Metal-insulator transition in $Pr_4Ni_3O_{10}$

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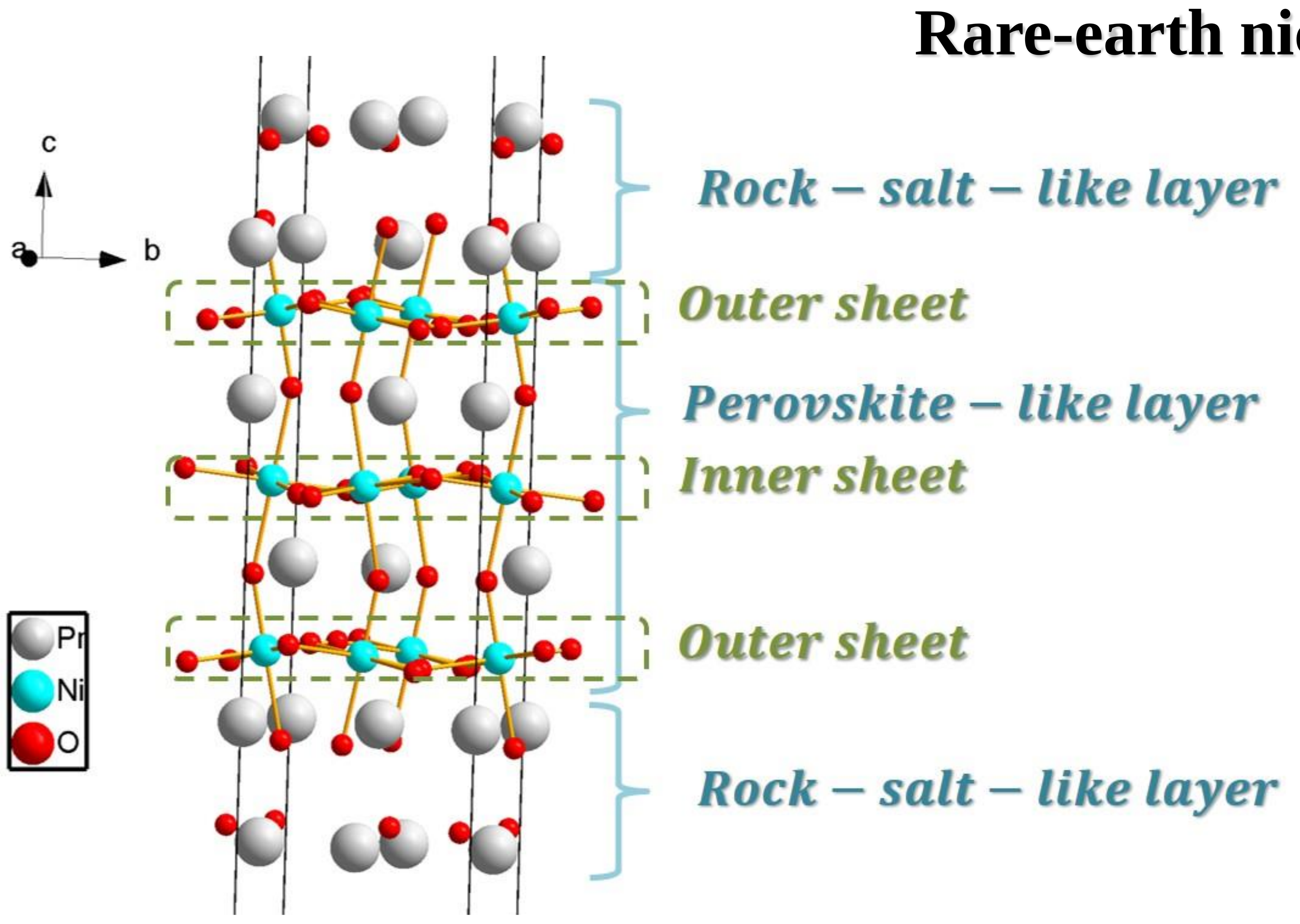
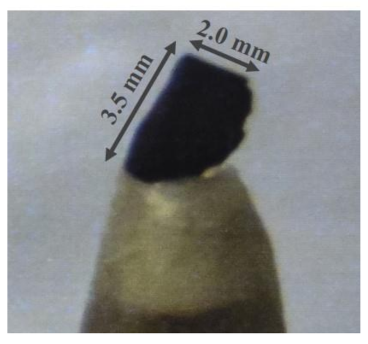
Rare-earth nickelate $Pr_4Ni_3O_{10}$



