



***In-Situ* Lorentz Microscopy Studies of Vortex Domain Walls in Nanowires Containing Pinning Potentials**

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- a. Fabrication of nominally identical nanowires by EBL and FIB***
- b. Formation of domain walls in nanowires***
- c. Domain wall propagation process by applying magnetic field***
- d. Influence of edge effect on DWs spin structures***



Domain walls as carrier of information

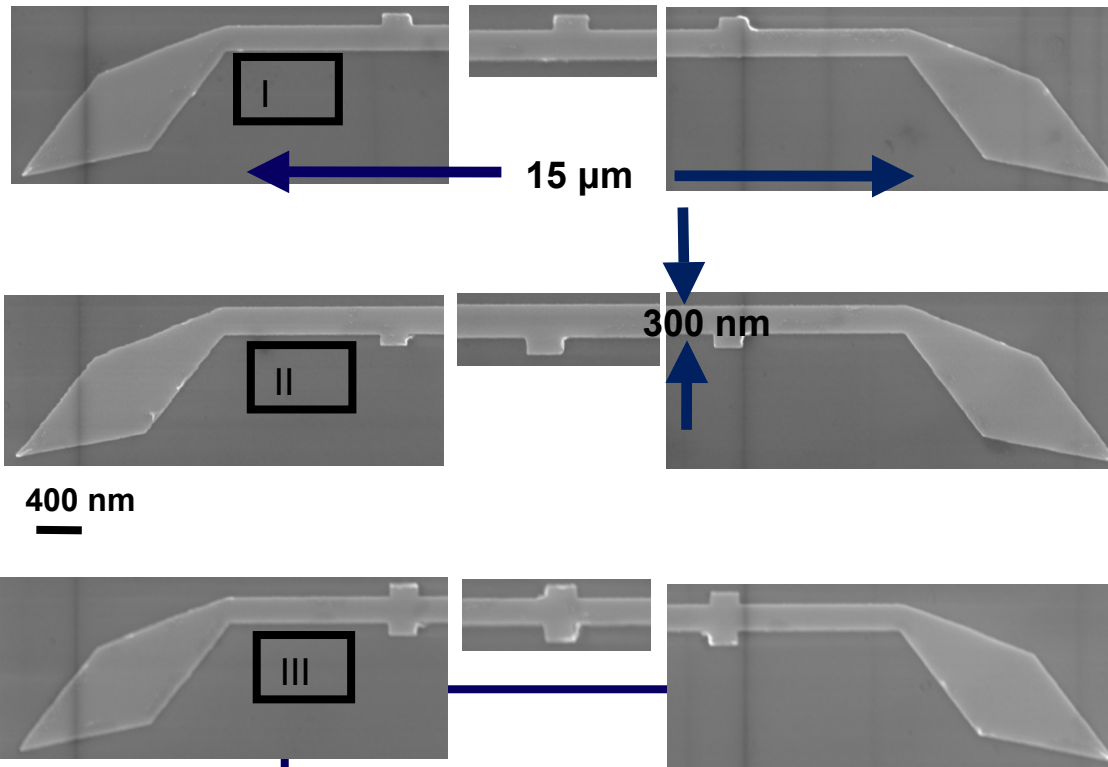
Two proposed applications are:

- 1. Magnetic logic device, and*
- 2. Magnetic race track memory device.*

Important to understand

- a. domain wall propagation process along the nanowires*
- b. controlled pinning and de-pinning of DWs*

Structure of the nanowires



Permalloy thickness:

20 nm

Width of the anti-notch:

