Researchers find adding rare-earth element to piezoelectric crystals dramatically improves performance

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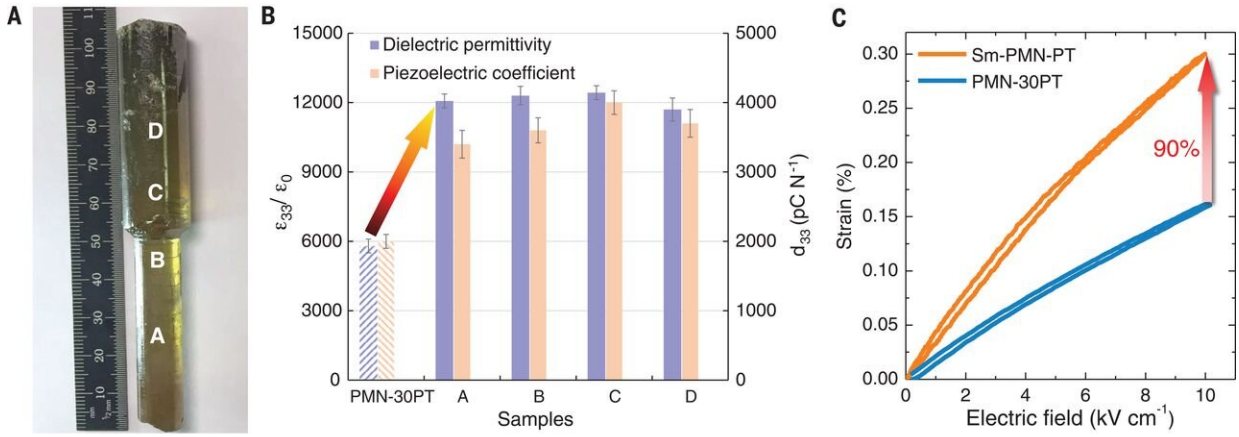

Image and electromechanical properties of [001]-oriented Sm-doped PMN-PT crystals. (A) Image of as-grown Sm-PMN-PT crystal. The compositions of points A, B, C, and D are listed in table S1. (B) Dielectric and piezoelectric coefficients of Sm-PMN-PT crystals versus those of PMN-30PT (patterned). (C) Electric field–induced strains for Sm-PMN-PT (sample B: 0.66 mol % Sm-doped PMN-30PT) and PMN-30PT crystals. Credit: *Science* (2019). 10.1126/science.aaw2781

A team of researchers from China, the U.S. and Australia has found that adding the rare-earth element samarium to piezoelectric crystals can dramatically improve their performance. In their paper published in the

journal *Science*, the group describes their work and how well the altered crystals performed when tested. Jiří Hlinka with Fyzikální ústav Akademie Věd České Republiky has published a Perspective piece on the work done by the team in the same journal issue.

Piezoelectric devices have been in the news a lot lately as scientists have been looking into whether they could be used to produce electricity from novel sources, such as in shoes as people walk, or affixed to clothes as they bend. They are convenient to use because they can convert mechanical oscillations into electrical signals. Less well known is that they are also used in sensors such as in ultrasound tools. For a piezoelectric device to work it must have a material inside of it that responds to vibrations—to date, the best material for the job has been a perovskite oxide crystal called PMN-PT. Scientists have been looking for ways to improve the performance of piezoelectric devices by looking for other materials and by looking for ways to improve the performance of PMN-PT crystals. In this new effort, the researchers chose the latter approach and claim to have found a way to double its performance.

The researchers found that adding samarium to the mix as PMN-PT was grown (using a modified Bridgman approach) resulted in a version of PMN-PT crystal that was dramatically better at generating an electric charge. More specifically, they found that adding just one atom of samarium for each 1000 parent crystals was all that was needed. They note that conventional PMN-PT crystals generate on average from 1,200 to 2,500 pC/N. Testing the enhanced version showed it capable of producing 3,400 to 4,100 pC/N. The researchers also found that adding samarium to the crystals made them more heterogeneous and also resulted in making other properties of the crystal more uniform in general. And, doing so also allowed the crystals to grow bigger which could result in cost savings.

The researchers suggest sensors with improved crystals would have

better resolution and more sensitivity. They would also be more efficient.

More information: F. Li el al., "Giant piezoelectricity of Sm-doped $Pb(Mg1_{/3}Nb_{2/3})O_3$-$PbTiO_3$ single crystals," *Science* (2019). science.sciencemag.org/cgi/doi … 1126/science.aaw2781

"Doubling up piezoelectric performance," *Science* (2019). science.sciencemag.org/cgi/doi … 1126/science.aax0693