Modelling of ME2 devices for hybrid spintronic-CMOS logic circuits

A Data Management Plan created using DMPonline.be

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Project abstract:

We live in a world where everyday objects are smart and each need their appropriate logic circuitry. However, an increasing need for logic circuitry in a world with limited resources, together with the current energy crisis, forces us to consider energy-saving solutions. One of these solutions is hybrid spintronic-CMOS logic circuitry, which can possibly outperform conventional CMOS in terms of energy-delay product if and only if they make use of ultralow-energy ($\sim$1-10 aJ) transducers between the magnetic and electric domain. The ME² device is proposed as such transducer to meet those strict energy requirements. It consists of magnetoelectric (ME) composite materials, containing piezoelectric and magnetostrictive layers that couple via strain. It encodes information in its magnetization state and uses the ME effect for both its input and output mechanism. However, not much is yet known about the ME effect at the nanoscale, and, with the aim of energy optimization, a complete understanding of this is crucial to design an ultralow-energy ME² device. Therefore, in this project, I will identify a full physical framework as well as the working principles of the novel ME² device via simulations, where I will determine its input and output physics and will propose ME² designs going towards low-voltage performance. Achievement of this project enables optimization of the ME² device and paves the path for development of full hybrid spintronic-CMOS circuits.

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FWO DMP (Flemish Standard DMP)

1. Research Data Summary

List and describe all datasets or research materials that you plan to generate/collect or reuse during your research project. For each dataset or data type (observational, experimental etc.), provide a short name & description (sufficient for yourself to know what data it is about), indicate whether the data are newly generated/collected or reused, digital or physical, also indicate the type of the data (the kind of content), its technical format (file extension), and an estimate of the upper limit of the volume of the data.

Dataset Name	Description	New or reused	Digital or Physical	Only for digital data	Only for digital data	Only for digital data	Only for physical data
				Digital Data Type	Digital Data format	Digital data volume (MB/GB/TB)	Physical volume
		Please choose from the following options: - Generate new data - Reuse existing data	*Please choose from the following options:* - Digital - Physical	*Please choose from the following options:* - Observational - Experimental - Compiled/aggregated data - Simulation data - Software - Other - NA	*Please choose from the following options:* .por, .xml, .tab, .csv,.pdf, .txt, .rtf, .dwg, .gml, … - NA	*Please choose from the following options:* <100MB <1GB <100GB <1TB <5TB <10TB <50TB >50TB - NA	
Mumax3 models and data	Micromagnetic simulations of nanomagnets/magnetic waveguides	Generate new data	Digital	Simulation data	.ovf	<100 GB	
Python models and data	Analytical models of ME² device	Generate new data	Digital	Simulation data	.csv .dat	<100 GB	
Python data	post processing of simulation data obtained from Mumax3 and COMSOL	Generate new data	Digital	Simulation data	.csv .dat	<100 GB	
COMSOL models and data	COMSOL model of nanomagnets/ME² devices/ magnetic waveguides	Generate new data	Digital	Simulation data	.mph .csv	<100 GB	

If you reuse existing data, please specify the source, preferably by using a persistent identifier (e.g. DOI, Handle, URL etc.) per dataset or data type:

/

Are there any ethical issues concerning the creation and/or use of the data (e.g. experiments on humans or animals, dual use)? Describe these issues in the comment section. Please refer to specific datasets or data types when appropriate.

- No

Will you process personal data? If so, briefly describe the kind of personal data you will use in the comment section. Please refer to specific datasets or data types when appropriate.

- No

Does your work have potential for commercial valorization (e.g. tech transfer, for example spin-offs, commercial exploitation, …)? If so, please comment per dataset or data type where appropriate.

- No

Do existing 3rd party agreements restrict exploitation or dissemination of the data you (re)use (e.g. Material/Data transfer agreements/ research collaboration agreements)? If so, please explain in the comment section to what data they relate and what restrictions are in place.

- No

Are there any other legal issues, such as intellectual property rights and ownership, to be managed related to the data you (re)use? If so, please explain in the comment section to what data they relate and which restrictions will be asserted.

