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# Temperature-switch nanomagnetic logic gates for cellular hyperthermia

Rute A. Pereira, Rui Oliveira-Silva, Fábio M. Silva, Vítor M. Gaspar, Alfonso Ibarra, Ángel Millán, Filipa L. Sousa, João F. Mano and Nuno J. O. Silva

University of Aveiro, Portugal



# outline

motivation

development

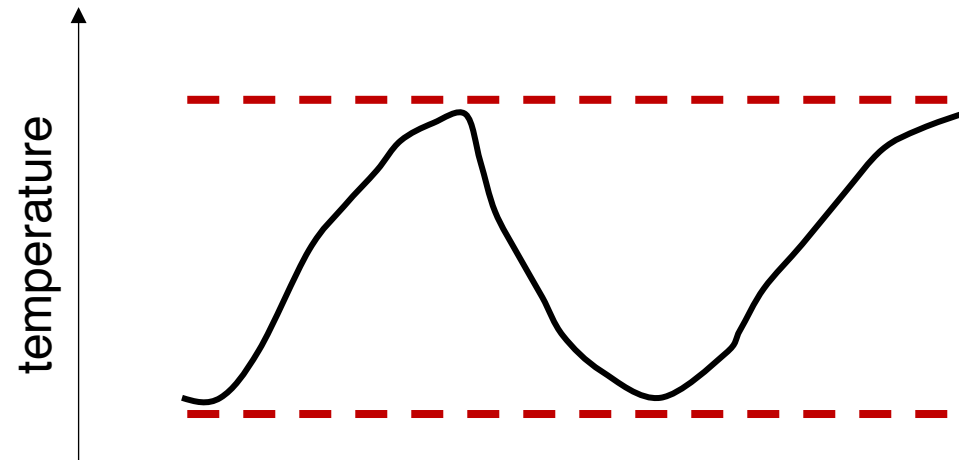
evaluation

conclusions

# temperature control



daily life

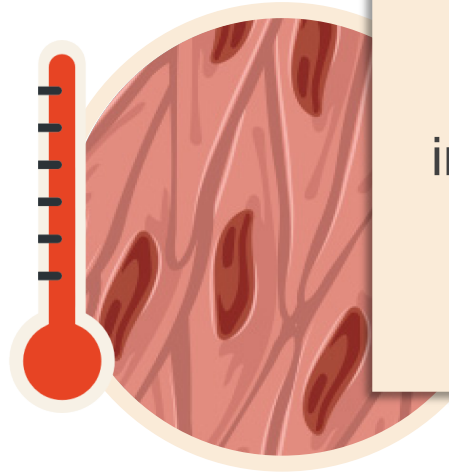


a device that gives information about an event in which temperature is crossed is helpful



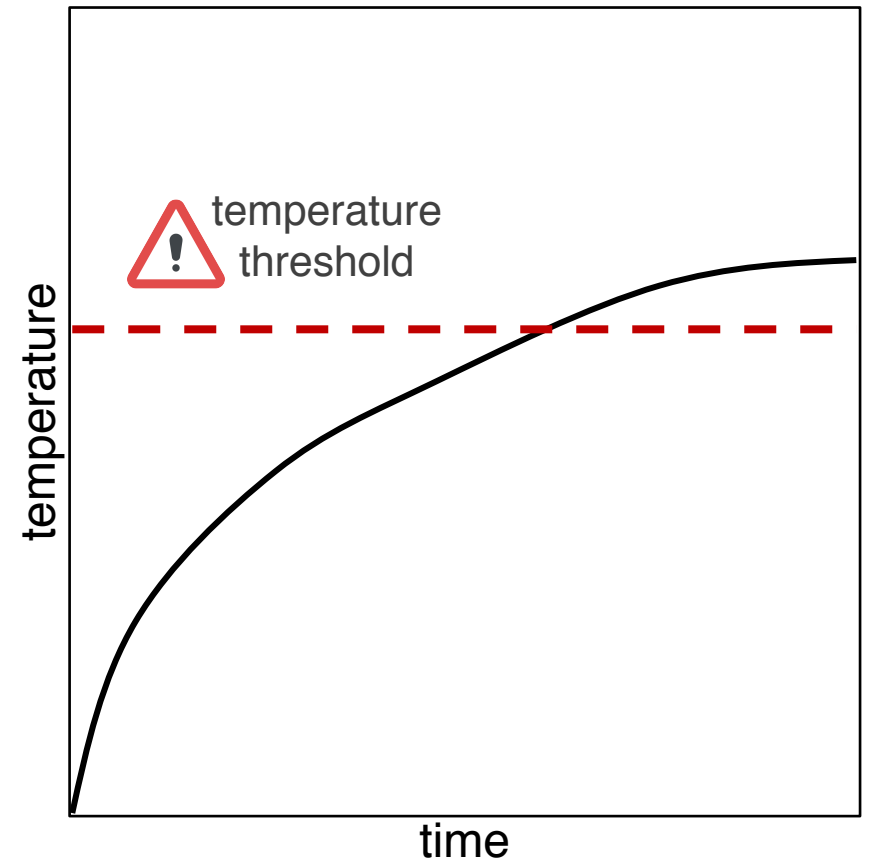
# temperature control

other times, the crossing of temperature limits is used to achieve something else

