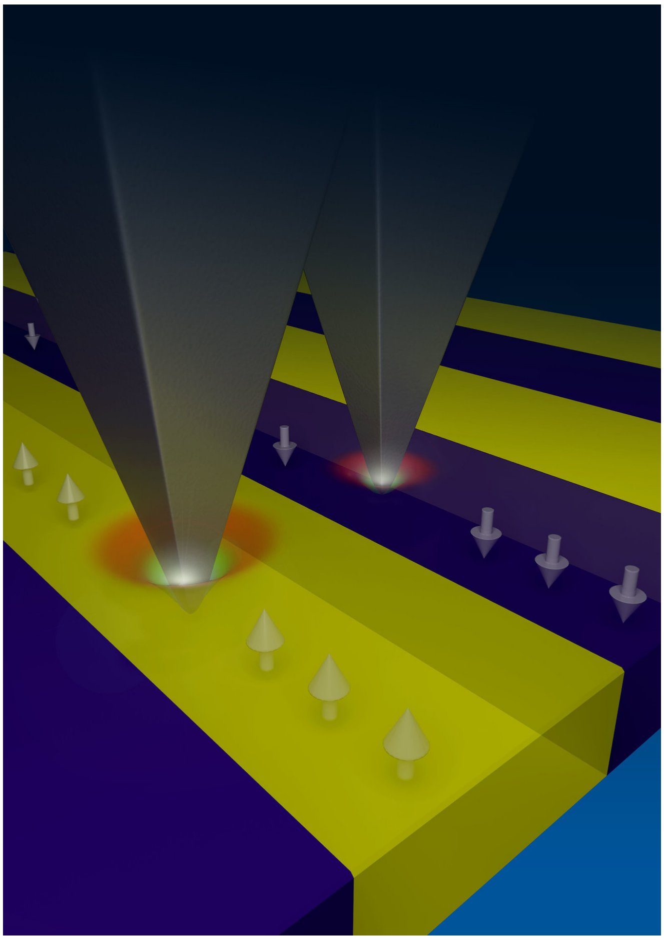
Turning a material upside-down can sometimes make it softer

20 October 2017



Artistic representation of the new material. Credit: ICN2

Through the combined effect of flexoelectricity and piezoelectricity, researchers at the ICN2 led by ICREA Gustau Catalán in collaboration with the UAB have found that polar materials can be made more or less resistant to dents when they are turned upside down or when a voltage is applied to switch their polarization. This research could lead to 'smart mechanical materials for use in smart coatings and ferroelectric memories.

Prof. Gustau Catalán and his collaborators published the findings in *Advanced Materials*. Ph.D. student Kumara Cordero-Edwards is the lead author. The article outlines how the indentation toughness of polar crystals can be manipulated in such a way that the crystals become easier or harder to dent from a given direction. This is the result of the interaction between the localised flexoelectric polarisation caused by the mechanical stress gradient of the indentation, along with the piezoelectric polarisation inherent in polar crystals. If the two polarisations run parallel, overall polarisation is going to be very strong.

This carries a higher energy cost, which makes the act of indentation itself more difficult. But if we turn the material over, the flexoelectric effect of the knock will be acting in the opposite direction to the spontaneous piezoelectric effect, making total polarisation weaker and indentation correspondingly easier. Additionally, in the case of ferroelectrics, it is not even necessary to physically turn the material upside down; simply applying an external voltage to flip its polar axis has the same effect.

These effects were observed not only in the case of forceful indentations and/or perforations, but also for the gentler, non-destructive pressures delivered by the tip of an atomic force microscope. Aside from potential applications in smart coatings with switchable toughness, these effects could one day be used as a means of reading ferroelectric memories by touch alone.

More information: Kumara Cordero-Edwards et al, Ferroelectrics as Smart Mechanical Materials, *Advanced Materials* (2017). DOI: 10.1002/adma.201702210

Provided by Autonomous University of Barcelona