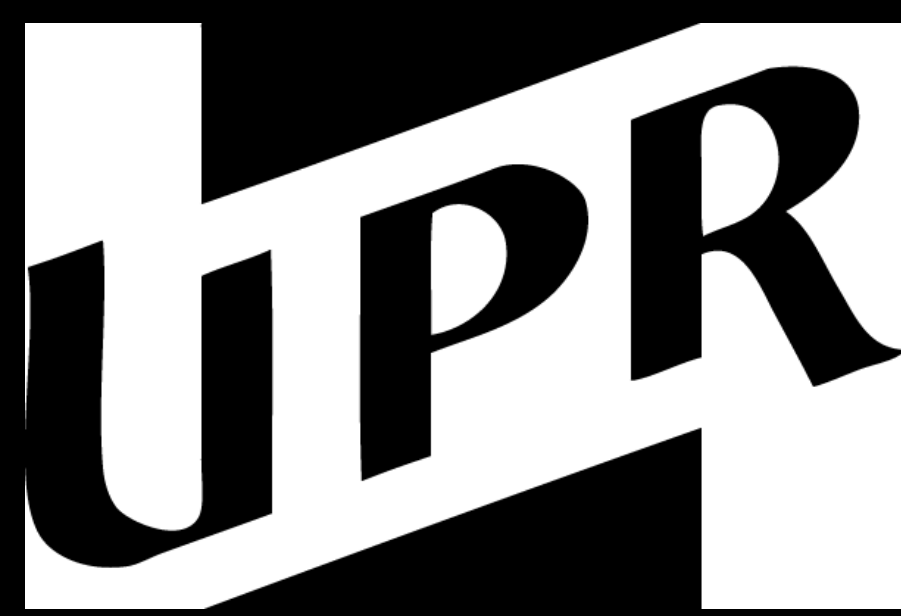


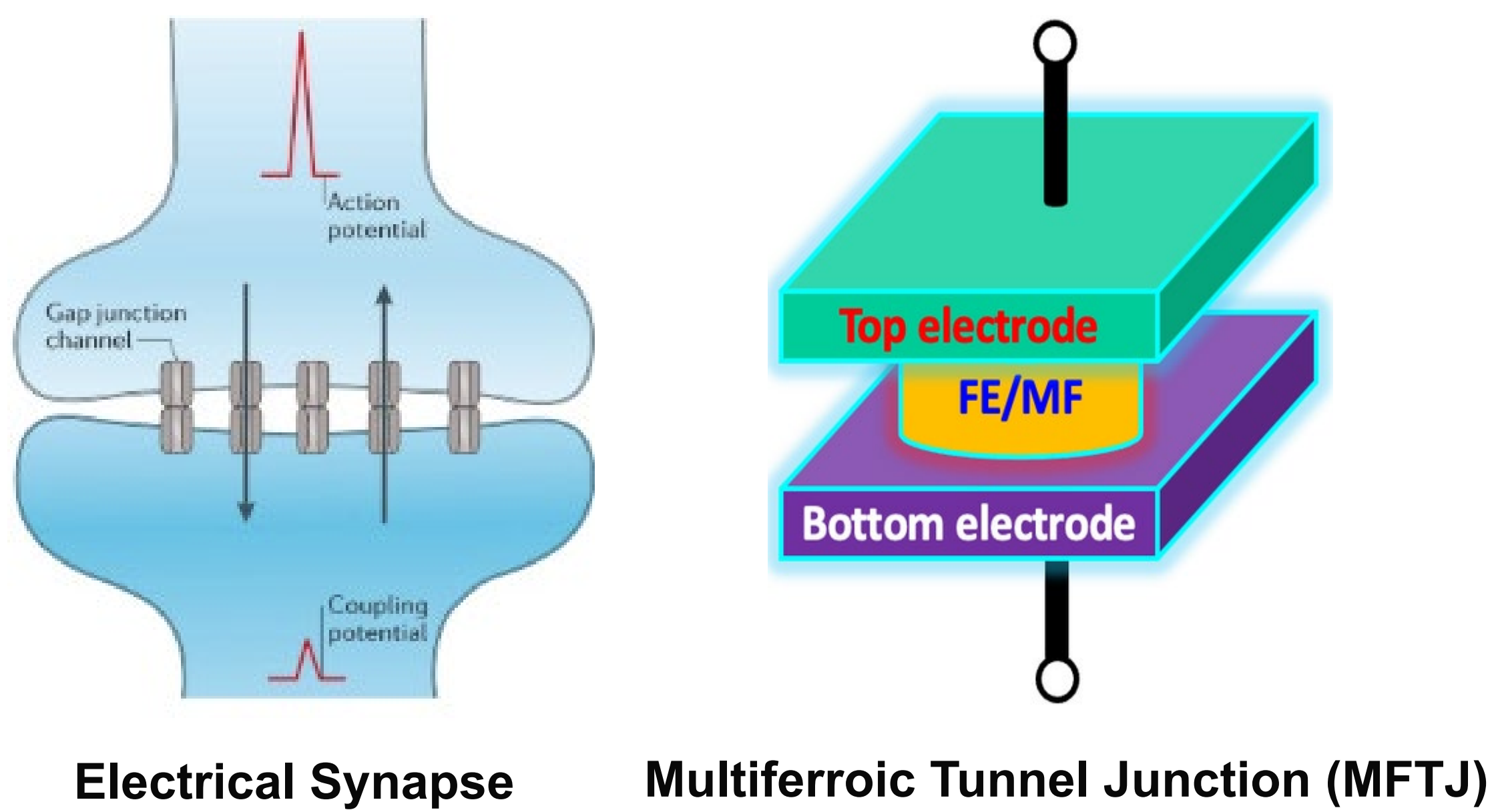
Improvements on low-density parity-check (LDPC) codes and high-performance neuromorphic engineering for communication systems



