A tiny magic drawing board to track the penetration of magnetic flux in superconductors

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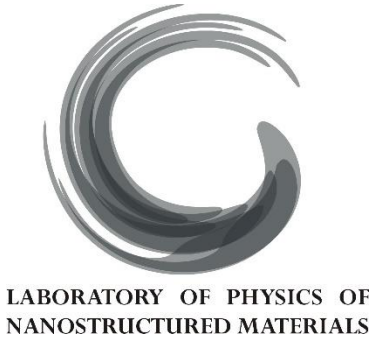
BELGIUM



VORTEX X, Rhodes (Greece) Sept09-Sept14 2017

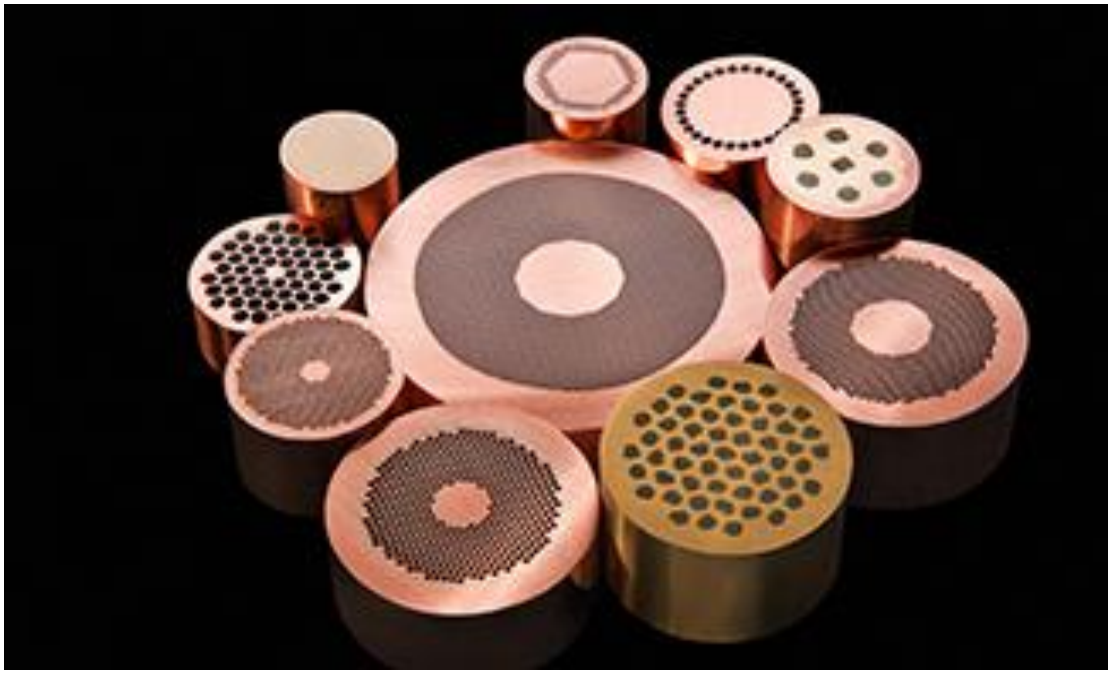
Collaborators

J. Brisbois, G. Shaw, J. Avila, B. Vanderheyden, Ph. Vanderbemden, N.D. Nguyen (ULg)

R.B.G. Kramer, T. Devillers, N. Dempsey, K. Hasselbach (Grenoble, France)

