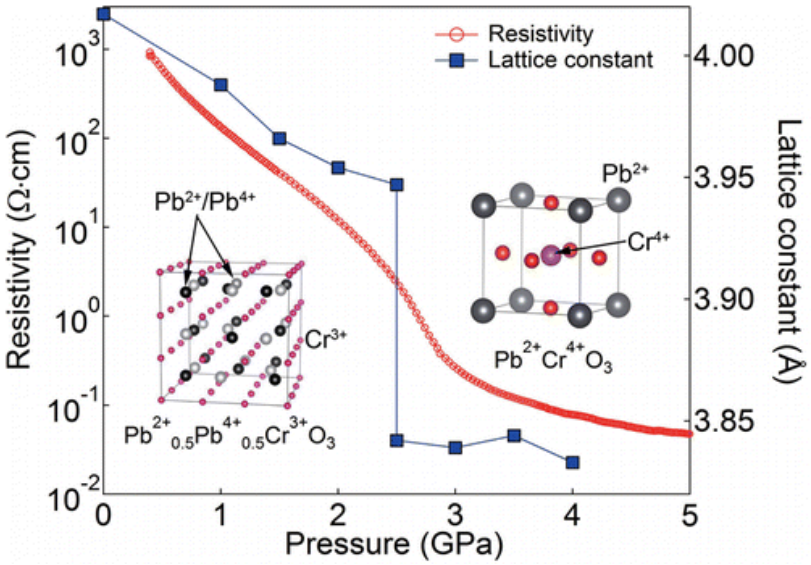
Melting of unexpected charge glassy state leads to a pressure induced metal-insulator transition



Applying pressure causes a dramatic volume collapse accompanied by a insulator to metal transition. This is revealed as being due to a melting of a charge glassy state that results in an intermetallic charge transfer. This change was found to alter the valence in the material from $Pb^{2+}_{0.5}Pb^{4+}_{0.5}Cr^{3+}O_3$ to $Pb^{2+}Cr^{4+}O_3$. This valence change occurs since Pb is a so-called valence skipper, i.e. it goes directly from 2+ to 4+ and cannot form a 3+ state. This characteristic is utilized in lead batteries.

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Scientific Achievement

$PbCrO_3$ shown to have Pb^{4+} and Pb^{2+} ions that form an unexpected charge glassy state, explaining a large volume collapse and metal-insulator transition.

Significance and Impact

A metal to insulator transition in integer or half integer charge systems can be regarded as a crystallization of charges. The insulating state tends to have a glassy nature when randomness or geometrical frustration exists. However, this charge glass state was realized in a perovskite compound $PbCrO_3$, which has been of interest for almost 50 years, without inhomogeneity or triangular arrangements in the charge system. From this state a pressure induced melting of charge glass and simultaneous Pb–Cr charge transfer causes an insulator to metal transition and ~10% volume collapse.

Research Details

- Neutron, x-ray and scanning microscope measurements provided structural and valence details.
- Density functional theory calculations supported the results.

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