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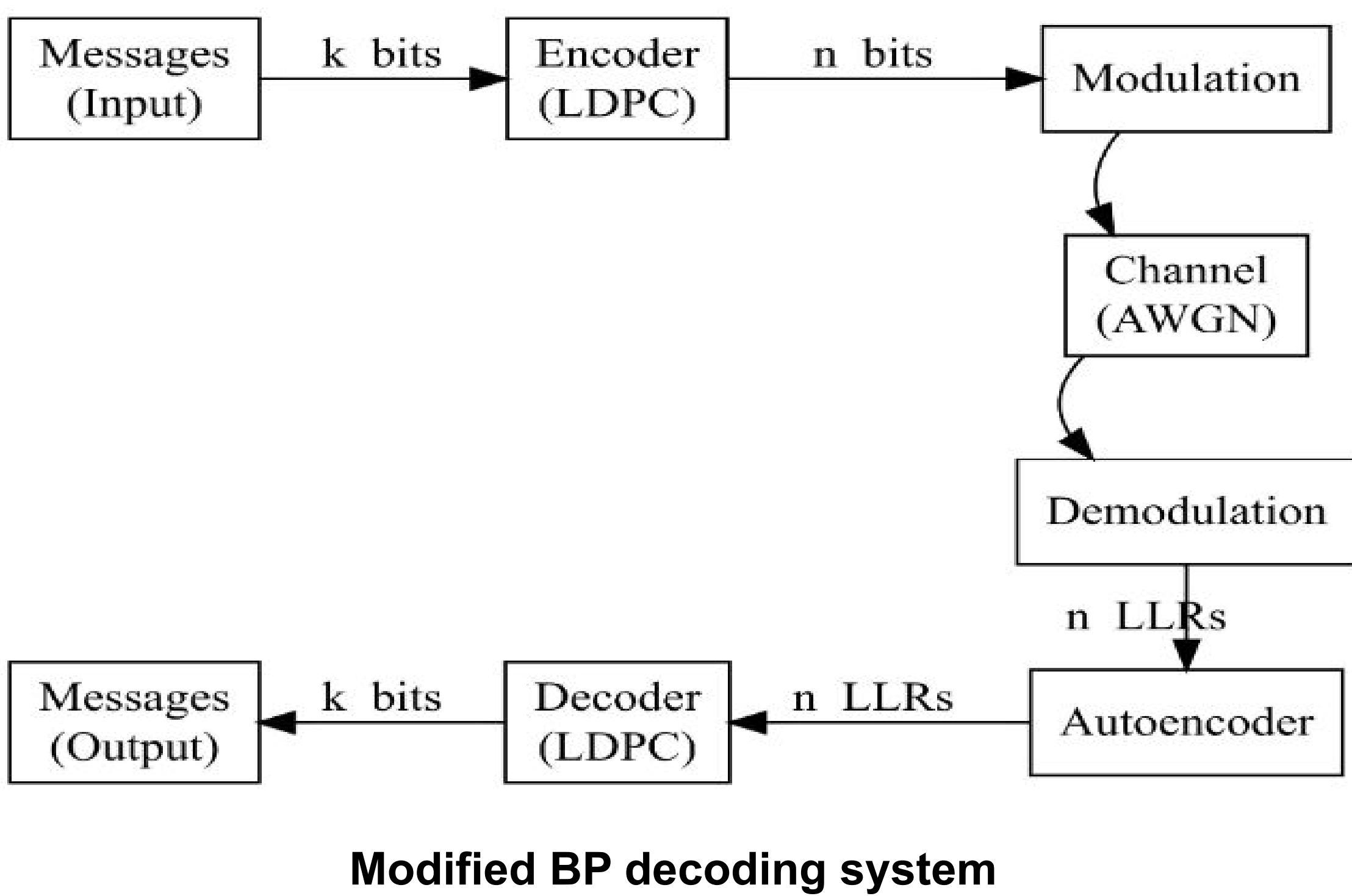
INTRODUCTION

