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Lead-free (Ag,K)NbO3 materials for high-performance energy conversion

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Explosive energy conversion materials with extremely rapid response times have a diverse and growing range of applications in energy, medical, and mining areas. Research into the underlying mechanisms and the search for new candidate materials is so limited that Pb0.99(Zr0.95Ti0.05)0.98Nb0.02O3 is still the dominant material after half a century. In this work, we report the discovery of a new, lead-free ferroelectric material, (Ag0.935K0.065)NbO3 for explosive energy conversion applications. This material not only possesses a record-high energy storage density of 5.401 J/g, but also exhibits excellent temperature stability (up to a disruptive ferroelectric to ferroelectric phase transition at 150oC) by comparison with Pb0.99(Zr0.95Ti0.05)0.98Nb0.02O3 (which exhibits the ferroelectric to ferroelectric phase transition but at the much lower temperature of 41~70oC). (Ag0.935K0.065)NbO3 enables extremely high power, energy conversion within 1.8 microseconds, generating a pulse with e.g. a current ~ 22 A. Furthermore, pressure-dependent physical characterization, together with transmission electron microscopy, in-situ neutron diffraction analysis and theoretical modelling, reveals the mechanism underlying the observed explosive energy conversion behavior. It is found that the fast release of the stored energy can be attributed to a pressure-induced octahedral tilt change from a-a-c+ to AgNbO3-type a-a-c-/a-a-c+, in accordance with an irreversible pressure driven FE-AFE phase transition. This work provides not only an alternative (with significantly better performance) to the current commercially-employed lead-containing materials, but also provides guidance for the further development of new materials and devices for explosive energy conversion applications.

Speakers Gender

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Level of Expertise

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Do you wish to take part in the poster slam

Yes

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