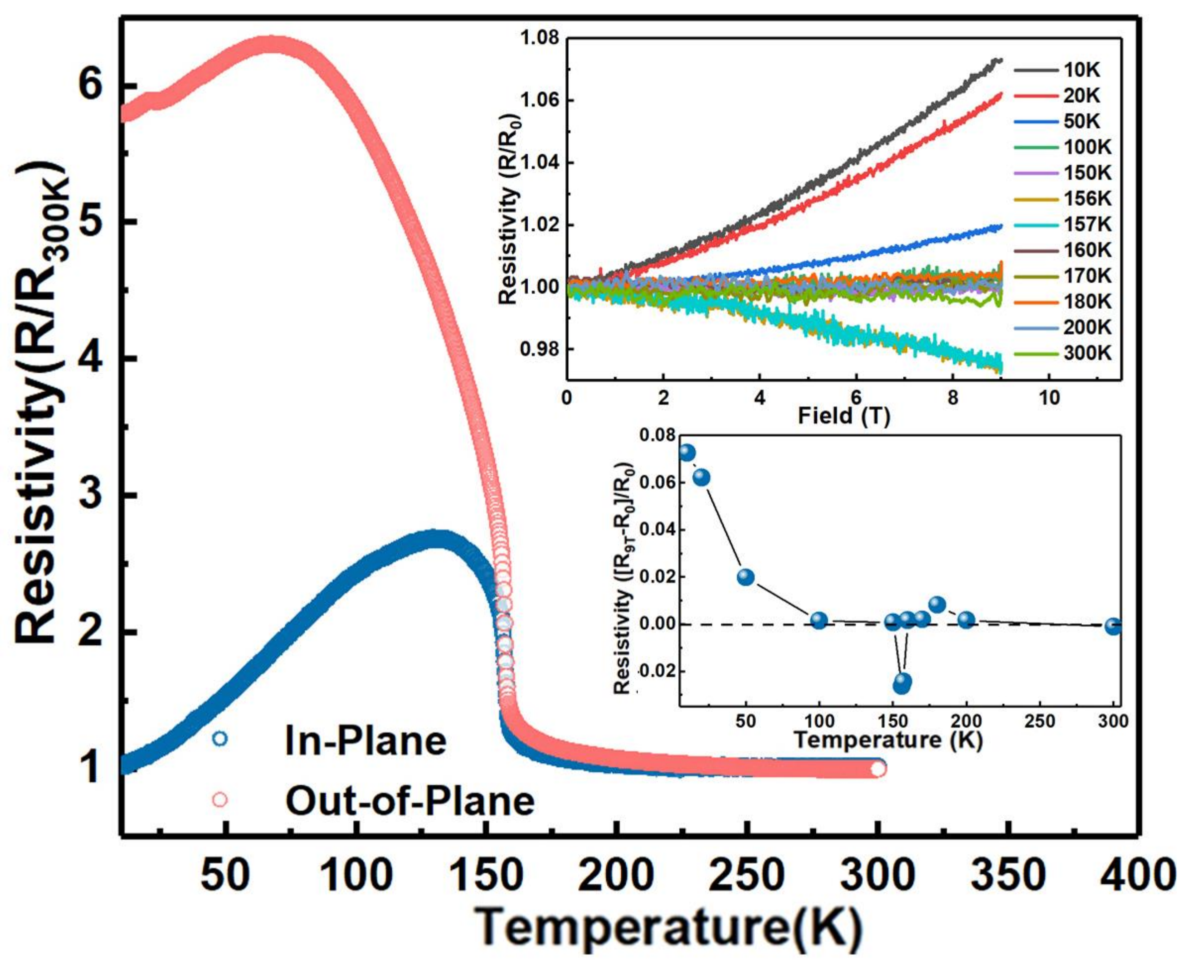
The Ruddlesden–Popper (R-P) rare-earth nickelate $Pr_4Ni_3O_{10}$ is constituted of infinite perovskite-like quasi-2D layered structures. These layers are connected by NiO_6 octahedra via shared vertex oxygen ions, and are separated by rock-salt like layers (PrO) along the crystallographic *c*-axis. There exist two different types of Ni sites, one in the inner perovskite layers, and the other type in the outer perovskite layers.



