric Force Microscopy", allows to us to directly measure the piezoelectric coefficient of different materials quantitatively and at the nanoscale." In addition, the new built-in device can measure currents in the order of femtoAmperes, equivalent to one thousand billionth of an Ampere, a billion times smaller than those that circulate in an LED.

Piezoelectric materials, on their own, make up a $ 1 billion industry, being their characterization one of the most important keys to their development. This new technique will allow a better understanding of their operation and of their possible future applications, beyond the many uses that they already have: lighters, ultra sound generators, accelerometers, injection systems, sensors, oscillators, power generators, etc. The study, published in Open Access in *Nature Communications*, has given rise to a European patent, and is currently in the process of commercialization.

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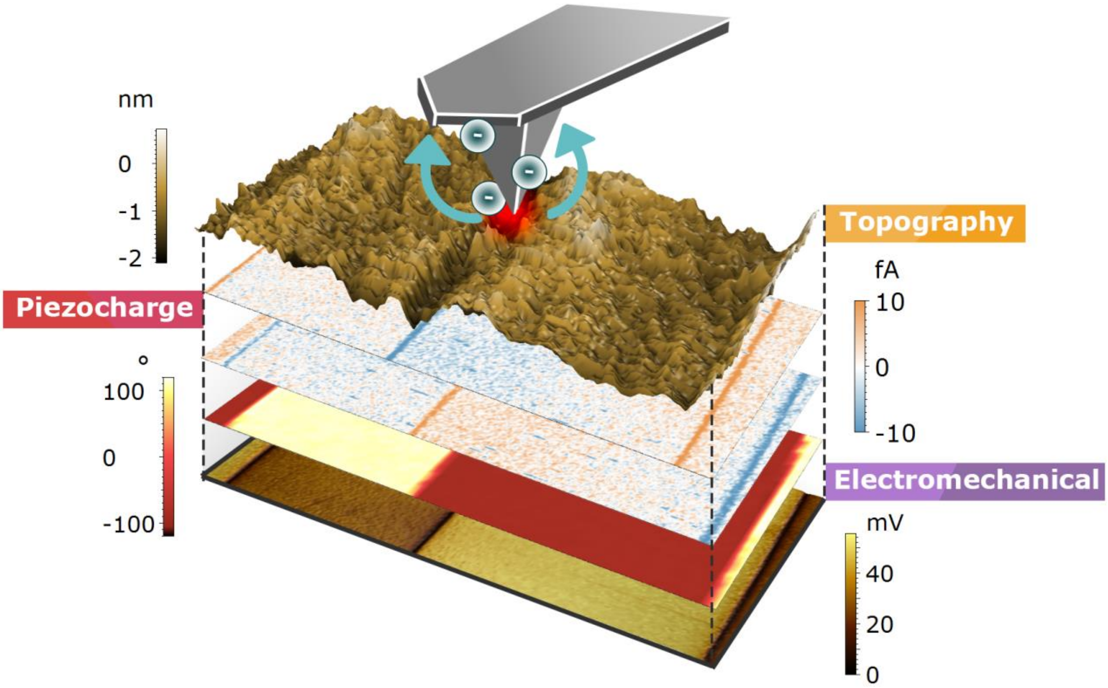

Figure: 3D composition in which the tip that scans the surface along with the rest of the properties of the material is represented, such as the topography, the generation of charge (fA), and its electromechanical response. Image size is 30x15 micrometers.

Reference of the published study:

Piezo-generated charge mapping revealed through Direct Piezoelectric Force Microscopy. *Andres Gomez, Marti Gich, Adrien Carretero-Genevrier, Teresa Puig, Xavier Obradors.* **Nature Communications** *8, 1113 (2017).* DOI: 10.1038/s41467-017-01361-2

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