300 nm

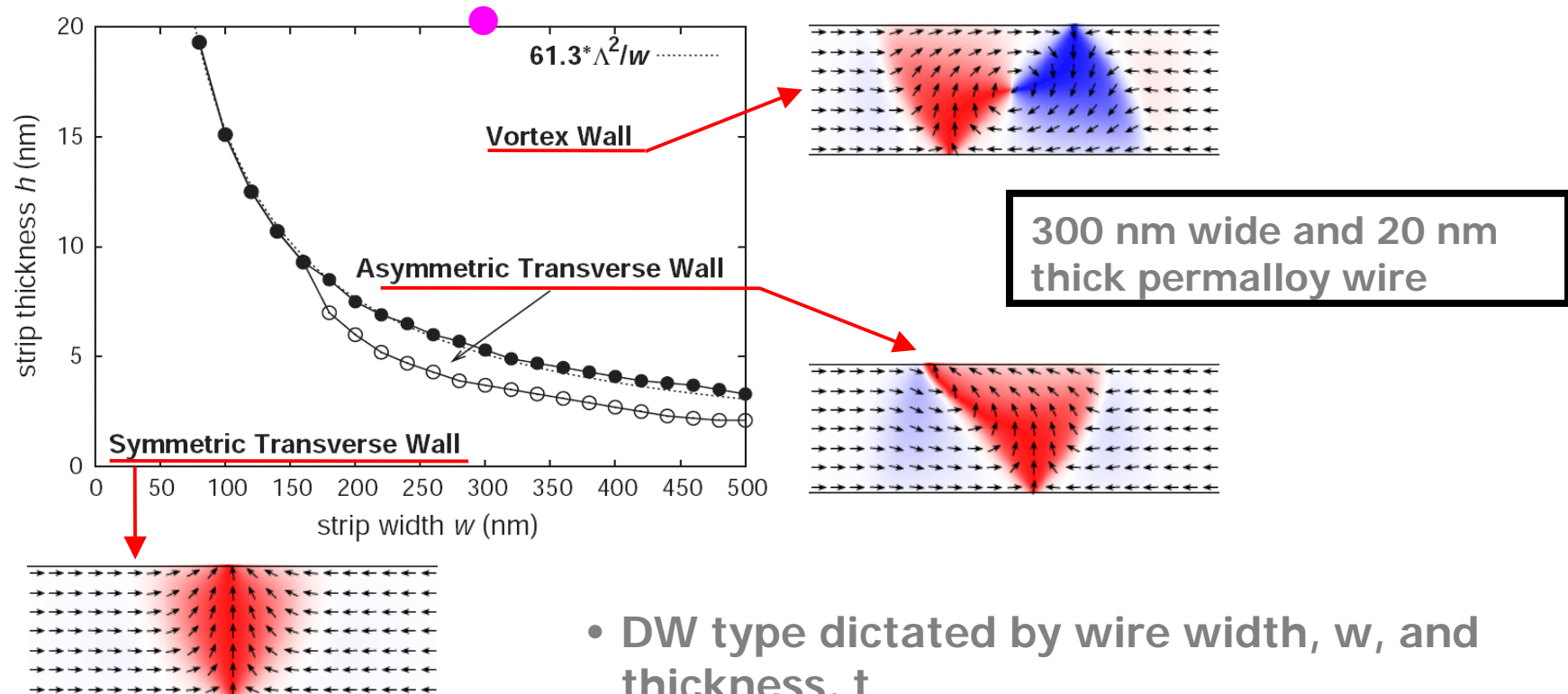
Height of the anti-notch:

