



# Magnetic **IN**formation storage Technology (**MINT**)

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**Department of Physics,**

**Faculty of Science**

**Maharakham University**

# Magnetic Information storage Technology (MINT) Group



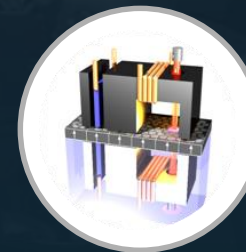
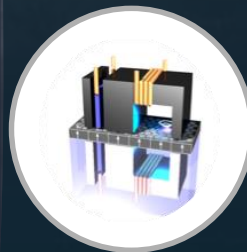
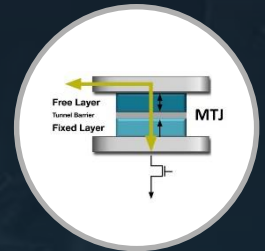
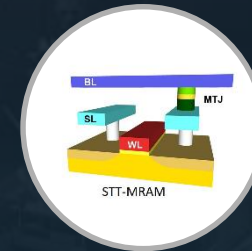
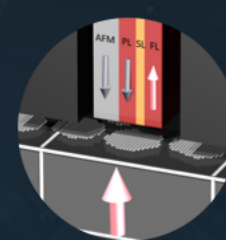
## Our Group Members

- 3 Academic staffs
- 1 Postdoc
- 5 PhD. students, 1 Master student



## Research Interests

- Hard disk drive components designs
- Heat-assisted magnetic recording media (HAMR)
- Spin transport in read elements
- Magnetic materials and their applications
- Magnetic random access memory (MRAM)
- Magnetization dynamics of MTJs structure

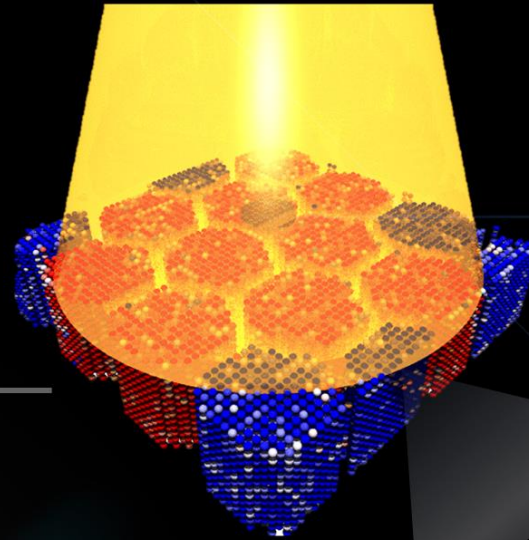


# Magnetic Information storage Technology (MINT) Group

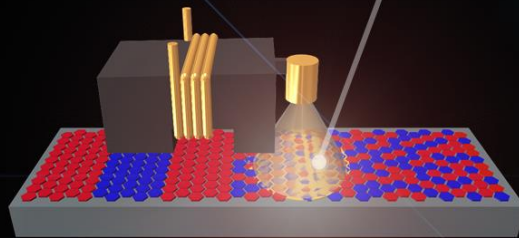


# Advanced Magnetic Modeling

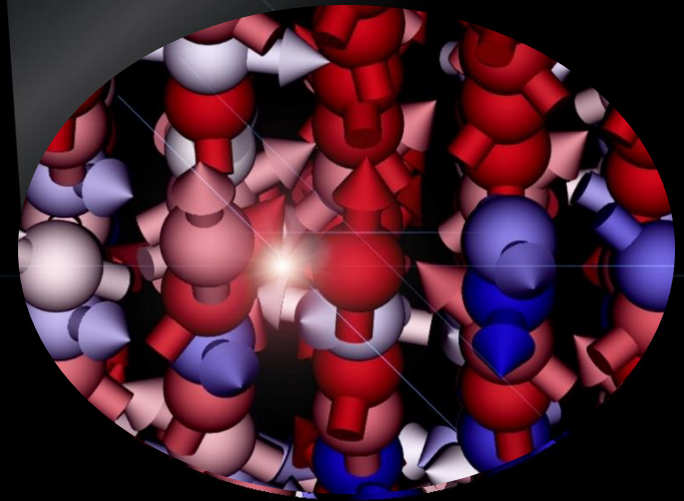
The image shows the visualization of the switching mechanism at the atomistic level for advanced technology called Heat Assisted Magnetic Recording (HAMR) technology. HAMR represents the most promising candidate to replace the current technology to achieve high areal densities by heating the storage layer with a short light of laser.