M. Motta, L. Pinheiro, W. Ortiz (UFSCAR, Brazil)

Superconductor / normal metal

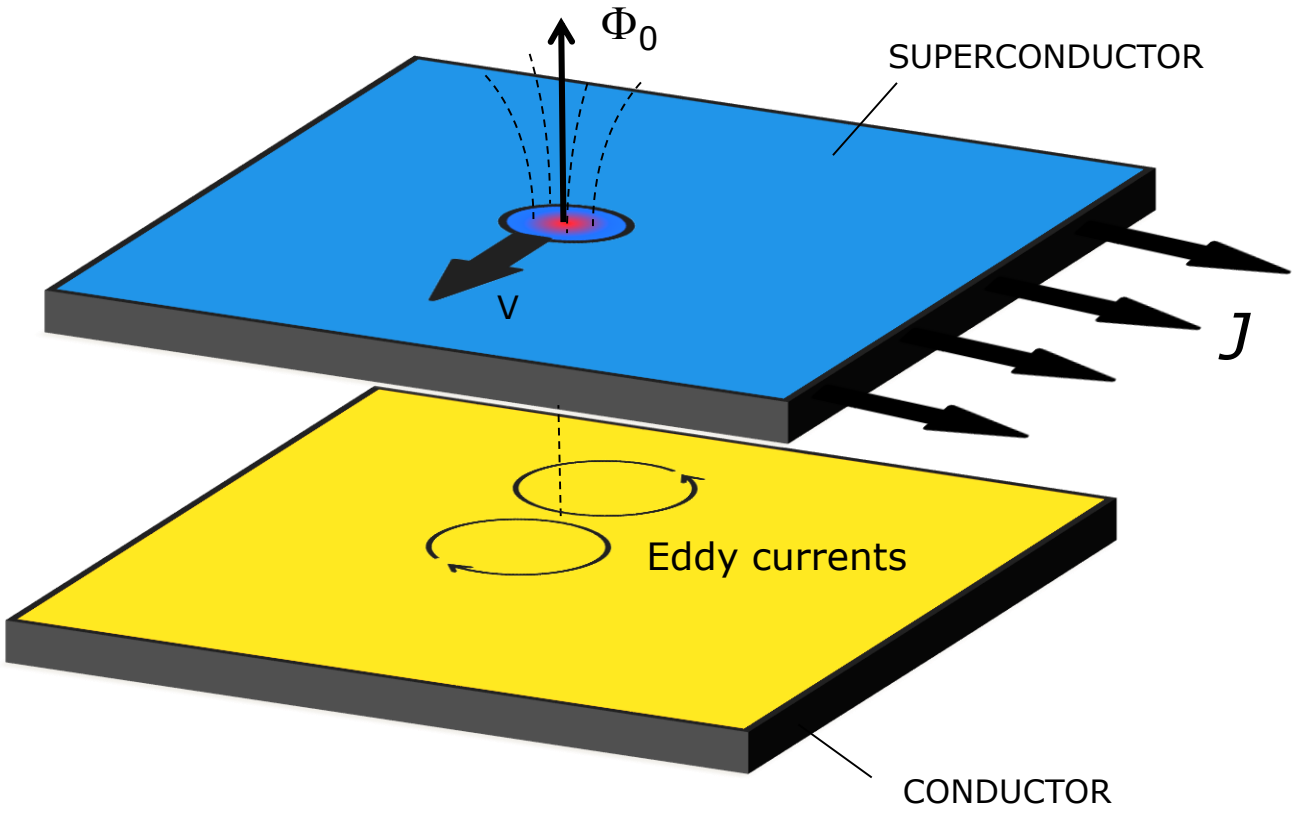


Three fold benefit,

1.- Quench protection
2.- Thermal sink
3.- Better stability by reducing the speed of the flux motion

Harrison *et al.*, J. Low Temp. Phys. **18**, 1 (1975) | Larbalestier *et al.*, Nat. Mat. **13**, 375 (2014)