The single-crystal growth of $Pr_4Ni_3O_{10}$ was performed in an optical-image floating-zone furnace in oxygen atmosphere at 140 bar. The obtained single crystals can be as large as $3.5\times2\times0.3$ mm^3.

Physical properties near the structural phase transition

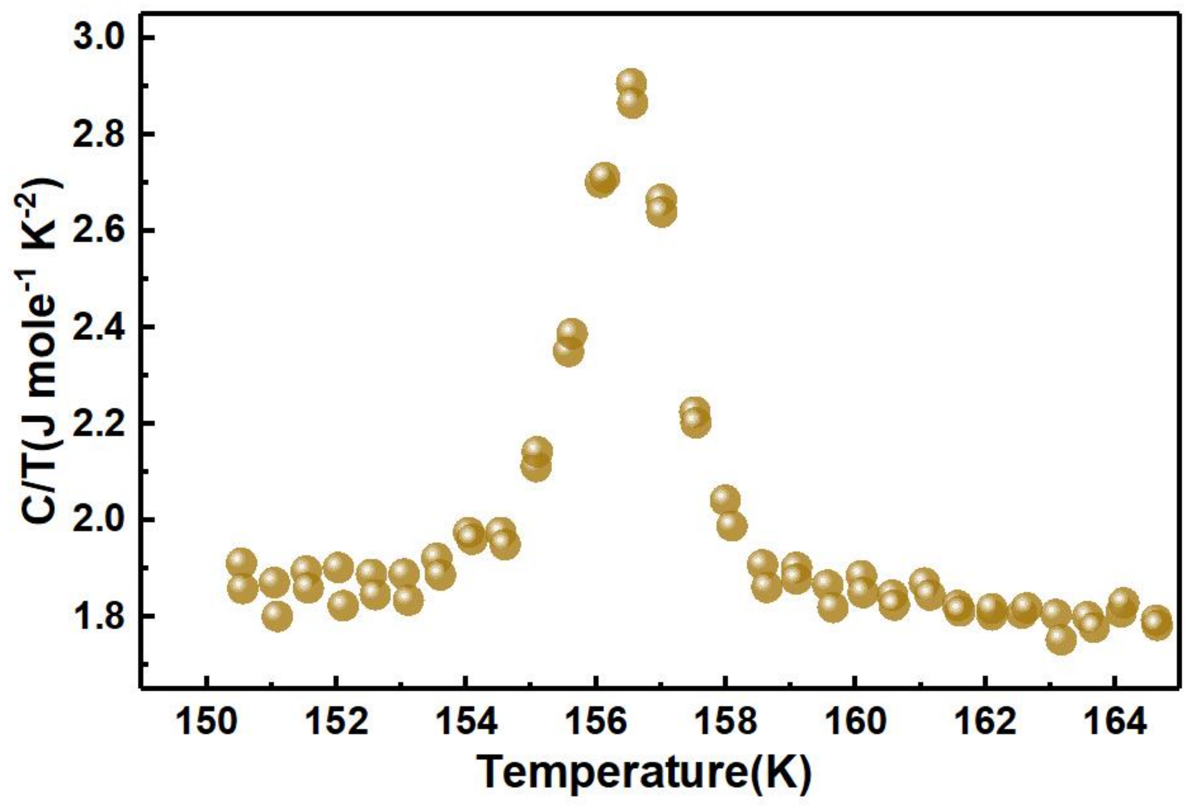
Resistivity

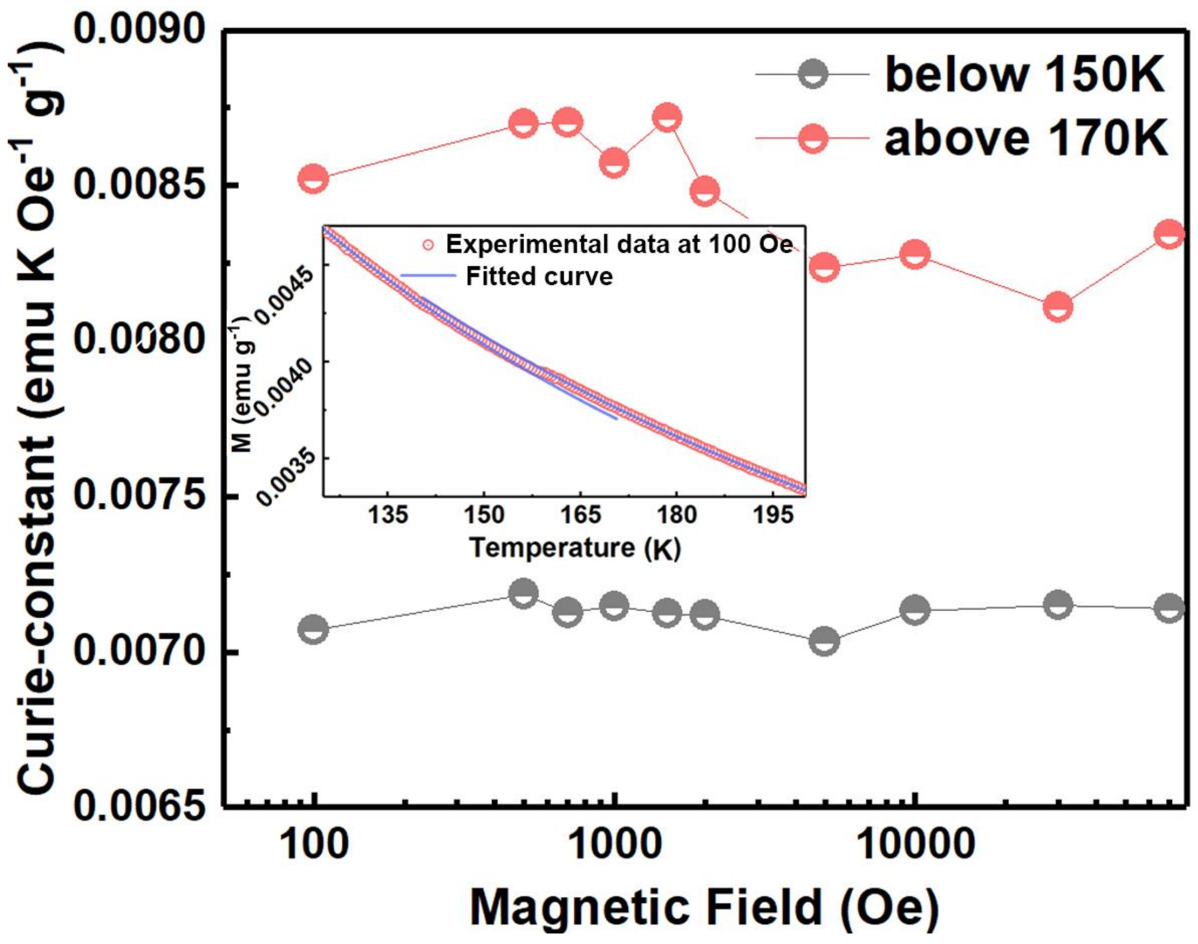


Zero-field resistivity measurements reveal a distinct anisotropy between the out-of-plane and the in-plane resistivity: a metal-to-metal transition within the *a-b* plane, and a metal-to-insulator transition along the *c*-axis. We conclude that, below T_{pt}, the electrical behavior along the *c*-axis of $Pr_4Ni_3O_{10}$ becomes insulator-like. The in-plane magneto-resistivity is positive at low temperatures, but turns negative at T_{pt} and vanishes above.

Heat capacity

The temperature dependence of the heat capacity ($C\ /\ T$) of $Pr_4Ni_3O_{10}$ shows a sharp δ-like peak at ~ 157 K, indicating a possible first order phase transition at T_{pt} .

