NDnano Undergraduate Research Fellowship (NURF)
2012 Project Summary

1) Student name: Ádám Papp
2) Faculty mentor name: Prof. György Csaba, Prof. Wolfgang Porod
3) Project title: Design of domain-wall based computing devices

4) Briefly describe any new skills you acquired during your summer research:
I learned how to model Co/Pt multilayers in OOMMF simulator program, and the dynamics of the domain-walls in this structure. I gained knowledge of micromagnetics, domain theory and physics of nanoscale magnetism.

5) Please briefly share a practical application/end use of your research:
Designed magnetic Full-adder and Programmable Logical Array based on magnetic domain-walls, observations in the static and dynamic behavior of the domain-walls in Co/Pt multilayer wires.

Project summary:

In this project I worked with out-of-plane magnetized domain walls in Co/Pt multilayer structures. The goal was to study the static and dynamic behavior of these domain-walls, and design computing devices based on the learned properties. The out-of-plane domain-walls have different properties, than the in-plane types, this enabling new kind of devices.
To the investigations I used the OOMMF (Object Oriented Micromagnetic Framework) simulation software, with parameters originate from experimental measurements in papers. In the first part of my work I studied the velocity of the domain wall as the function of the propagating field and the dimensional parameters, and the properties of the field generated by the structure. I observed an oscillatory motion of the domain-wall, which most of the cases caused an unpredictable operation in the designed devices, but it potentially can be exploited in dynamic computing devices.
I proposed a new technique to increase the velocity of the domain walls with a static field. This can yield at least one order of magnitude improvement in the device speed without increasing the power consumption of the device. This technique was already used by the design of the devices in this work.
I also designed a novel magnetic full adder structure, which is based on threshold gates. The threshold gate is shown in Fig. 1.

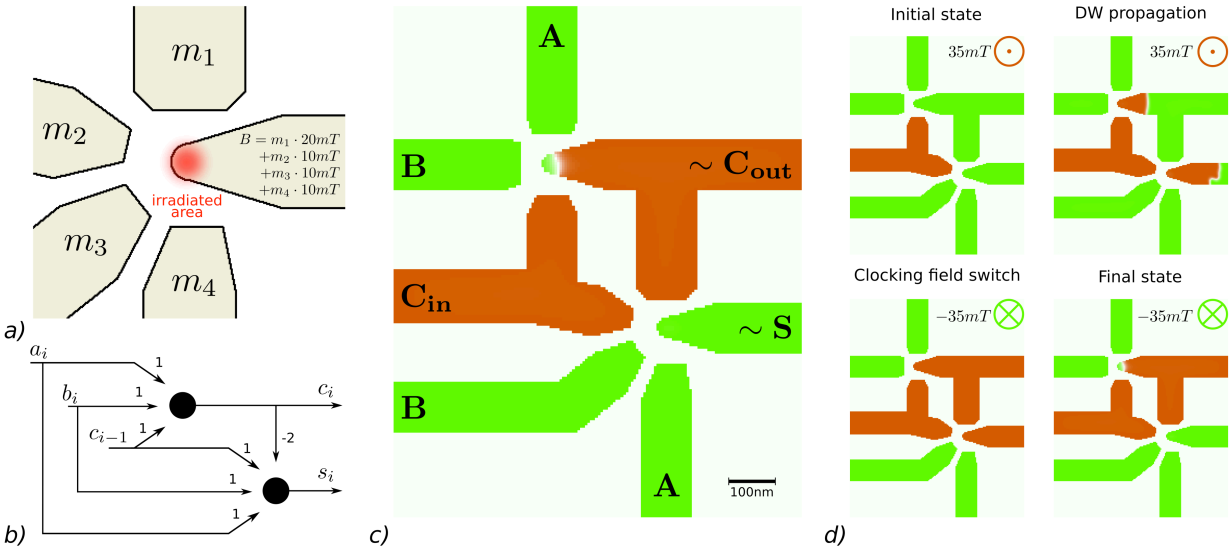

Figure 1. Layout of a nanomagnetic threshold gate, indicating the calculated interaction fields. Panels b) and c) show the circuit schematics and the designed layout, while d) gives snapshots from an OOMMF simulation.

The second designed device is a magnetic Programmable Logic Device (PLA) based on the interactions of the crossing magnetic nanowires. The structure consists of two layers of parallel wires and an additive layer to the programmability. The design was proved in micromagnetic simulations.

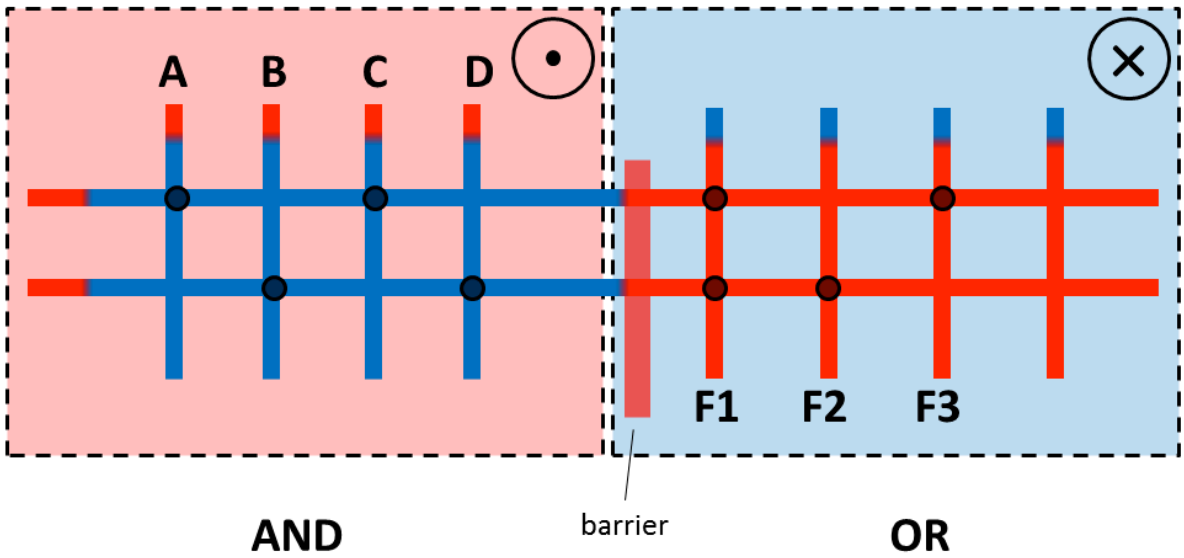

Figure 2. Schematic design of a PLA based on crossing domain-walls

Publications (papers/posters/presentations):

A. Papp, M. Niemier, A. Csurgay, M. Becherer, S. Breitkreutz, J. Kiermaier, I. Eichwald, X. Ju, W. Porod, G. Csaba, "Design of a threshold-gate based full adder from out of plane Nanomagnetic Logic", submitted to 12th Joint MMM/Intermag Conference