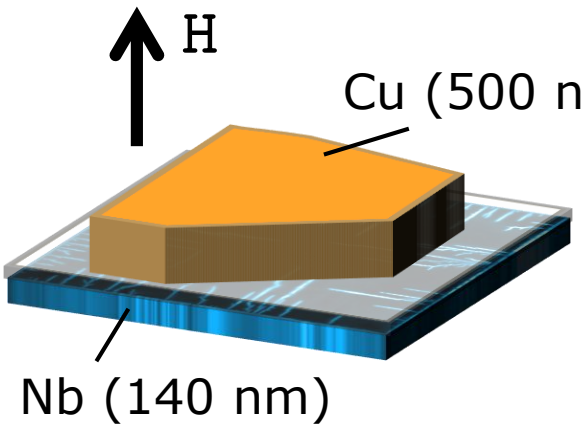
Superconductor / normal metal

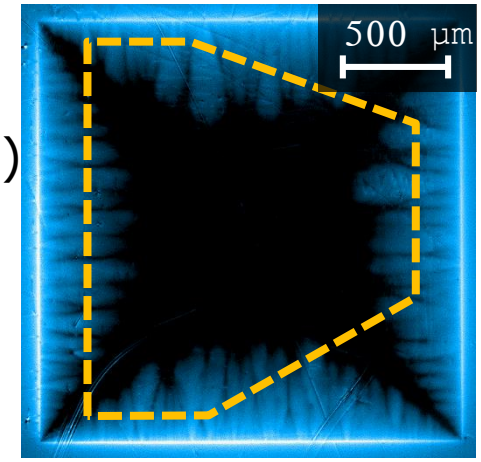


Increased damping due to induced eddy currents

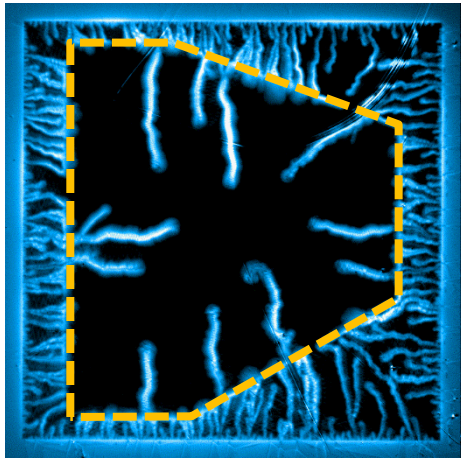
J. Brisbois et al. New J. Phys. 16, 103003 (2014)

