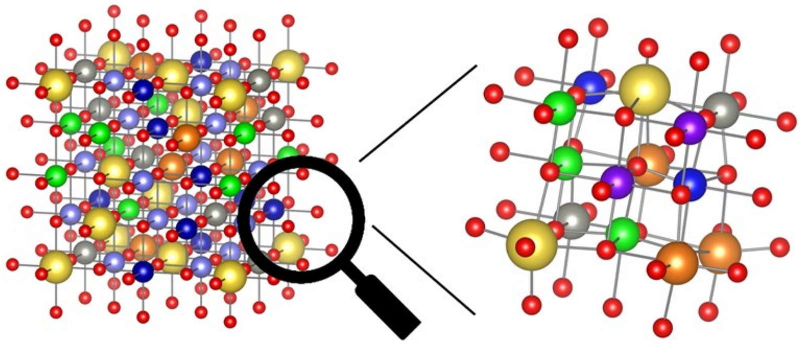
Master/Bachelor Thesis:

Karlsruhe Institute of Technology
Institute of Nanotechnology

High-Entropy Ferroelectric Materials for Electronic Applications



Ferro- and piezoelectric materials represent a special class of functional materials that exhibit unique electromechanical properties. They can convert mechanical energy into electrical energy, and vice versa. This occurs through vibrations in the crystal lattice that generate intrinsic electric dipoles, which in turn result in an electric field. This ability enables these materials to convert a mechanical impulse into an electrical signal, or respond mechanically to electrical impulses. This capability allows for their use in a variety of applications, such as non-volatile memory devices (FeRAM), sensors, actuators, energy harvesting, frequency generation and filtering, microphones and speakers, MEMS devices, and much more.

At INT, we aim to investigate these types of materials and create new compounds that do not currently exist, thereby enhancing or customizing the aforementioned properties. This is achieved through the application of high-entropy methods, where many different elements are incorporated into a crystal structure, resulting in interactions between the elements that impart unpredictable properties to these materials. By exchanging elements or adjusting stoichiometries, the properties can be controlled and optimized as needed. High-entropy materials have only been known since 2015, so many potential applications remain largely unexplored. The concept offers numerous advantages for application in piezoelectric and ferroelectric materials, as it directly influences the basics of piezoelectric properties through lattice distortions and changes in polarizability.

As part of a bachelor's or master's thesis, we would like to attempt the synthesis of ferroelectric high-entropy materials and test them for their structural and electronic properties. Due to the high-entropy concept, there is an almost infinite number of possible elemental compositions and material compositions, resulting in entirely novel materials that have never been synthesized before. Synthesis will be carried out using a high-throughput synthesis robot existing at INT, and structural characterizations can be performed using automated XRD systems. The first step will involve synthesizing single-phase ferroelectric high-entropy materials followed by structural characterization. In the second step, selected materials will be characterized for their electrical properties using various measurement techniques (e.g., impedance spectroscopy). The most promising materials will then be integrated directly into printed electrical systems, such as dielectrics in transistors.

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