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Technology Offer

High Ferroelectricity: First Method for Production of Bulk SnTiO3

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Abstract

The invention presents the first scalable method for producing bulk SnTiO3, a material with remarkable ferroelectric properties. Previously limited to thin films due to the instability of tin(II) oxide at high temperatures, this method circumvents these limitations, enabling industrial-scale synthesis. The new process produces high-purity SnTiO3 with unique crystalline structures, expanding its applicability across ferroelectric, piezoelectric, and electro-optical devices. This breakthrough facilitates the development of advanced electronics such as FeRAM, tunable capacitors, and precision actuators, marking a significant advancement in materials science and technology.

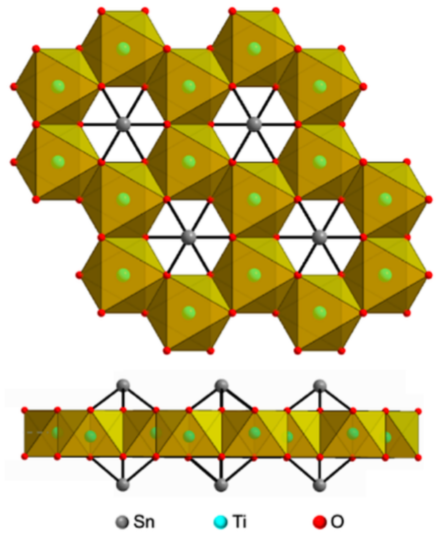

Figure 1: Illustration of the crystal structure of SnTiO3. The newly developed method according to the invention allows for the large-scale preparation of this bulk material. It is favorable for various applications, especially due to its ferroelectric properties (Diehl, et al., 2018).

Background

SnTiO3, a promising ferroelectric material, has historically been challenging to synthesize in bulk form. Existing methods like atomic layer or pulsed laser deposition are restricted to thin films, limiting their scalability and application. Additionally, traditional approaches requiring high temperatures lead to unwanted decomposition of tin(II) oxide. This new method overcomes these challenges, allowing for the cost-effective production of SnTiO3 in bulk, addressing the industry's demand for scalable, versatile materials with superior properties.

Technology

This invention provides a novel, scalable method for producing bulk SnTiO3 with high purity and unique crystalline structures. The process begins by reacting an alkali metal salt with titanium(IV) oxide at 550–650°C over a duration of 12 hours to create a layered alkali metal titanate. The precursor undergoes an ion exchange where tin(II) ions replace the alkali metal ions, forming a tin-exchanged titanate. Finally, the material is dehydrated and annealed below 350°C in an oxygen-free environment, preventing the decomposition of tin(II) oxide and enabling the formation of bulk SnTiO3. The method also facilitates the production of new crystalline structures, such as SnTi1-xMxO3. This approach ensures reproducibility, high material quality, and industrial scalability, addressing the limitations of traditional methods restricted to thin films.

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 München
www.max-planck-innovation.de

Advantages

- First bulk production method for $SnTiO_3$.
- Scalable and suitable for industrial applications.
- Enables access to diverse $SnTiO_3$-based materials.
- Produces high-purity materials validated by advanced characterization techniques.
- Unlocks potential for novel device applications due to unique structural and ferroelectric properties.

Potential applications

- Ferroelectric random-access memory (FeRAM) for data storage.
- Tunable capacitors for frequency control in electronics.
- Ferroelectric tunnel junctions (FTJ) for advanced computing architectures.
- Piezoelectric materials for ultrasound imaging.
- Electro-optical elements for high-speed data storage and transmission.

Patent Information

PCT *(WO2019211372A1*; 02.05.2019), active in EP, CN, JP, US

Publications

Diehl, L., Bette, S., Pielnhofer, F., Betzler, S., Moudrakovski, I., Ozin, G. A., ... & Lotsch, B. V. (2018). Structure-directing lone pairs: synthesis and structural characterization of $SnTiO_3$. *Chemistry of Materials*, *30*(24), 8932-8938.

Contact

Dr. Bernd Ctortecka

Senior Patent- & License Manager, Physicist
Phone: +49 (0)89 / 29 09 19 – 20
eMail: ctortecka@max-planck-innovation.de

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 München
www.max-planck-innovation.de