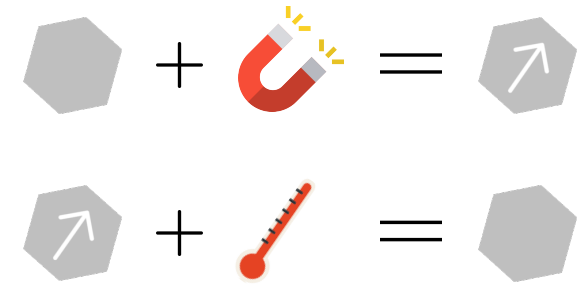
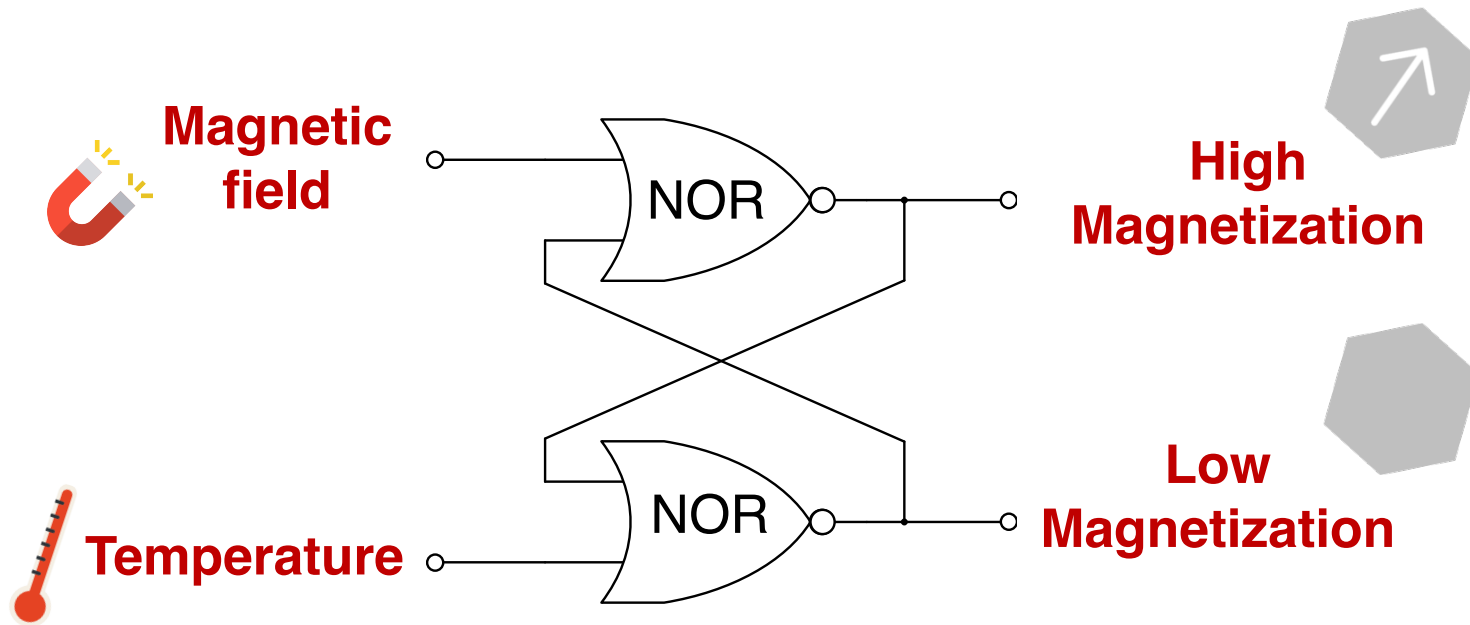


“at what radiation dose does temperature increase locally above a given threshold?”

hyperthermia therapy



# set/reset flip-flop logic gate



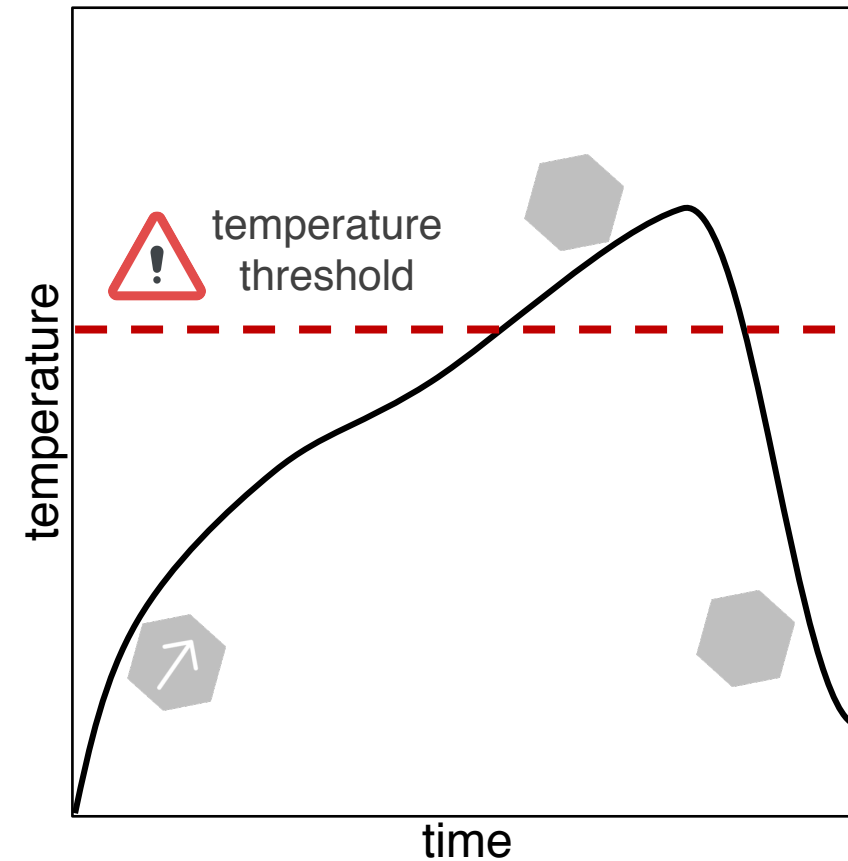
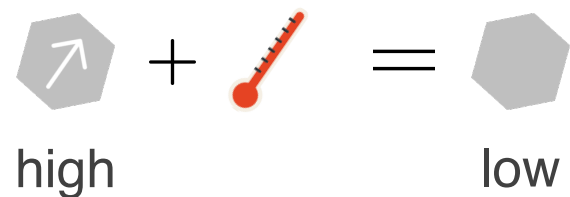
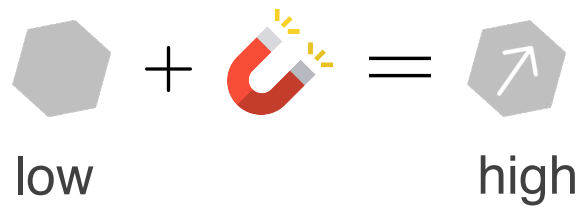
easy integration on *biosystems*