Belief propagation (BP) on LDPC codes is an iterative decoding algorithm that performs information transfer on the Tanner graph, which represents the code. In each iteration, the algorithm exchanges information (LLR) between variable nodes and check nodes through the edges of the graph. LLR values represent the probability that a given bit in a transmitted codeword equals 0 or 1, given a received word. In the hardware part, recent advancements in intelligent technologies, such as artificial intelligence, big data analytics, autonomous vehicles, and speech/image recognition, have heightened the demand for faster calculations and reduced energy consumption. Neuromorphic computing, integrating artificial synapses and neural network algorithms, emerges as a promising solution to tackle the limitations of existing computing architectures [3]. The development of electronic devices capable of emulating the synaptic plasticity of biological synapses has spurred research in neuromorphic computing. Such systems hold the potential to autonomously learn and execute tasks through interaction with their environment, making them applicable even in space exploration, a domain pertinent to agencies like NASA.



HYPOTHESIS

1. Introducing autoencoders into the BP decoder may improve the performance of the algorithm for short-length codes and reduce the complexity of the decoding process [1, 2].



2. Using a multiferroic tunnel junction offers the opportunity to get four-state logic because of the ferromagnetic and ferroelectric components, electron and spin tunneling can be controlled, and a four-state resistance device can be realized by polarization and magnetization switching. This project contributes to the pursuit of developing an ideal memory device with clear advantages of being non-volatility, low power consumption, high endurance, and high-speed writing.