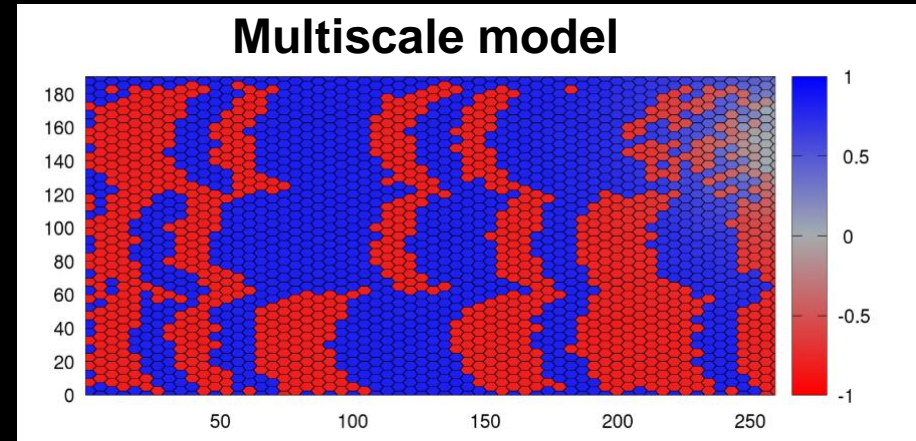
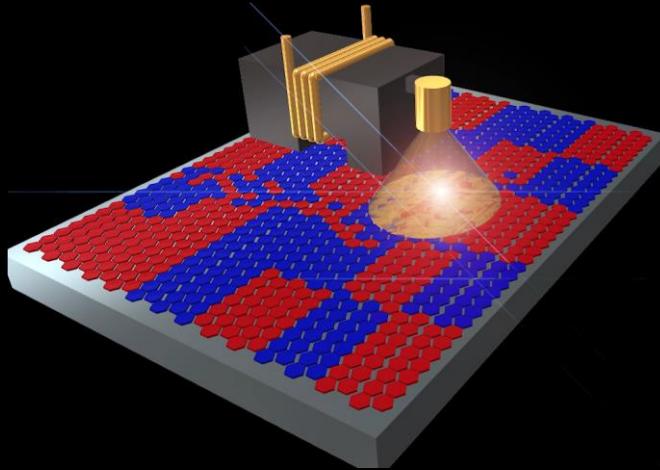
**Atomistic model**



**Micromagnetic model**



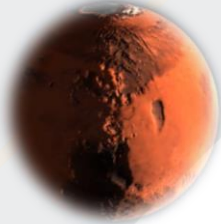
## Heat Assisted Magnetic Recording Technology (HAMR)



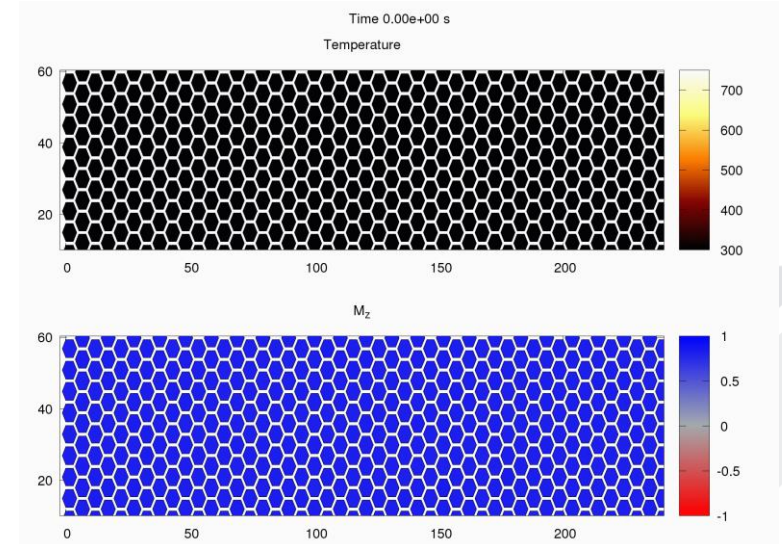
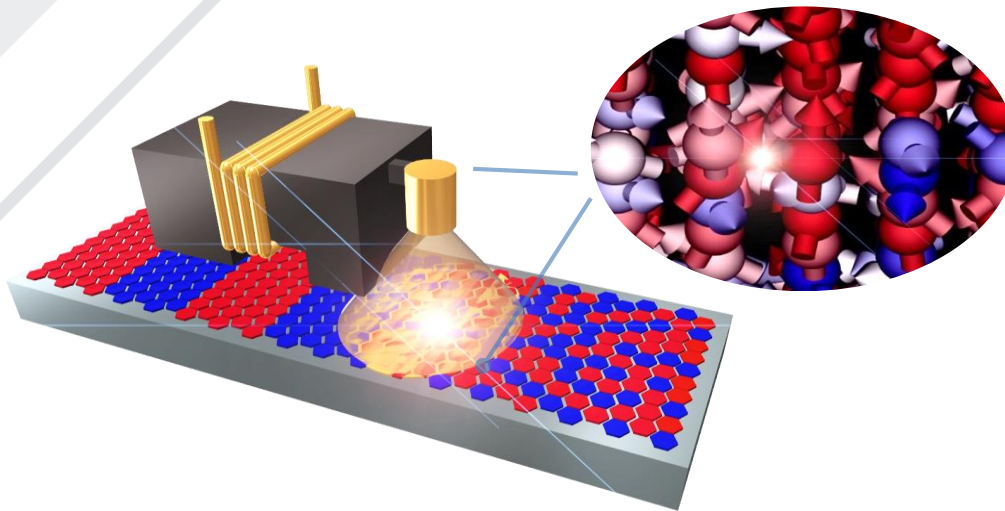
# OUTCOMES 2022