access to local properties

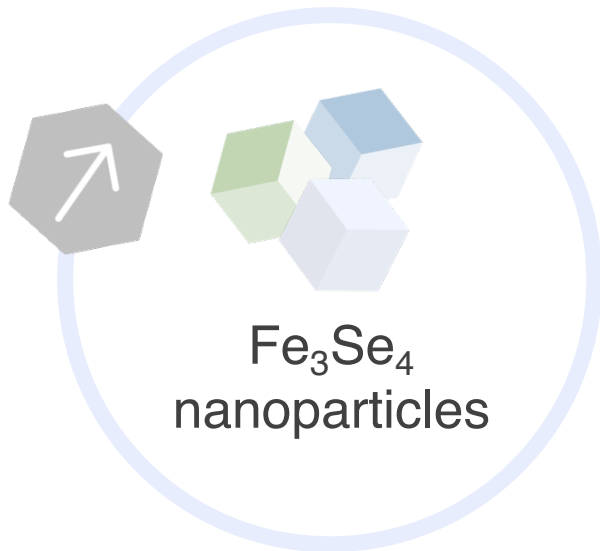


# set/reset flip-flop logic gate

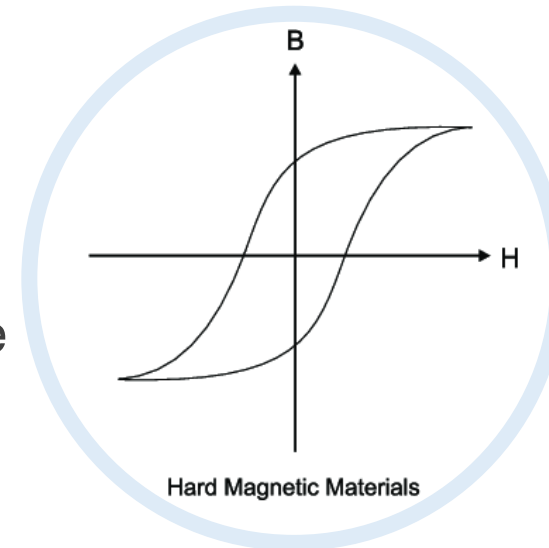
a device that records and retains memory of an event in which a temperature threshold was crossed



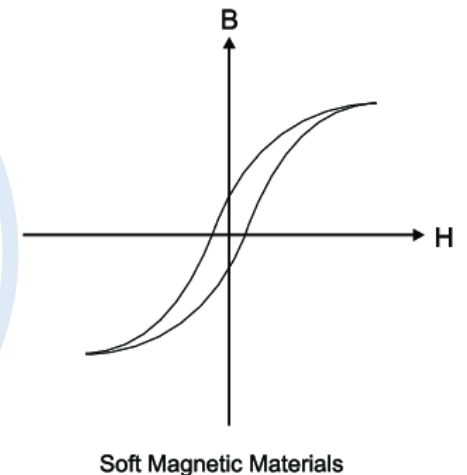
# $\text{Fe}_3\text{Se}_4$ nanoparticles as logic gates



hard magnetic  
materials can  
*naturally*  
display a bistable  
non-volatile  
response



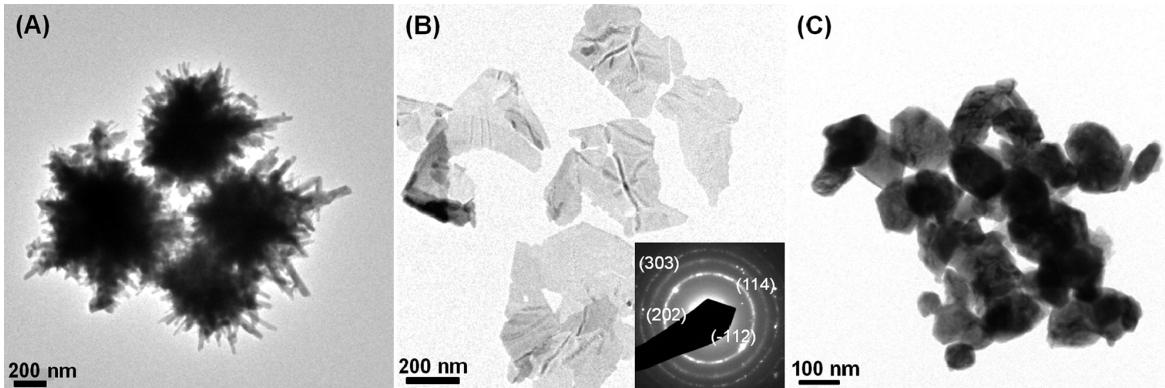
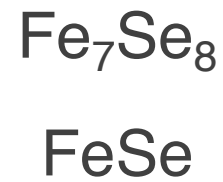
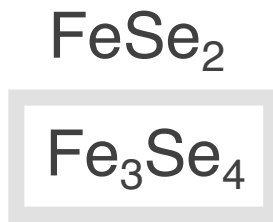
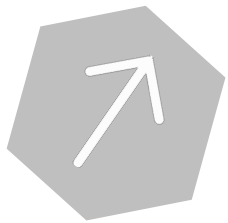
$\text{Fe}_3\text{Se}_4$   
nanoparticles