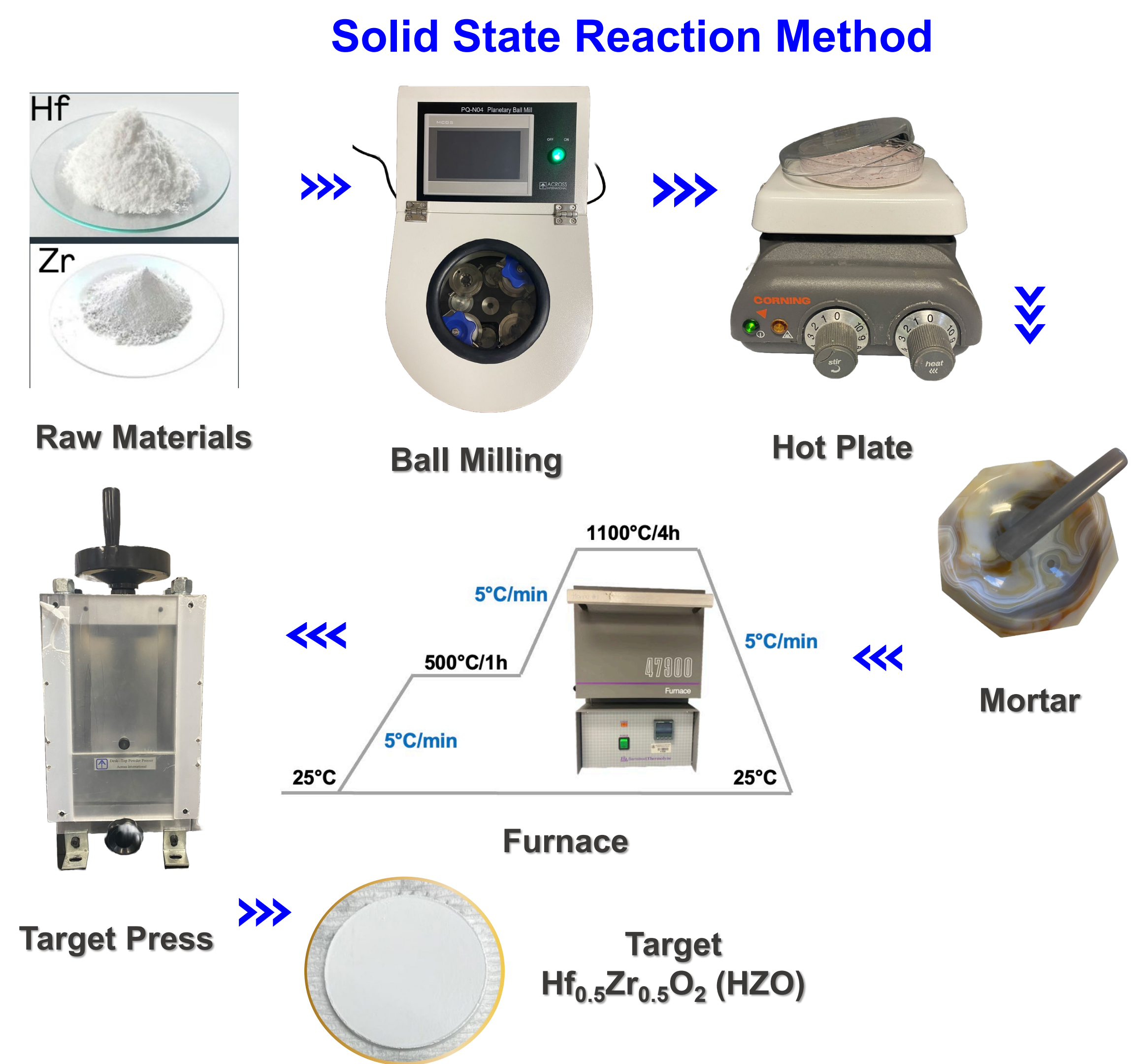
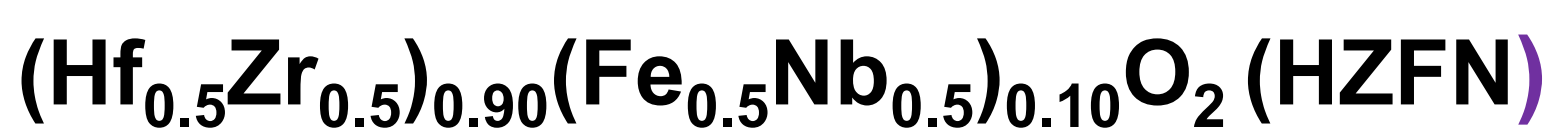
CONCENTRATION

1. Our research focuses on applying deep learning techniques to improve LDPC decoding.
2. Focusing on the development of hardware and software solutions that can effectively handle large volume of data for artificial intelligence applications (AI) there's a notable interest in building a neuromorphic system that emulates the human brain's information processing.