Superconductor / normal metal

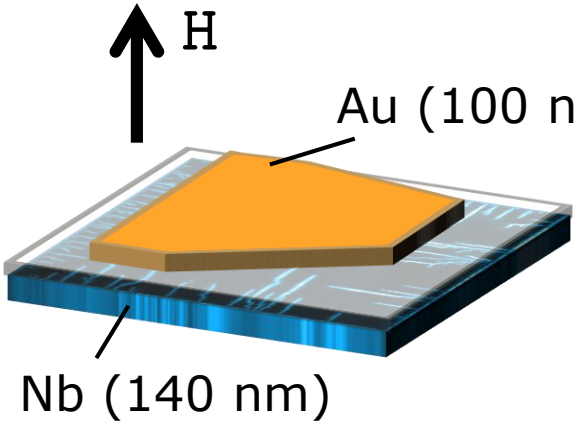




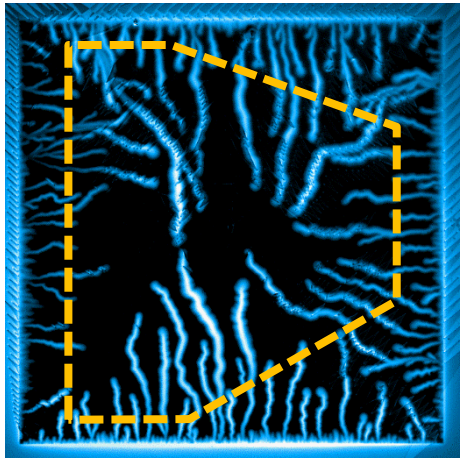
T = 5 K, H = 4.8 mT



T = 2.5 K, H = 4.8 mT

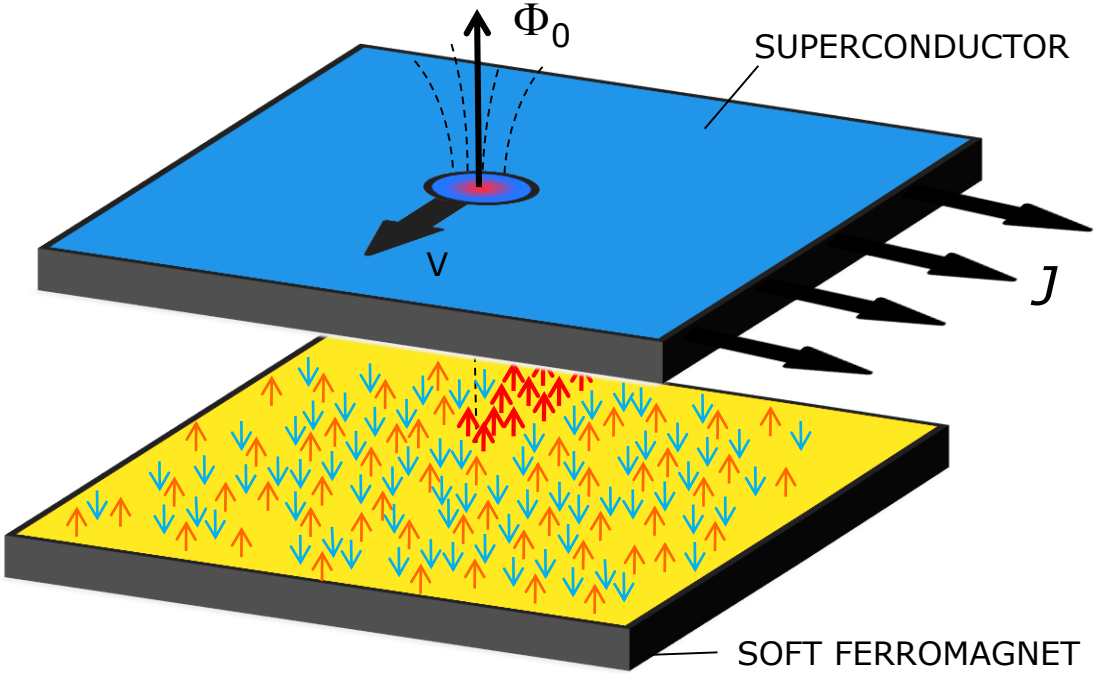


Influence of the indicator mirror in MOI?



J. Brisbois *et al.*, *Phys. Rev. B* **95**, 94506 (2017)

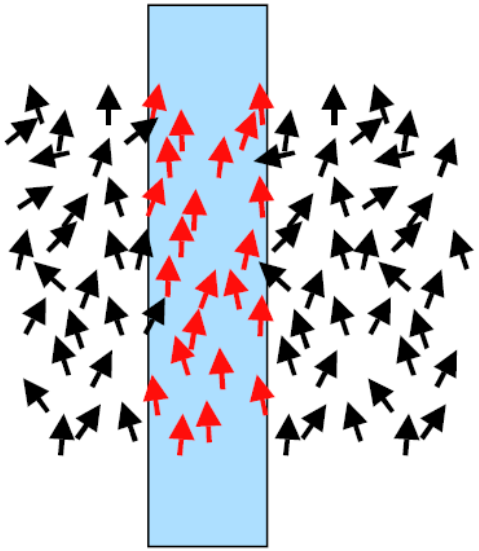
Superconductor / soft ferromagnet

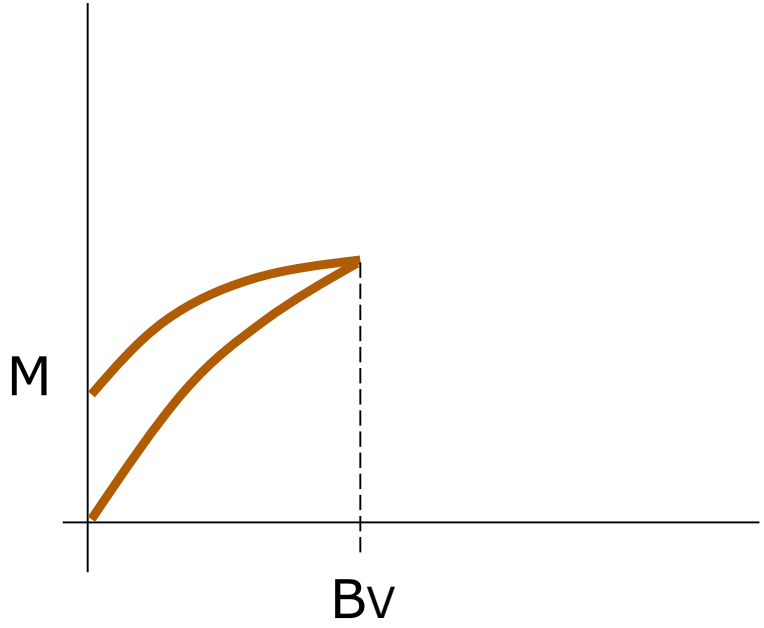


New emerging phenomena associated to the possible polarization of the magnetic layer,