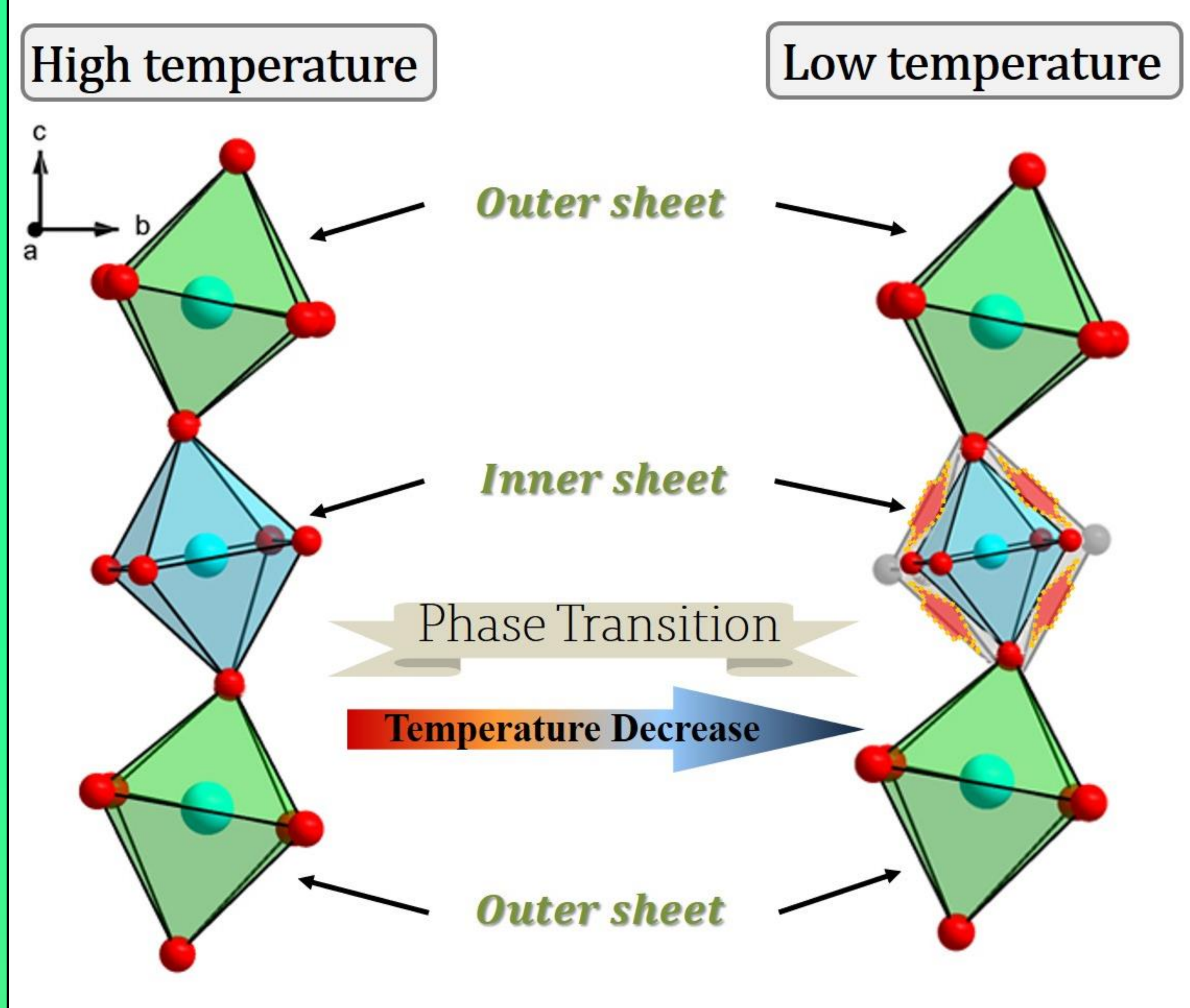




Magnetization

The magnetization of $Pr_4Ni_3O_{10}$ shows a paramagnetic behavior from 10 to 300 K that can be well fitted by a Curie-Weiss law. The fitted Curie constants are different between the high-temperature and the low-temperature phases. While the low-temperature values can be explained by the magnetic moments of the Pr^{3+} alone, the high-temperature values are compatible with one additional Ni^{2+} in a high-spin configuration.

Change of the crystal structure at the structural phase transition at T_{pt} ~ 157 K



In the low temperature phase, the inner NiO_6 octahedra shrink as compared to that of the high-temperature phase. However, there are no visible differences between these two phases in the outer NiO_6 octahedra. This subtle change of the environment of the inner Ni sites must be responsible for the differences in resistivity and magnetization between the high-temperature and the low-temperature phases.

Summary We have successfully grown single crystals of $Pr_4Ni_3O_{10}$. The heat capacity data suggest that the structural phase transition at T_{pt} ~ 157 K is of first order. A distinct anisotropy between the in-plane and out-of-plane resistivity measurements is observed. The magnetization is well fitted by a Curie-Weiss law, with distinctly different Curie constants for the high-temperature and the low-temperature phases.