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# Realistic Advanced Model



## Advanced Model (MARS) for Industrial Applications



# Publications



- We published 5 research articles in ISI Quartile 1-2 (2022-2023).

**Research Publication**  
MINT Research Unit  
Department of Physics, Mahasarakham University

**Scientific Reports**  
ISI Q1 in Physics  
IF: 4.996

**Magnetisation switching dynamics induced by combination of spin transfer torque and spin orbit torque**  
Andrea Meo, Jessada Churemart, Roy W Chantrell, Phrawadee Churemart, Scientific reports, 12, 3380 (2022)

We present a theoretical investigation of the magnetisation reversal process in CoFeB-based magnetic tunnel junctions (MTJs). We perform atomistic spin simulations of magnetisation dynamics induced by combination of spin orbit torque (SOT) and spin transfer torque (STT). Within the model the effect of SOT is introduced as a Stonewall formalism, whereas the effect of STT is included via a spin-accumulation model. We investigate a system of CoFeB/MgO/CoFeB coupled with a heavy metal layer where the charge current is injected into the plane of the heavy metal, meanwhile the other charge current flows perpendicular into the MTJ structure. Our results reveal that SOT can assist the precessional switching induced by spin polarized current within a certain range of injected current densities yielding an efficient and fast reversal on the sub-nanosecond timescale. The combination of STT and SOT gives a promising pathway to improve high performance CoFeB-based devices with high speed and low power consumption.

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10.1038/s41598-022-07272-2

**Research Publication**  
MINT Research Unit  
Department of Physics, Mahasarakham University

**Computer Physics Communications**  
ISI Q1 in Physics, Applied  
IF: 4.717

**Models of advanced recording systems: A multi-timescale micromagnetic code for granular thin film magnetic recording systems**  
S.E. Rannala, A. Moo, S. Rata, W. Pantari, R.W. Chantrell, P. Churemart, Computer Physics Communications 279 (2022) 108462

We present the creation and release of an open source multi-timescale micromagnetic code combining three key solvers: Landau-Lifshitz-Gilbert, Landau-Lifshitz-Bloch; Kinetic Monte Carlo. This code, called MARS (Models of Advanced Recording Systems), is capable of accurately simulating the magnetisation dynamics in large and structurally complex single and multi-layered granular systems as is shown by comparison to established atomistic simulation results. The short timescale simulations are achieved for systems far from and close to the Curie point via the implemented Landau-Lifshitz-Gilbert and Landau-Lifshitz-Bloch solvers respectively. This enables real-time simulations for general perpendicular magnetic recording and also state of the art heat assisted magnetic recording (HAMR).

