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## **Professor Jong Seok Lee's research team discovers a metal with electrical polarization by relaxation of compressive strain**

□ GIST (Gwangju Institute of Science and Technology, President Kiseon Kim) Department of Physics and Photon Science Professor Jong Seok Lee's research team discovered that metallic materials can have electrical polarization due to compressive strain\* relaxation in transition metal oxide thin films.

- By applying this to electronic circuit devices, it is expected to implement a high-capacity data storage device with high concentration or a battery with high storage capacity.

\* compressive strain: compressive strain acting in-plane direction

□ The electrical properties of a material can be classified into metal/non-metal depending on the degree of electrical conduction within the material. Among them, non-metals are classified into polarity and non-polarity depending on whether they can have an electrical polarization of an anode (+) or a cathode (-). Meanwhile, in general, a metal material through which electricity flows cannot have electric polarization because free electrons inside the metal fundamentally block electrical polarization.

- Nevertheless, it was discovered that polar conductors in which metallicity and electrical polarization coexist may exist in nature, and by weakening the path that electrical polarization is blocked by free electrons, a metal with artificial

electrical polarization (hereinafter, polar metal) is created and efforts have been continuously attempted in the condensed physics field.

- The research team focused on the strain present in thin film materials and the relaxation process of that strain. In the stress relaxation process in the strontium ruthenium oxide (SrRuO<sub>3</sub>) thin film\*, it was confirmed that the polar metal state can appear at the level of the atomic layer thickness.

\* strontium ruthenium oxide (SrRuO<sub>3</sub>) thin film: a representative transition metal oxide having electrical conductivity and ferromagnetic properties and has an orthorhombic structure

- The research team spatially separated the structure deformed due to strain and the agglomerated structure due to strain relaxation in the strontium ruthenium oxide thin film subjected to compressive strain by using second harmonic generation\* and a scanning tunneling electron transmission microscope\*\*, which are nonlinear optical phenomena. It was successfully observed that the polar triclinic structure, which coexisted and the central symmetry was broken during strain relaxation and stabilization.

- In addition, by using the first-principles calculation\*\*\*, it was confirmed that the polar phase was stabilized and the metallic and ferromagnetic properties were maintained due to the spatial asymmetry distribution of the oxygen octahedral rotation pattern.

\* second harmonic generation: a phenomenon when a material is irradiated and light having a half wavelength band is emitted from a substance

\*\* scanning tunneling electron transmission microscopy: a microscope that transmits an electron beam accelerated with high voltage through a specimen to obtain an enlarged image with a high magnification

\*\*\* first-principles calculation: a method to analyze the properties of a material by minimizing the model and variables considered theoretically

- Professor Jong Seok Lee said, "The results of this study are of great significance in newly suggesting that the stress relaxation phenomenon can be used as a method of controlling the structure of transition metal oxides with high academic and application value. Through this, it is expected that various functions in the oxide thin film can be expressed, and furthermore, it can contribute to the research of condensed substances and the development of new materials."

- This research was led by GIST Professor Jong Seok Lee (corresponding author) and conducted by researcher Chang Jae Roh (first author) Basic Research Projects (Middle-sized Researcher Support Projects) and the Lead Research Center

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