1.- Additional damping mechanism
2.- Trail of imprinted spin polarization

Pioneer ideas
Additional damping mechanism





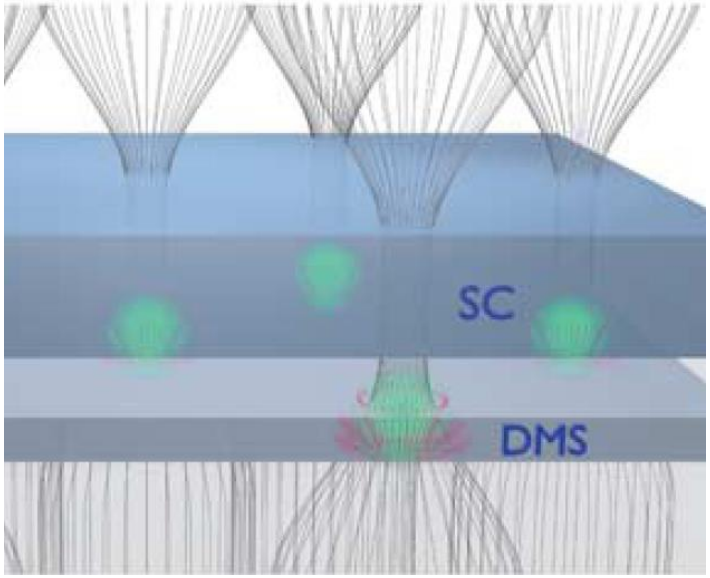
Palau et al.
Phys. Rev. Lett. 98, 117003 (2007)

PHYSICAL REVIEW B **89**, 054516 (2014)

Magnon radiation by moving Abrikosov vortices in ferromagnetic superconductors and superconductor-ferromagnet multilayers

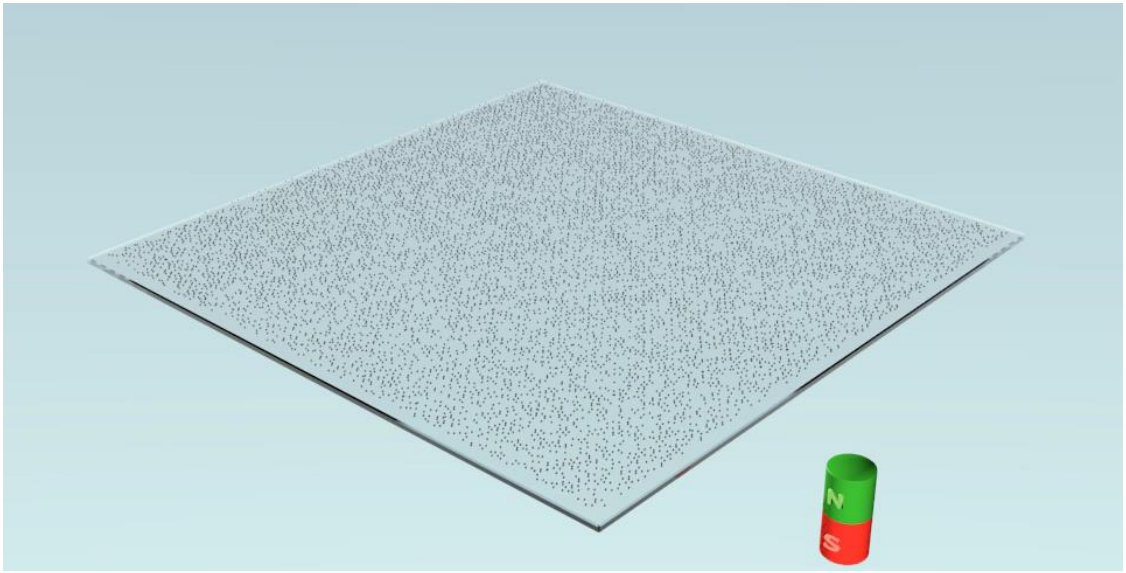
A. A. Bespalov,[1,2] A. S. Mel'nikov,[1,3] and A. I. Buzdin[2]