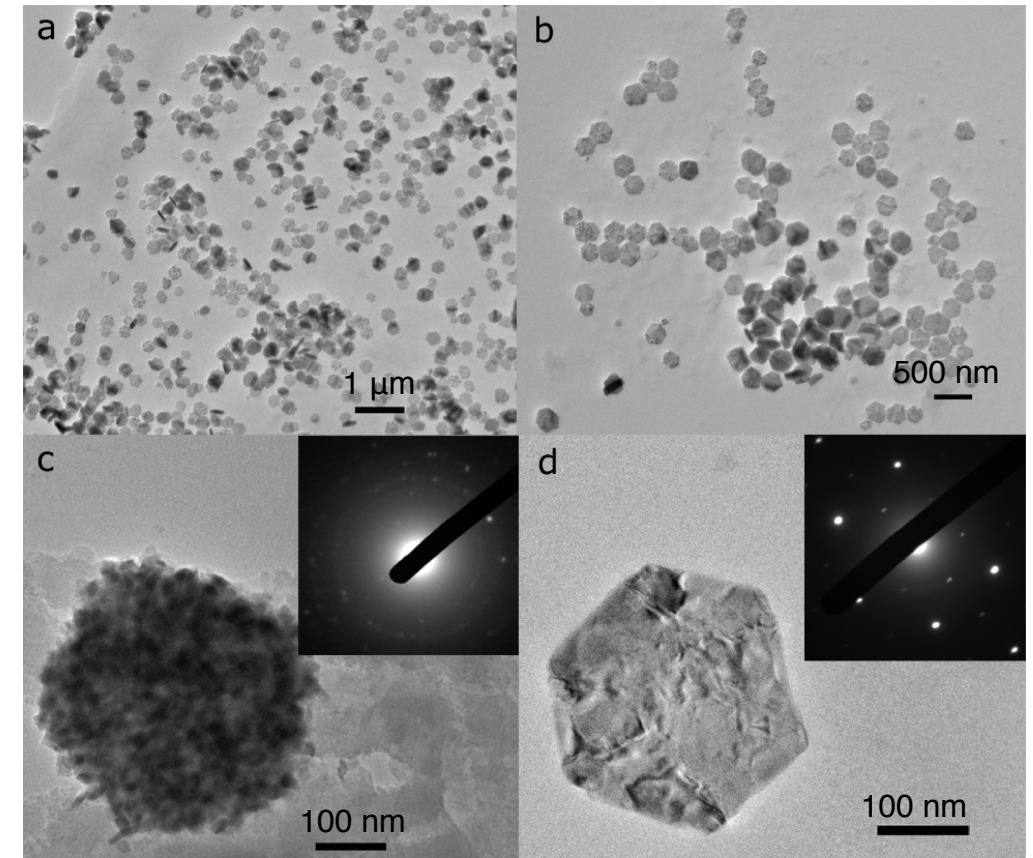
$\text{Fe}_3\text{O}_4$   
nanoparticles



# iron selenides



$\text{Fe}_3\text{Se}_4$  Nanostructures with Giant Coercivity Synthesized by Solution Chemistry, Chem. Mater. 23, 3769-3774, 2011

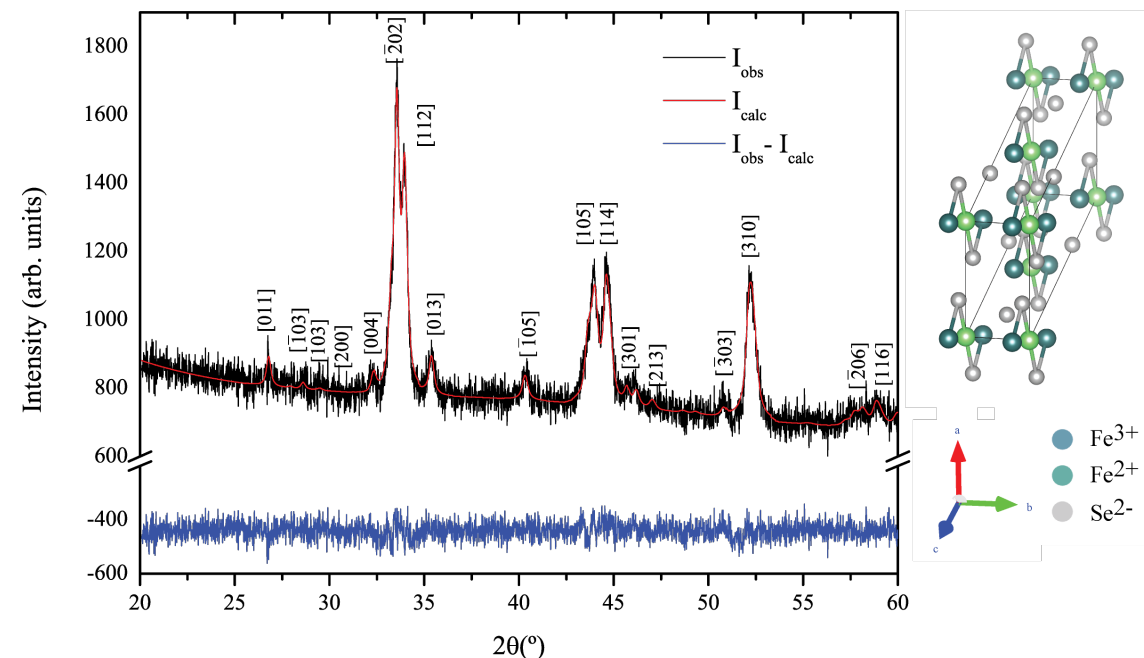
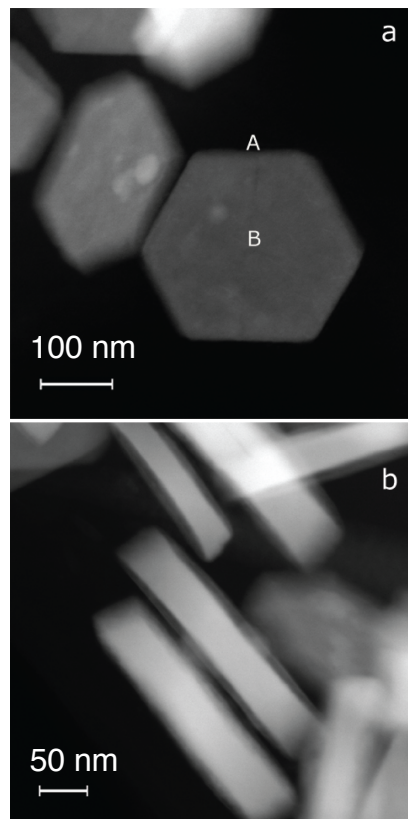