150 nm

Electron beam
lithography and lift off
technique

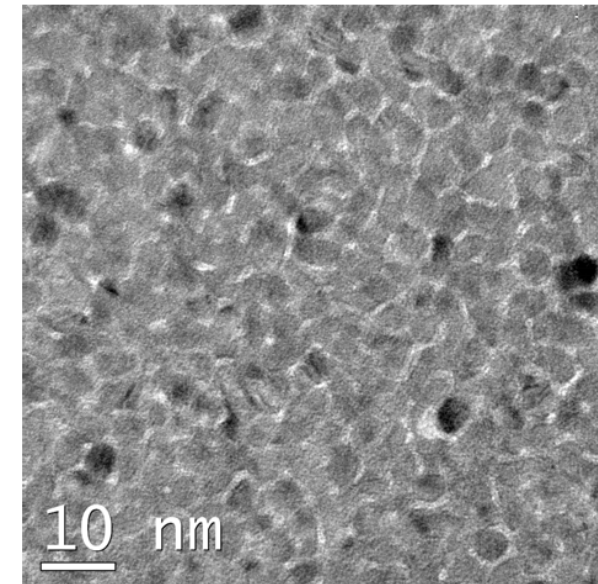
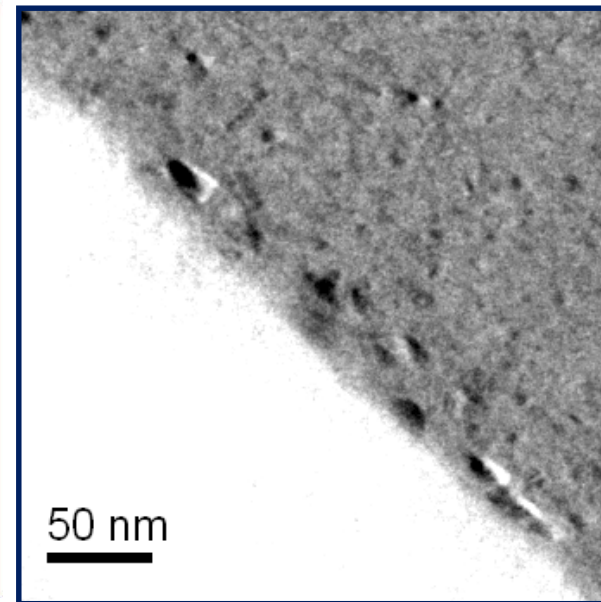
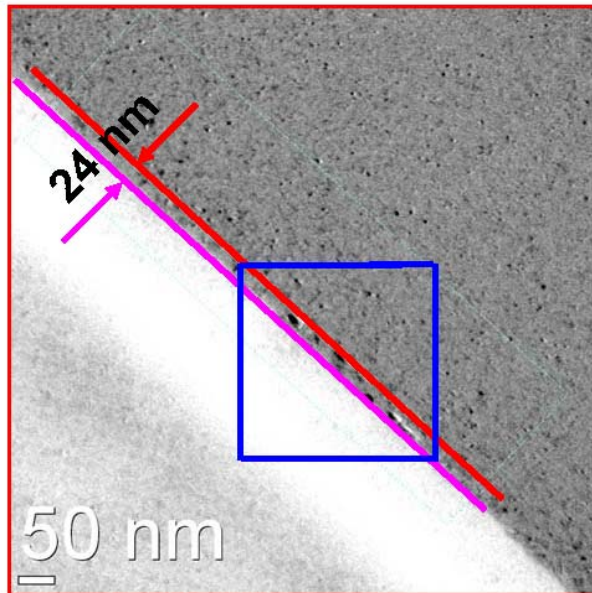
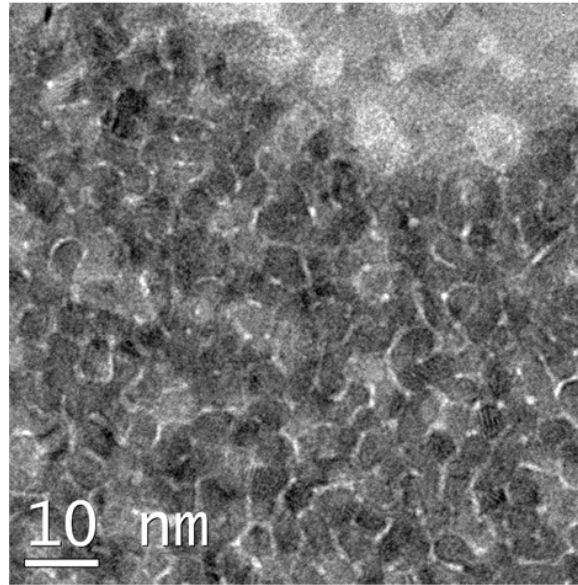
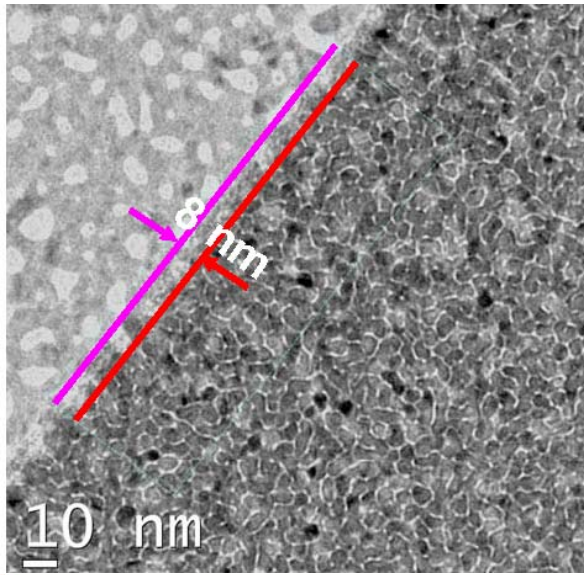
Focused ion beam
technique