- No

2. Documentation and Metadata

Clearly describe what approach will be followed to capture the accompanying information necessary to keep data understandable and usable, for yourself and others, now and in the future (e.g., in terms of documentation levels and types required, procedures used, Electronic Lab Notebooks, README.txt files, Codebook.tsv etc. where this information is recorded).

- Simulation data (COMSOL, Mumax3, Python, HFSS) are saved in an automatised format defined by the simulation software. Both simulation data and postprocessing data will be saved in origin and throughout Powerpoint.
- Models written in python will be explained in Powerpoint or in the simulation script itself. Models made in COMSOL and Mumax3 are explained in Powerpoint

Will a metadata standard be used to make it easier to find and reuse the data? If so, please specify (where appropriate per dataset or data type) which metadata standard will be used. If not, please specify (where appropriate per dataset or data type) which metadata will be created to make the data easier to find and reuse.

- No

3. Data storage & back-up during the research project

Where will the data be stored?

- Simulation data is saved in Imec's central servers
- Metadata, selected important data and reports are saved in clouds (SharePoint and Onedrive)

How will the data be backed up?

Backing up of data is carried out by Imec and cloud service provider (Microsoft)

Is there currently sufficient storage & backup capacity during the project? If yes, specify concisely.
If no or insufficient storage or backup capacities are available, then explain how this will be taken care of.

- Yes

Central servers and clouds are shared and have large capability

How will you ensure that the data are securely stored and not accessed or modified by unauthorized persons?

Access to the central servers is only possible for specific users after approval by Imec. Data on the group's SharePoint is only accessible by people in the research group, with the exception of specific files shared with the collaborators.

What are the expected costs for data storage and backup during the research project? How will these costs be covered?

costs are covered by Imec.

4. Data preservation after the end of the research project

Which data will be retained for at least five years (or longer, in agreement with other retention policies that are applicable) after the end of the project? In case some data cannot be preserved, clearly state the reasons for this (e.g. legal or contractual restrictions, storage/budget issues, institutional policies...).

All the data will be retained for 5 years following the end of the project.

Where will these data be archived (stored and curated for the long-term)?

The data will be left where it's currently saved (Imec's central servers and clouds) as capacity is sufficient.

What are the expected costs for data preservation during the expected retention period? How will these costs be covered?

Costs are covered by Imec.

5. Data sharing and reuse

Will the data (or part of the data) be made available for reuse after/during the project? In the comment section please explain per dataset or data type which data will be made available.

- Yes, in a restricted access repository (after approval, institutional access only, …)

- Relevant data will be published in journals or reported in the PhD thesis.

If access is restricted, please specify who will be able to access the data and under what conditions.

Data can be accessed by relevant collaborateurs or other parties upon request. All data can be be shared with FWO and KU Leuven.

Are there any factors that restrict or prevent the sharing of (some of) the data (e.g. as defined in an agreement with a 3rd party, legal restrictions)? Please explain in the comment section per dataset or data type where appropriate.

- No

Where will the data be made available? If already known, please provide a repository per dataset or data type.

Relevant data will be published in journals or reported in the PhD thesis

When will the data be made available?

- upon publication of the research results

Which data usage licenses are you going to provide? If none, please explain why.

Data usage license will be discussed with Imec/KUL before any licenses are granted

Do you intend to add a PID/DOI/accession number to your dataset(s)? If already available, you have the option to provide it in the comment section.

- Yes

What are the expected costs for data sharing? How will these costs be covered?

No costs are expected.

6. Responsibilities

Who will manage data documentation and metadata during the research project?

The PI will be the responsible for the data documentation and metadata under the supervision of the PI's advisors (Dr. Florin Ciubotaru and Dr. Christoph Adelmann).

Who will manage data storage and backup during the research project?

The PI will be responsible for the data storage and backup. Additional back ups of important data are carried out by the PI's advisors (Dr. Florin Ciubotaru and Dr. Christoph Adelmann)

Who will manage data preservation and sharing?

The PI's advisors (Dr. Florin Ciubotaru and Dr. Christoph Adelmann) and other research group members will be responsible for data preservation and sharing.

Who will update and implement this DMP?

The PI bears the end responsibility of implementing this DMP

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