# synthesis of $\text{Fe}_3\text{Se}_4$ nanoplatelets

Iron Oleate  
Selenium-octadecene  
precursors

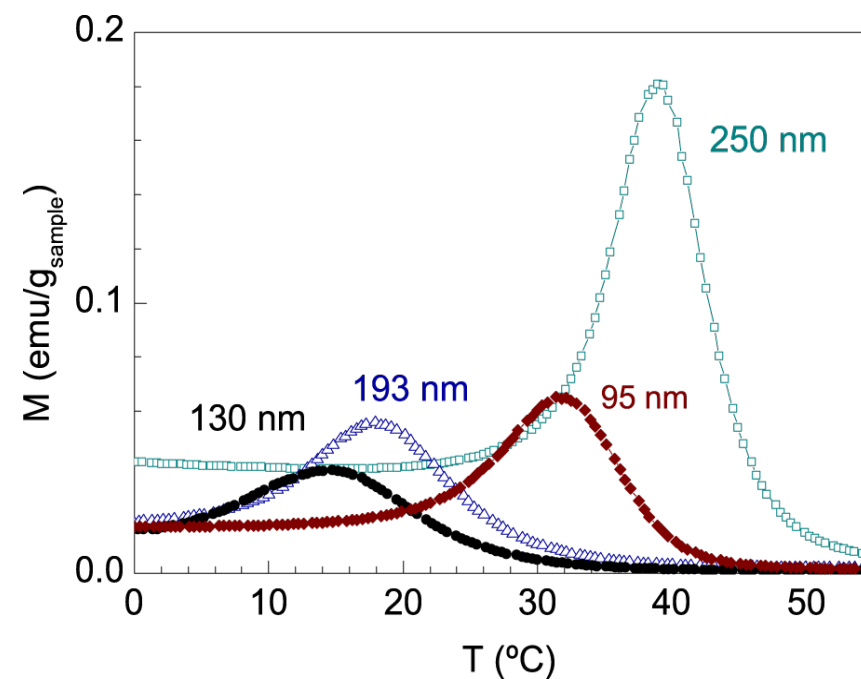
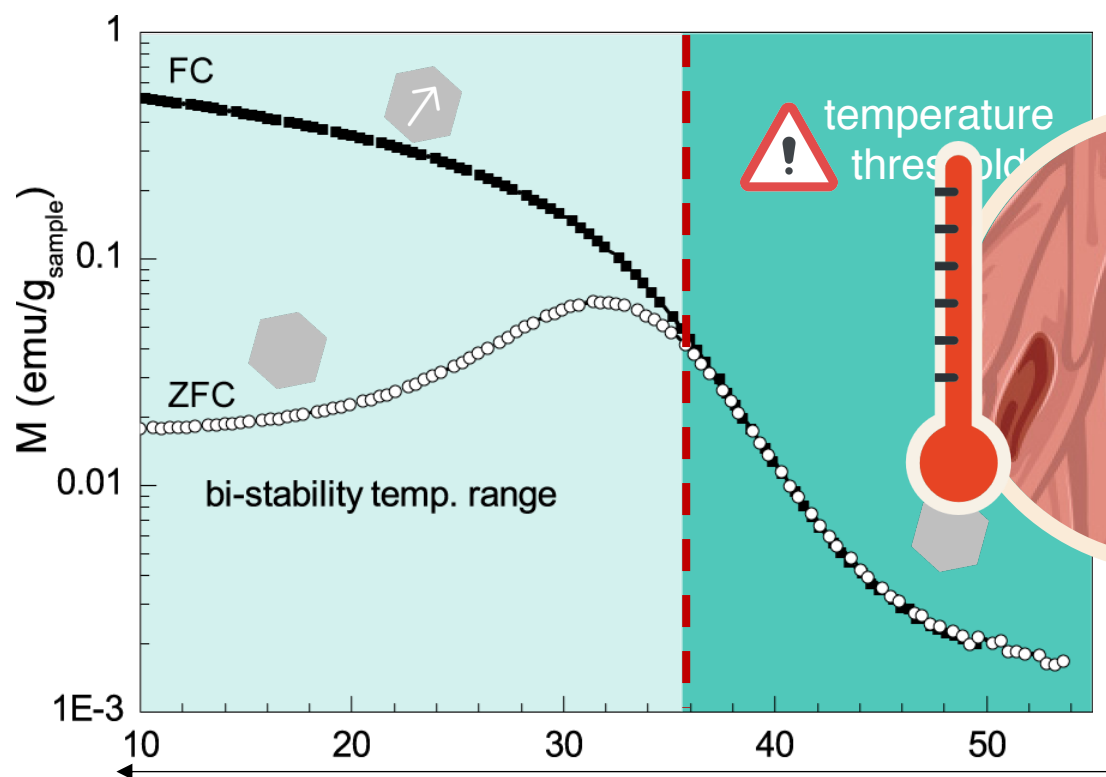
Tetradecylphosphonic acid  
1-Dodecanethiol  
ligands

