

## *Summary*

### **"Analysis of the dynamics of magnetization of low-dimensional ferromagnetic structures for applications in memory systems and information processing"**

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Due to the achievement of technological limits in modern electronics, scientific trends are emerging in an attempt to respond to the growing consumer demand. Spintronics is one of them and is undergoing rapid development. The domain of this research activity are magnetic systems, some features of which may be used in electronics. In particular, magnetic systems with ferromagnetic elements are subject to intensive theoretical and experimental work conducted by a large group of scientists for applications in electronics. In order for ferromagnetic systems to have the features expected by electronics, their structure should be provided in such a way as to obtain the expected response of the system to its activation with specific signals. Unfortunately, ferromagnetic systems are usually too complex to study analytically and thus obtain the desired properties. That is why numerical tools - simulators - are used to study such systems. There are different versions of the simulation software for ferromagnetic circuits that are widely available on the web and do not require the purchase of a license. However, these simulators can usually simulate systems for very low temperatures close to absolute zero. Commercial electronics, however, work in the temperature range close to room temperature, so there is a need to study ferromagnetic systems for temperatures above absolute zero, including those close to the temperatures close to the disappearance of ferromagnetic phenomena (Curie temperature). Therefore, for the purposes of this dissertation, the author decided to respond to the demand in the form of a high-temperature simulator of ferromagnetic systems and created his own software. With its help, he investigated his proposed model of magnetic memory, which is composed of a matrix of separate cells and has a switching time of hundreds of picoseconds, and also does not require the use of switching heads. Thanks to this, there is a chance to provide shorter memory access time compared to modern solutions, e.g. compared to memories made of continuous magnetic layers. The prepared software and the proposed model give hope for further research development and finding a memory model with the lowest switching time and the highest recording density, which is expressed in the thesis. The MAGPAR software developed at the Vienna University of Technology and used for micromagnetic simulations at temperatures close to absolute zero was used as the basis for the proprietary IT system. This simulator had the desired technological features, such as the possibility of distributed processing and the use of multiple computing nodes to accelerate the computation (MPI). The use of high temperatures in the study of ferromagnetic systems required obtaining their distribution for the entire tested model, so it was necessary to properly solve additional equation, also defining heat flows and implement them in the finite element methodology, as shown in this paper. With increasing temperatures, the equation describing the time-space evolution of magnetization changes in the ferromagnetic system changed, which replaced the equation implemented to describe the evolution of magnetization for low temperatures. Temperatures above absolute zero affect the terms of the effective field, which translates into the course of the evolution of magnetization. The changed equation of the evolution of magnetization and the modified terms of the effective field had to be properly implemented in the finite element methodology, which was also included in the paper. The research issues that are the domain of spintronics were reviewed, including potential applications in computer architectures inspired by the structure of the nervous system of living creatures, which, as shown, may have a significant impact on improving the efficiency of numerical distributed computing.