Thermal
evaporation
technique

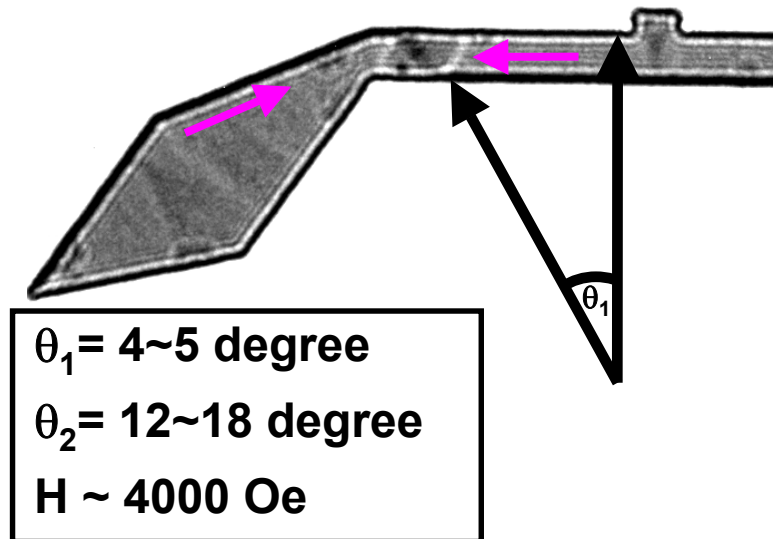


- DW type dictated by wire width, w , and thickness, t
- Asymmetric transverse DW predicted by Nakatani et al. [2]

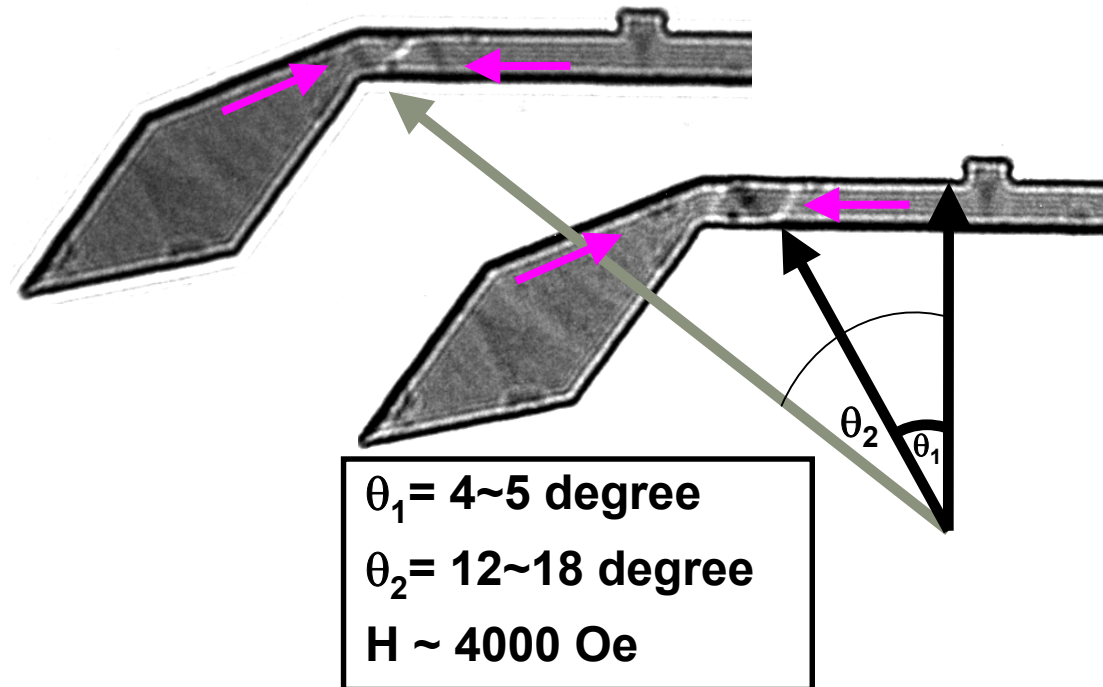
[1] Nakatani et al., J. Magn. Magn. Mater. 290-291, 750 (2005)