Pioneer ideas
Local spin polarization

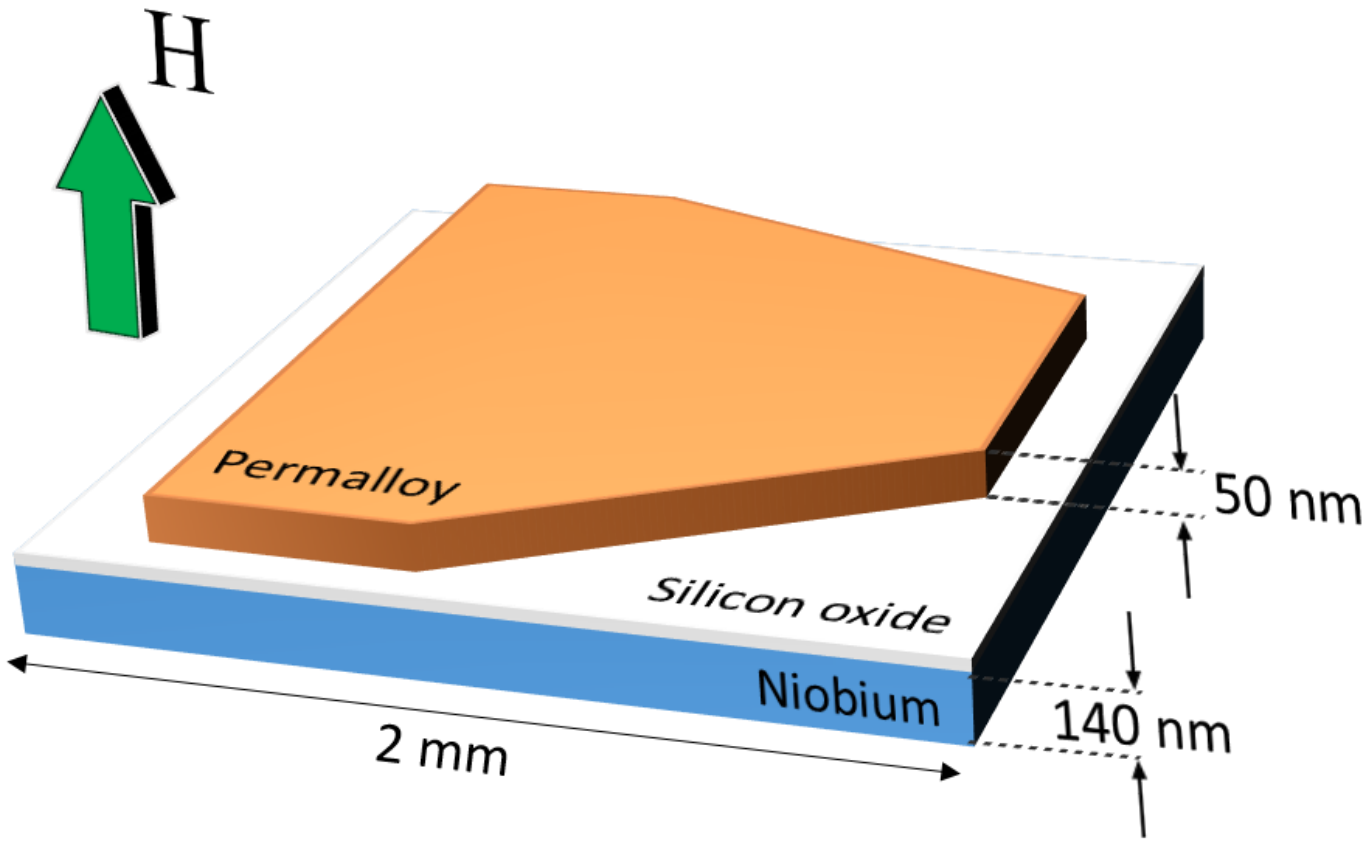


Berciu, Rappoport, Janko,
Nature **435**, 71 (2005)