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10.1016/j.cpc.2022.108462

**Research Publication**  
MINT Research Unit  
Department of Physics, Mahasarakham University

**Journal of Applied Physics**  
ISI Q1 in Physics  
IF: 2.877

**Exchange bias model including setting process: investigation of antiferromagnetic alignment fraction due to thermal activation**  
R. Khantkai, W. Daeng-am, P. Churemart, R. W. Chantrell, and J. Churemart, J. Appl. Phys. 133, 022603 (2023)

An exchange bias (EB) model taking the setting process into account is developed to study the effect of the crucial parameters, such as the AFM anisotropy constant ( $K_{AF}$ ), the setting temperature ( $T_{set}$ ), and the physical microstructure on the exchange bias field of an AFM/FM system. The magnetization dynamics of the EB system is treated using the kinetic Monte Carlo approach and by integrating the Landau-Lifshitz-Gilbert equation for AFM and FM layers, respectively. We first investigate the variation of the exchange bias field (EB) as a function of  $K_{AF}$  in the IrMn/CoFe system. It is found that EB strongly depends on the energy barrier dispersion determined by dispersions of  $K_{AF}$  and the grain volume. It is shown that the EB is affected by the physical microstructure of the IrMn layer: film thickness and grain diameter. We also demonstrate that the maximum setting fraction ( $f_{set}$ ) related to EB can be achieved by optimizing the value of  $K_{AF}$  and  $T_{set}$ . The simulation results of the setting process are in good agreement with previous experimental works. This confirms the validity of the EB model, including the setting process that can be used as a powerful tool for the application of spintronics, especially for read sensor design to achieve high thermal stability with scaling down of components.

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10.1063/1.5045102

**Research Publication**  
MINT Research Unit  
Department of Physics, Mahasarakham University

**IOP Journal of Physics: Condensed Matter**  
ISI Q1 in Physics  
IF: 2.745

**The role of interfacial intermixing on HAMR dynamics in bilayer media**  
A. Meo, P. Churemart, R. W. Chantrell, and J. Churemart J. Phys.: Condens. Matter, 34, 465801, (2022)

We use an atomistic spin model to simulate FePt-based bilayers for heat assisted magnetic recording (HAMR) devices and investigate the effect of various degrees intermixing that might arise throughout the fabrication, growth and annealing processes, as well as different interlayer exchange couplings, on HAMR magnetisation dynamics. Intermixing can impact the device functionality, but interestingly does not deteriorate the properties of the system. Our results suggest that modest intermixing can prove beneficial and yield an improvement in the magnetisation dynamics for HAMR processes, also relaxing the requirement for weak exchange coupling between the layers. Therefore, we propose that a certain intermixing across the interface could be engineered in the fabrication process to improve HAMR technology further.

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10.1088/1361-6480/ab2d10

**Research Publication**  
MINT Research Unit  
Department of Physics, Mahasarakham University

**Journal of Magnetism and Magnetic Materials**  
ISI Q2 in Physics  
IF: 2.993

**HAMR switching dynamics and the magnetic recording quadrilemma**  
M. Stungaru, B.T. Nguyen, K. Yuanhao, R.F.L. Evans, R.W. Chantrell, P. Churemart, J. Churemart, Journal of Magnetism and Magnetic Materials, 504, (2022), 170041

We investigate the dynamical switching process of Heat Assisted Magnetic Recording (HAMR) by numerical calculations of switching probability using an atomistic model. Calculations show that at the elevated write temperature of HAMR there is a loss of information arising from 'backswitching', a thermodynamic phenomenon which comes into play when the ratio of the Zeeman energy to the thermal energy is insufficiently large to completely stabilise the switched direction. We consider the special case of Heated Dot Magnetic Recording, where a reduction of switching probability can be related to a bit error rate. We show that the backswitching becomes more pronounced at faster write times. Also, we show that in the case of current recording media, based on the binary alloy FePt, backswitching will be a more stringent limitation on recording density than the usually assumed thermal stability criterion.