Formation of domain wall



Formation of domain wall



EBL patterned nanowire

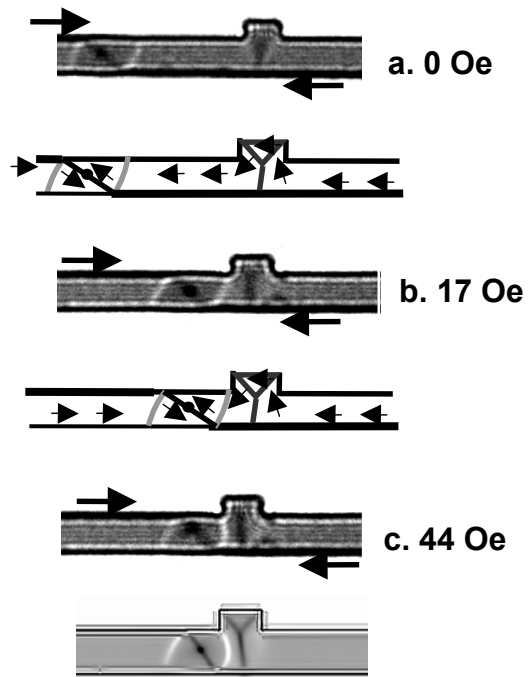
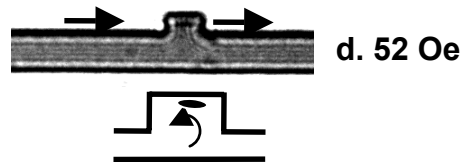
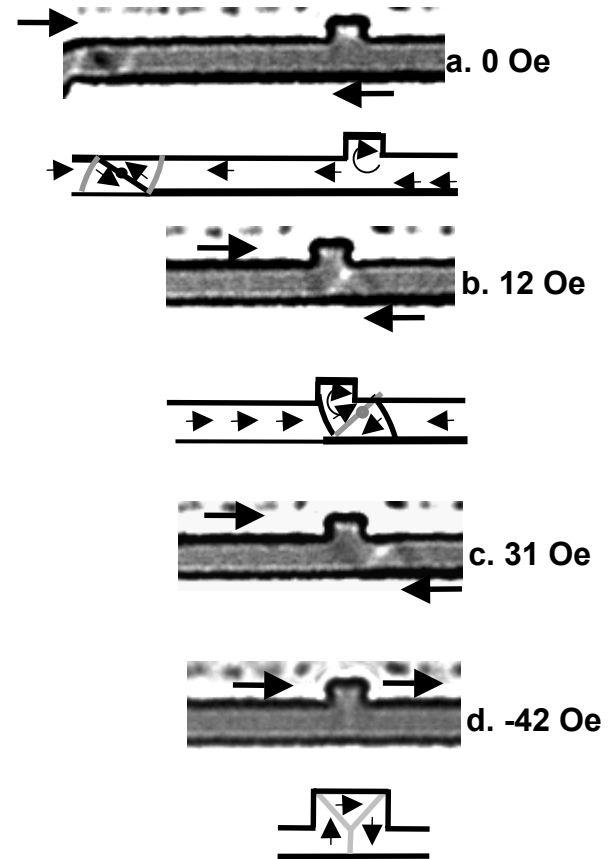


Image from simulation

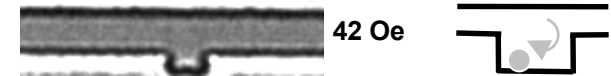
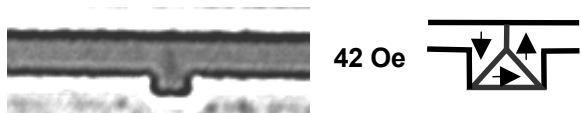
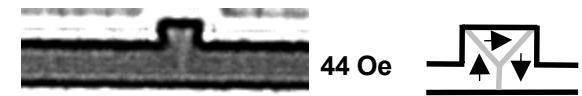
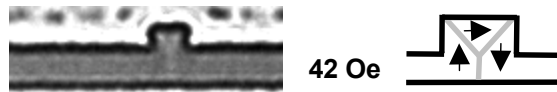


FIB patterned nanowire





Domain structure inside the anti-notch



Estimated edge effect using TEM BF imaging

*-for the e-beam patterned nanowires around
3~8 nm*

*-for the FIB patterning nanowires around
20~25 nm*

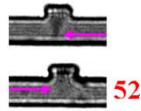
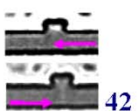
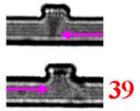
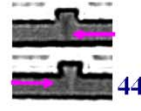




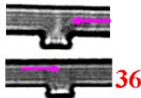
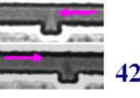
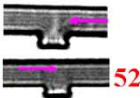






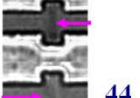

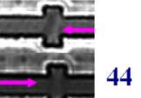
*Domain structure inside the anti-notch was
varied in the case of FIB milling nanowires*



*SSP members, University of Glasgow
Glasgow University and ORSAS*

THANK YOU VERY MUCH

Table : Propagation field, de-pinning field and potential characteristics of pinning sites

Wires	Propagation field (Oe)				De-pinning field (Oe)				Potential Characteristics			
	CCW		CW		CCW		CW		CCW		CW	
	EBL	FIB	EBL	FIB	EBL	FIB	EBL	FIB	EBL	FIB	EBL	FIB
I	17	12	18	17	 52	 42	 39	 44				
II	14	22	14	18	 36	 42	 52	 42				
III	22	23	17	20	 52	 44	 42	 44				

 Potential barrier  Potential well