Ramp rate: 5°C/min  
Temperature range: 200-220°C  
conditions



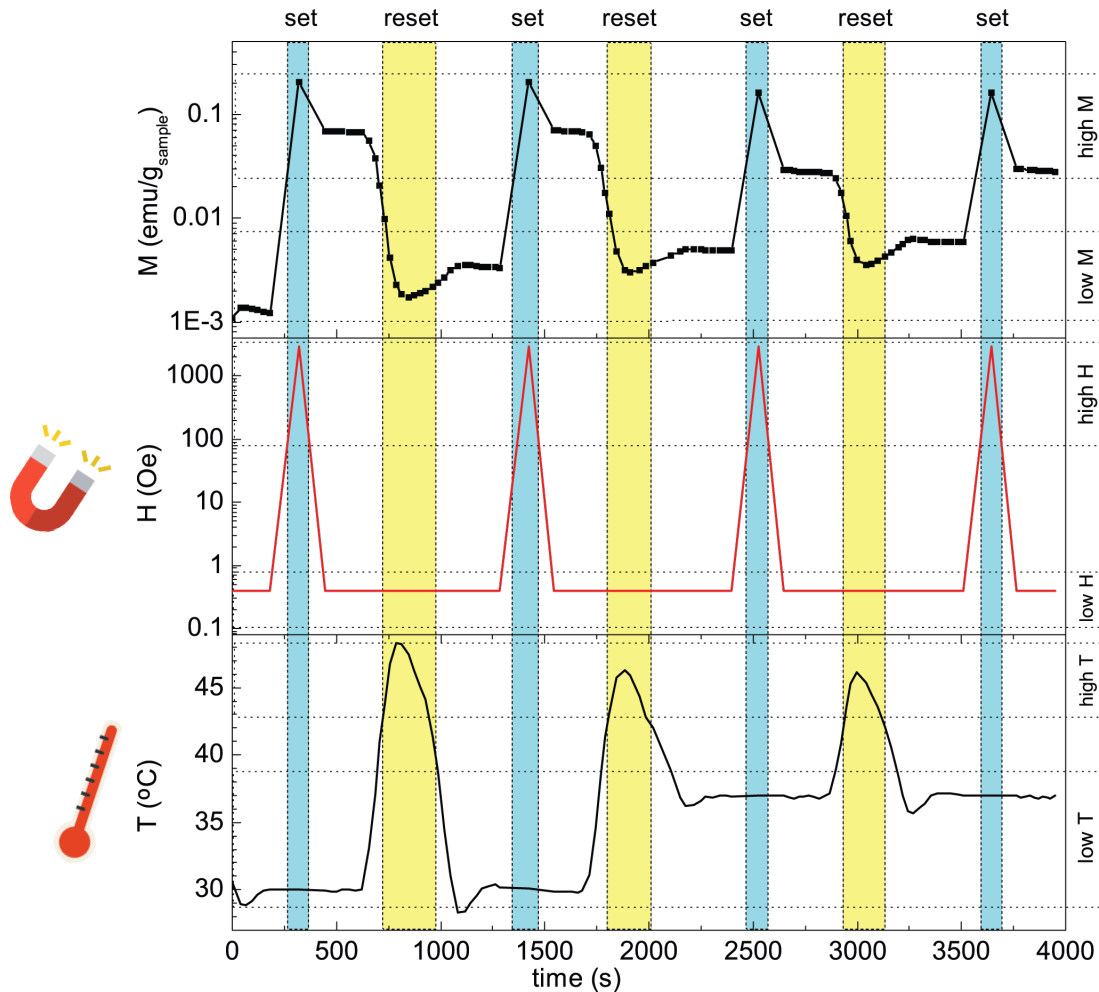
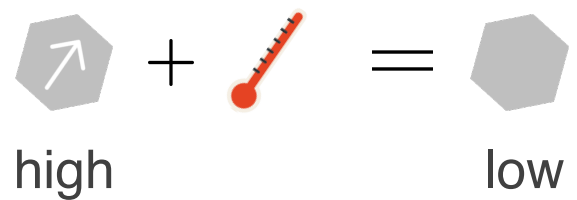
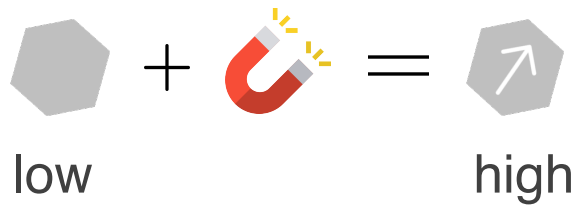