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10.1016/j.jmmm.2022.170041



# International Conferences

## IEEE MAGNETIC SOCIETY- TH CHAPTER 16-18 Nov 2022



# Technical Course Training for Industry



## HAMR Technology Reskil/Upskill Training June 23-24, 2022 (Teparuk)



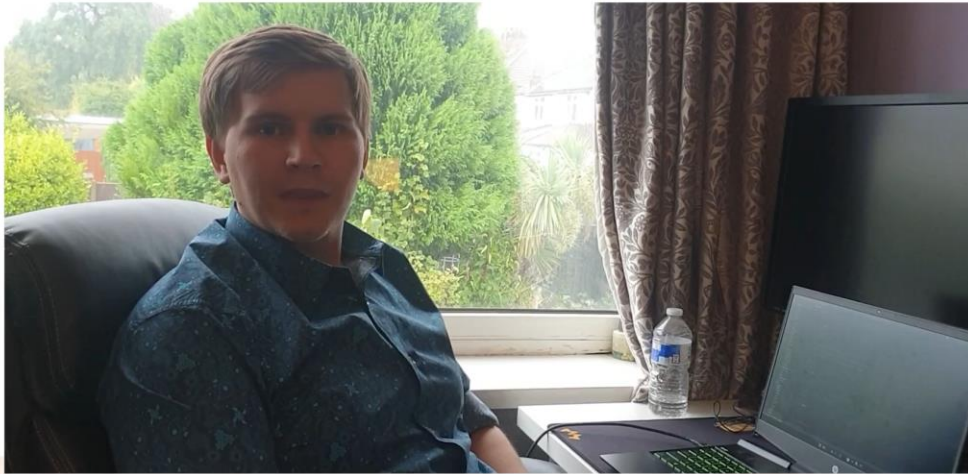
## HAMR Technology Reskil/Upskill Training

June 23-24, 2022, Seagate Technology (Teparuk)

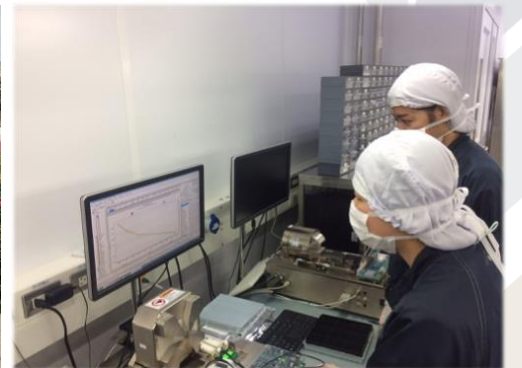
# Student Opportunities

## Exchange Student from UoY-MSU

### INTERVIEW: VISITING STUDENTS FROM UoY



## Seagate Internship



# **ACTION PLAN & OUTCOMES 2023**

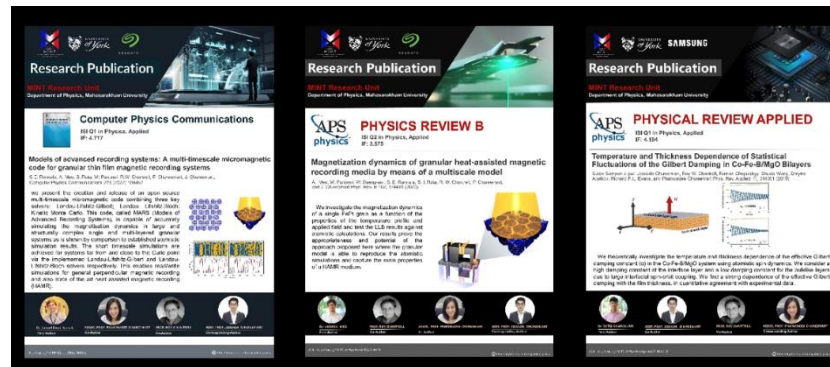
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# Action Plan 2023

กิจกรรมที่จะดำเนินการ	2023-2024			
	Q1	Q2	Q3	Q4
1. ประชุมวางแผน โครงการวิจัยที่จะดำเนินการ ตั้งเป้าหมาย ผลลัพธ์ของหน่วยวิจัย รวมถึงการสร้าง เครือข่ายความร่วมมือกับอุตสาหกรรม				
2. ดำเนินงานวิจัยด้านที่วางแผนและทำการเผยแพร่ งานวิจัยและทำการตีพิมพ์ในวารสารที่มีคุณภาพ				
3. จัดงานประชุมวิชาการ school/ workshop ภายใต้ การนำของสมาคม IEEE Magnetic Society (Thailand Chapter) เพื่อเป็นการถ่ายทอดเทคโนโลยีและแลกเปลี่ยน ความรู้ระหว่างมหาวิทยาลัยและภาคอุตสาหกรรม				
4. จัดอบรม course training ให้กับภาคอุตสาหกรรม เพื่อสร้างเครือข่ายวิจัยและเพื่อพัฒนาทักษะ องค์ความรู้แก่นิสิตระดับบัณฑิตศึกษาเพื่อเข้าทำงานและรองรับการ ขยายตัวของภาคอุตสาหกรรม				

# Expected Outcomes 2023

- We expect to publish 4 research articles in ISI Quartile 1-2.
- We plan to organize the workshop or school to expand magnetic society and set up the collaboration between MSU and other universities.
- We plan to organize the technical course training in order to deliver and share the knowledge from university to industry



# Magnetic Information storage Technology (MINT) Group



THANK  
YOU

Any Question?