REASONING

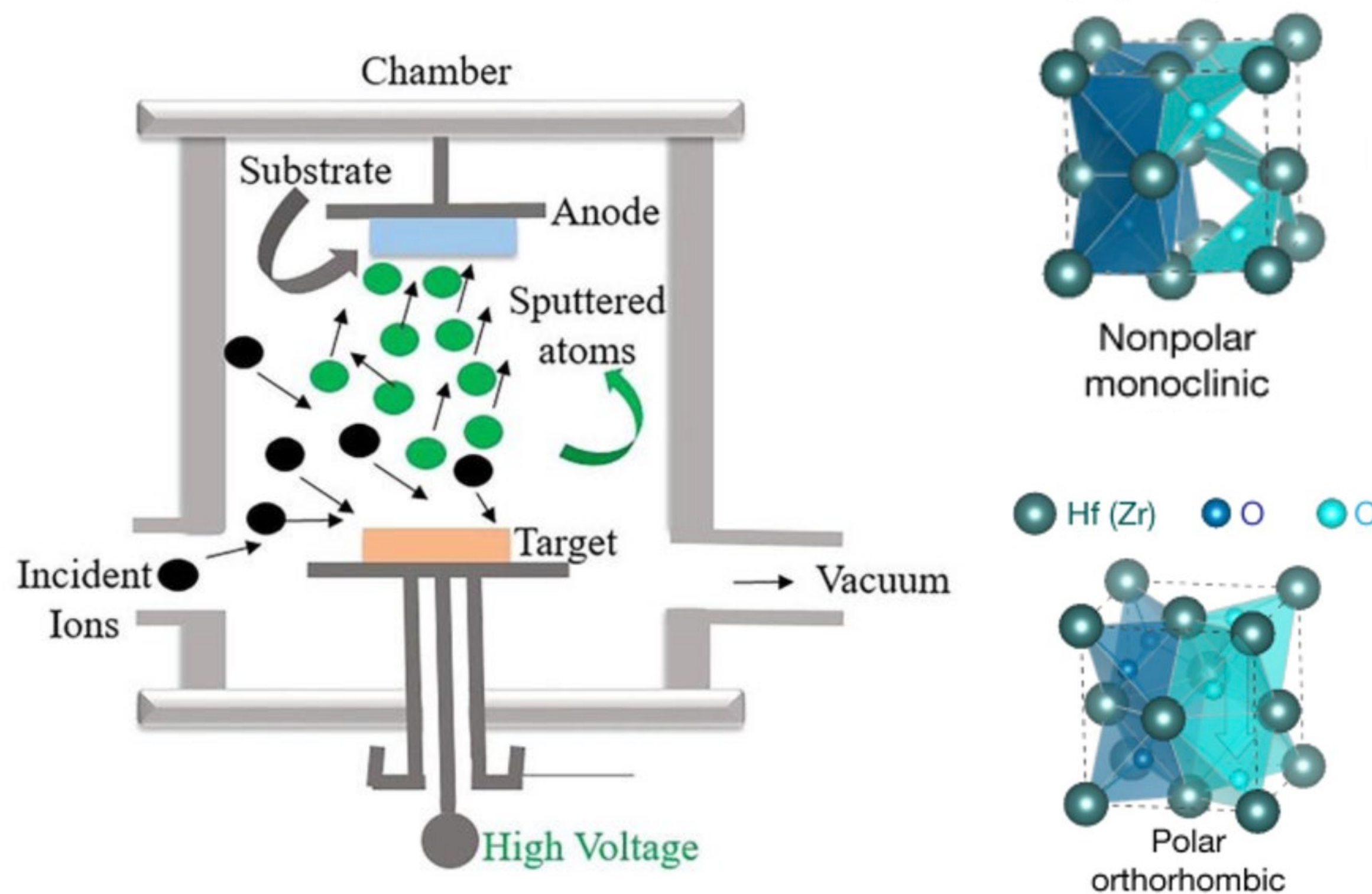
1. We are integrating a denoising autoencoder into the decoding process to reduce the noise introduced during data transmission and to enhance decoding performance. This integration is based on the understanding that a denoising autoencoder can help minimize transmission noise. This noise reduction is expected to improve the performance of the BP algorithm.
2. This project centers on the growth, optimization, and characterization of multiferroic tunnel junctions.

Synthesis:



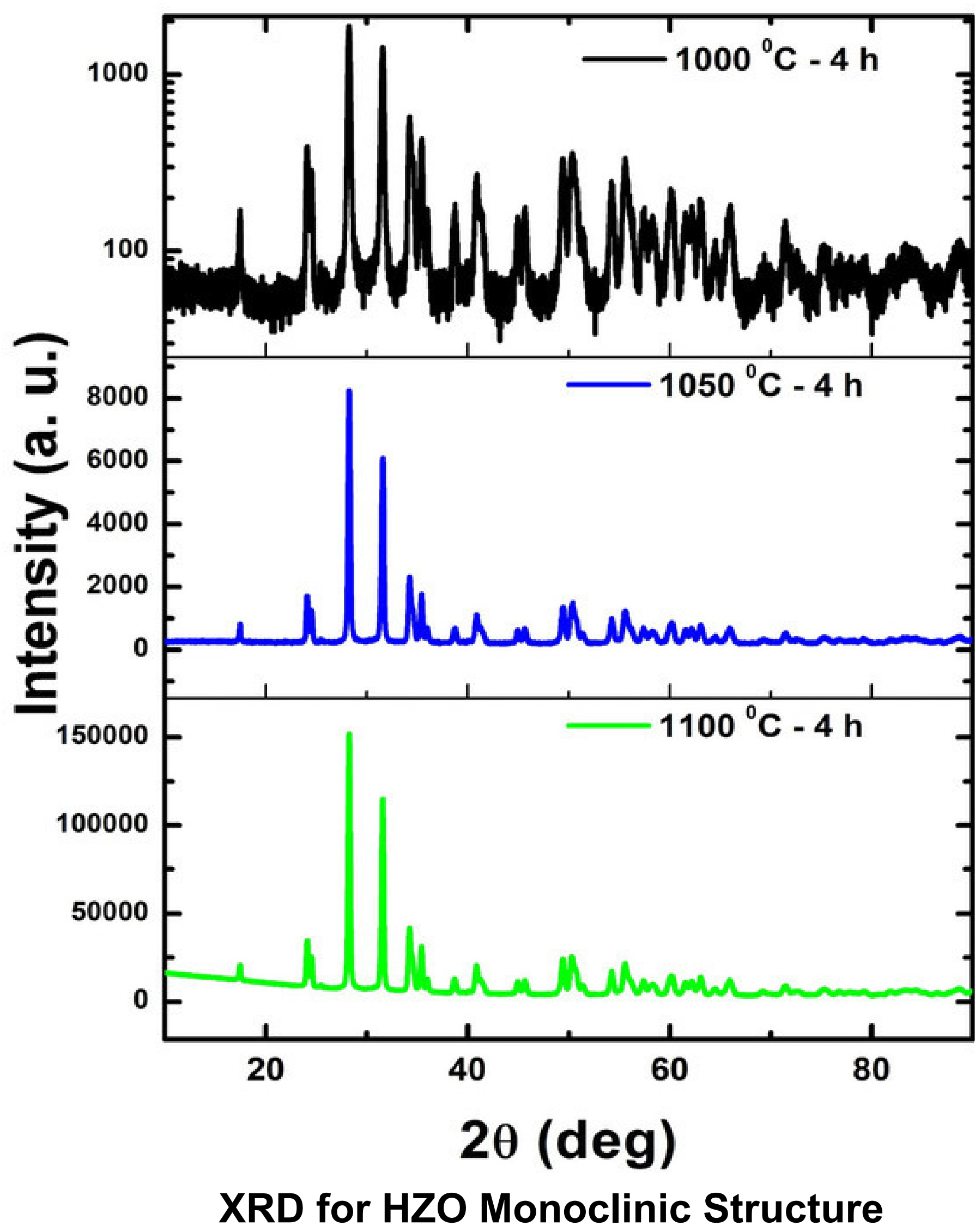
. After developing the solid-state reaction method, X-Ray Diffraction was assessed to the HZO target to verify the accuracy of the crystalline structure. For the thin film structure, RF sputtering deposition technique will be used to grown the HZFN samples, so it can be created a tunnel junction with platinum (Pt) and LSMO ($\text{La}_{0.67}\text{Sr}_{0.33}\text{MnO}_3$) metals.

RF Sputtering Deposition Technique



RELATED DATA

1. We have developed a code to generate datasets essential for our research. This code utilizes a parity check matrix H to define values for k and n. Given a number of messages m, it generates m unique messages. For each message, the code calculates the corresponding codeword, simulates its transmission over an AWGN channel, computes Log-Likelihood Ratios (LLRs), and decodes the codewords using the Belief Propagation (BP) algorithm. These vectors can be generated in real-time or stored for future use, facilitating efficient data management and analysis.
2. XRD was developed for 1000°C, 1050°C and 1100°C. The monoclinic structure required for HZFN was confirmed at 1100 °C.



CONCLUSION

- Integrating a denoising autoencoder with the BP algorithm led to a 25% to 30% improvement in error correction for short-length LDPC codes with k=16 and n=32. The implementation of a convolutional autoencoder proved effective. Future efforts will explore different architectural configurations to support longer-length LDPC codes, aiming to further enhance decoding performance.
- Temperatures for HZFN target construction were 1000°C, 1050°C and 1100°C. The monoclinic structure required for HZFN was confirmed by the X-Ray Diffraction Method at 1100°C.

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