# evaluation of $\text{Fe}_3\text{Se}_4$ nanoplatelets as logic gates



# evaluation of $\text{Fe}_3\text{Se}_4$ nanoplatelets as logic gates

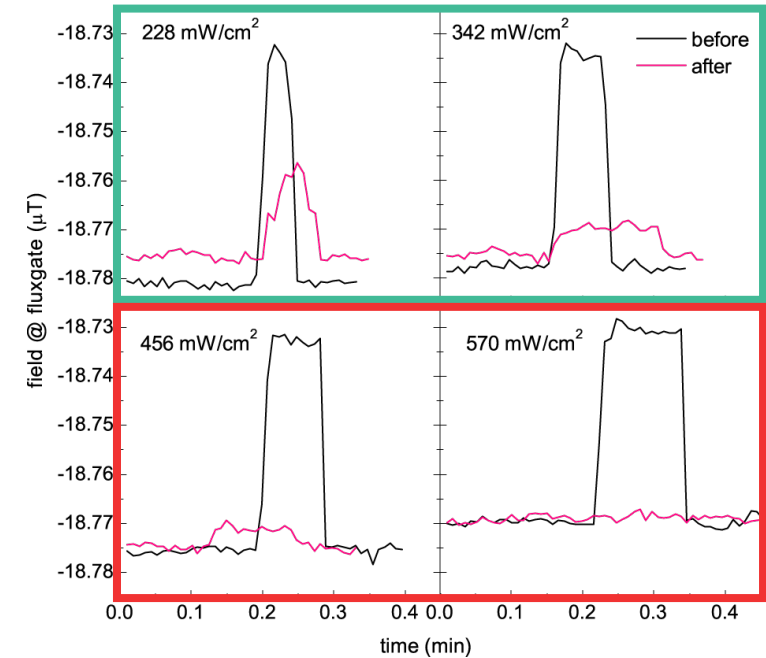
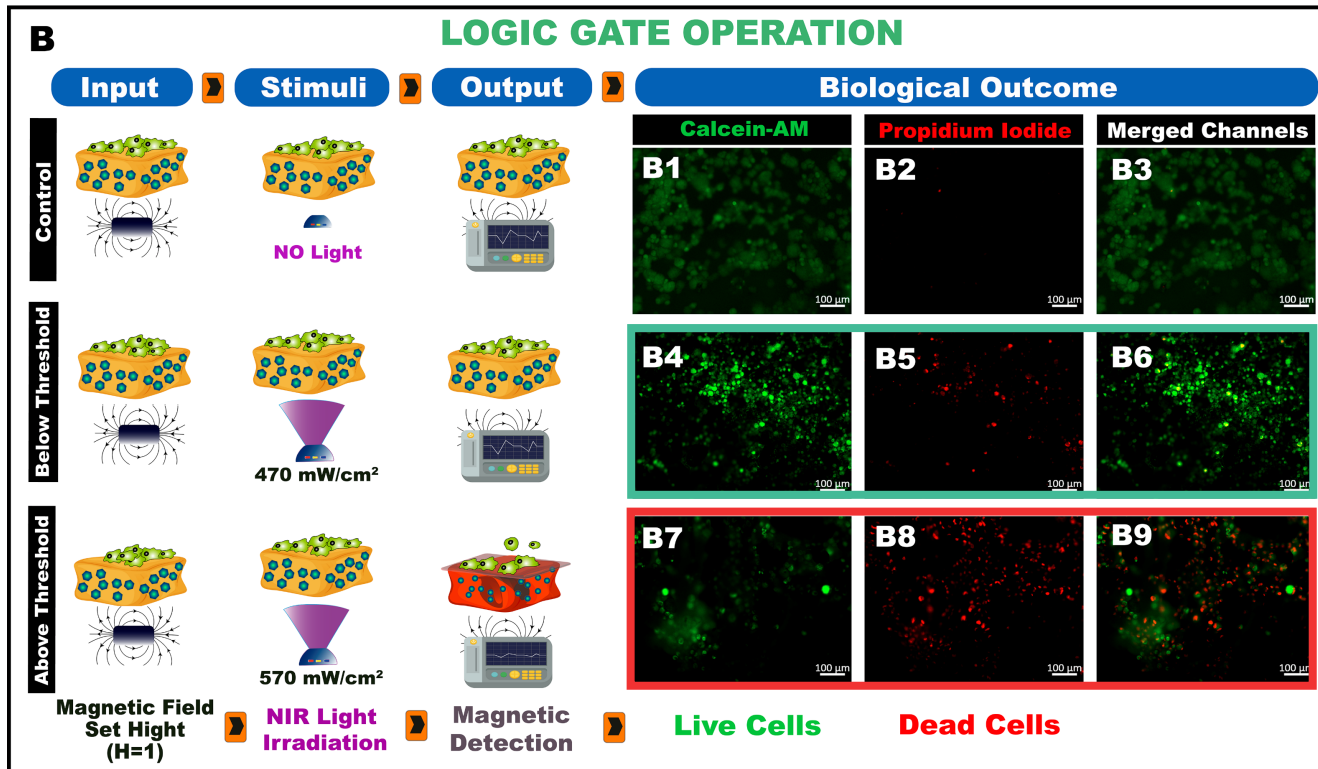
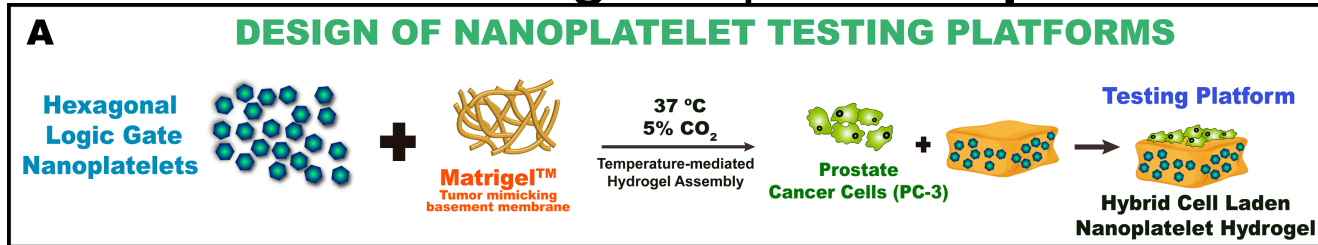
Time diagram of the proposed logic gate



M(t)	H	T	M(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	RC
1	1	1	RC
1	0	0	1
1	0	1	0
1	1	0	1



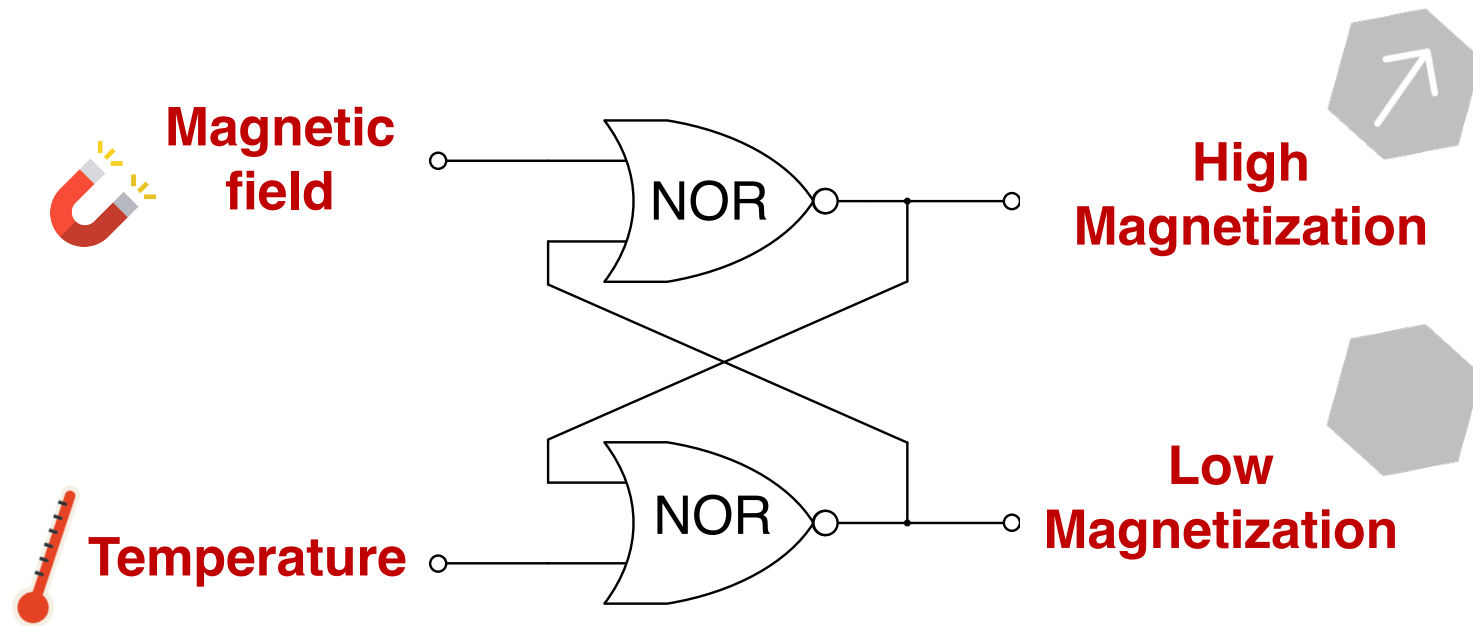
# evaluation of $\text{Fe}_3\text{Se}_4$ nanoplatelets as logic gates



< 42 °C

> 42 °C

# conclusions and outlook

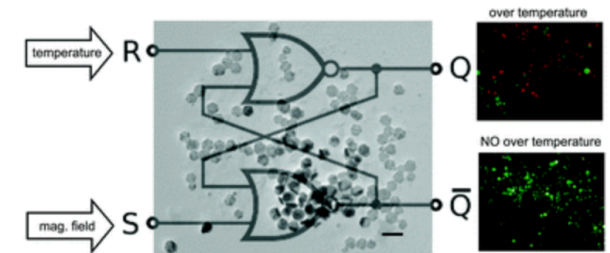


Communication

## Temperature-responsive nanomagnetic logic gates for cellular hyperthermia

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The article was first published on 13 Dec 2018

*Mater. Horiz.*, 2019, Advance Article

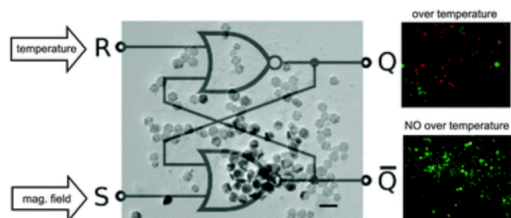
<http://dx.doi.org/10.1039/C8MH01510D>



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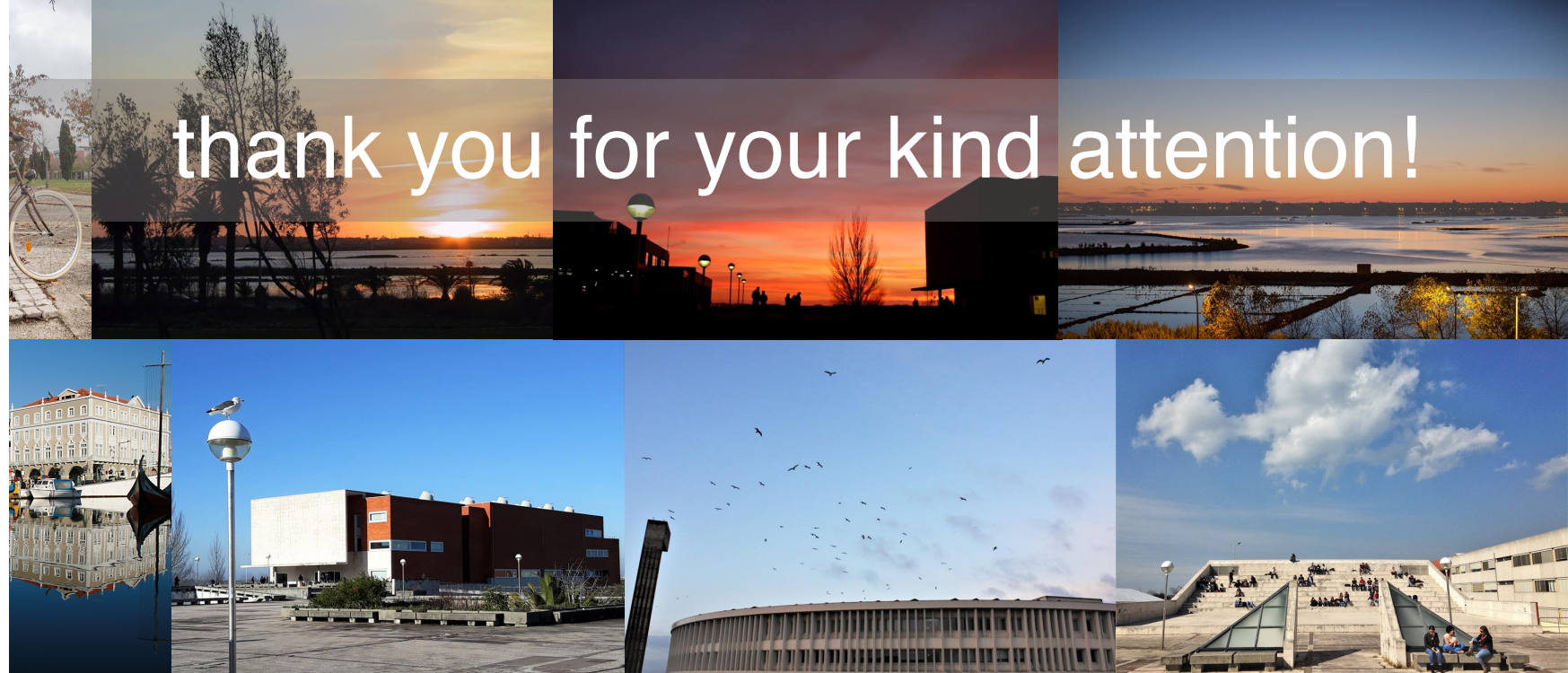
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