Classical analogy



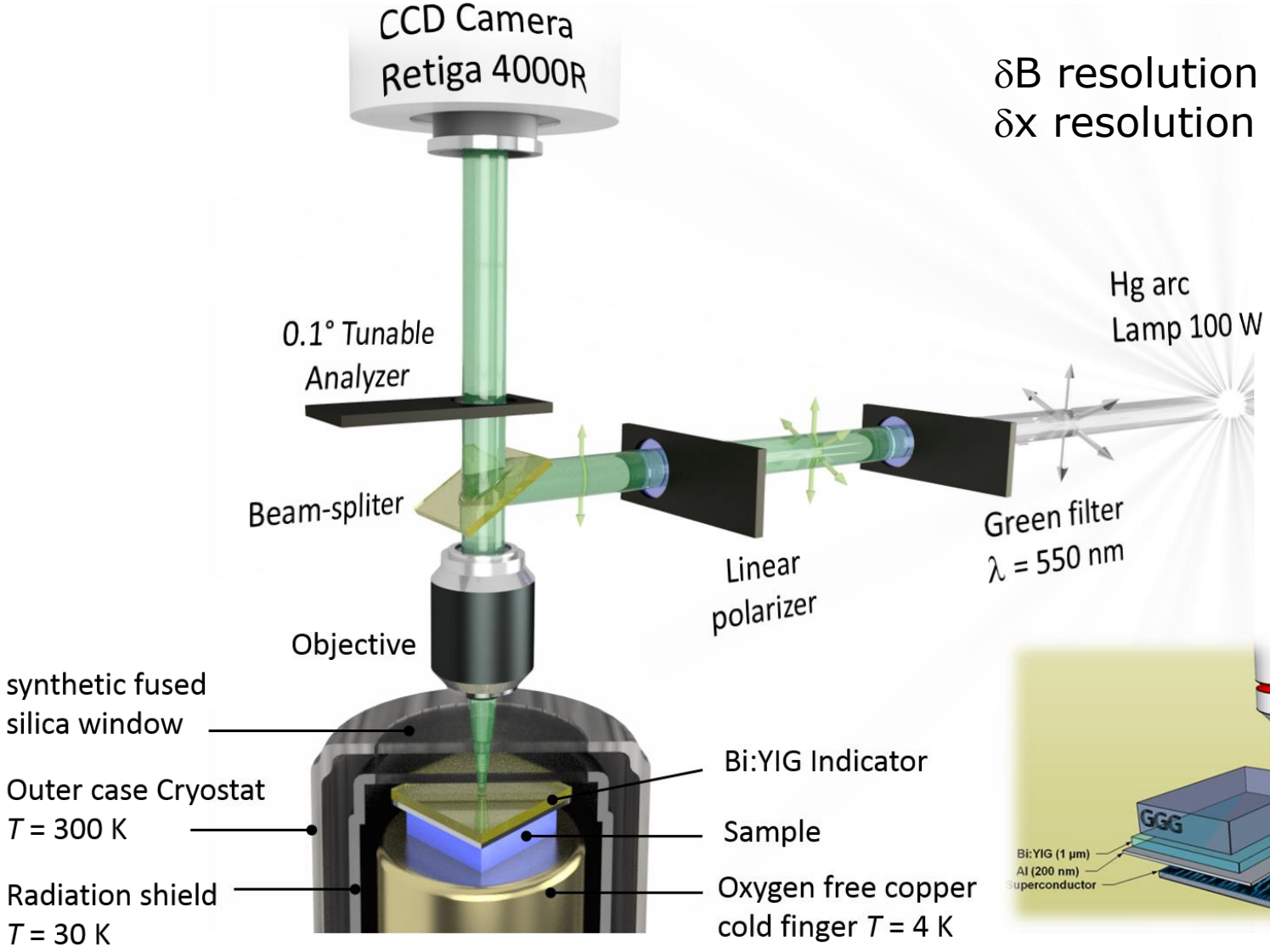
The investigated sample



T_c = 9 K

J. Brisbois *et al.*, *Sci. Rep.* **6**, 27159 (2016)

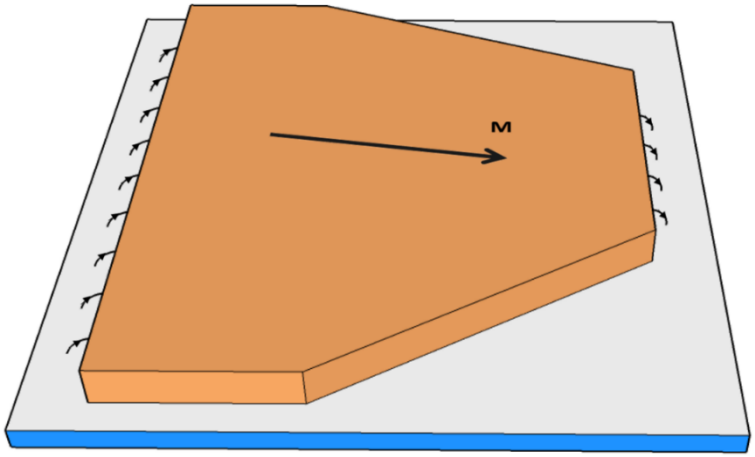
The experimental setup



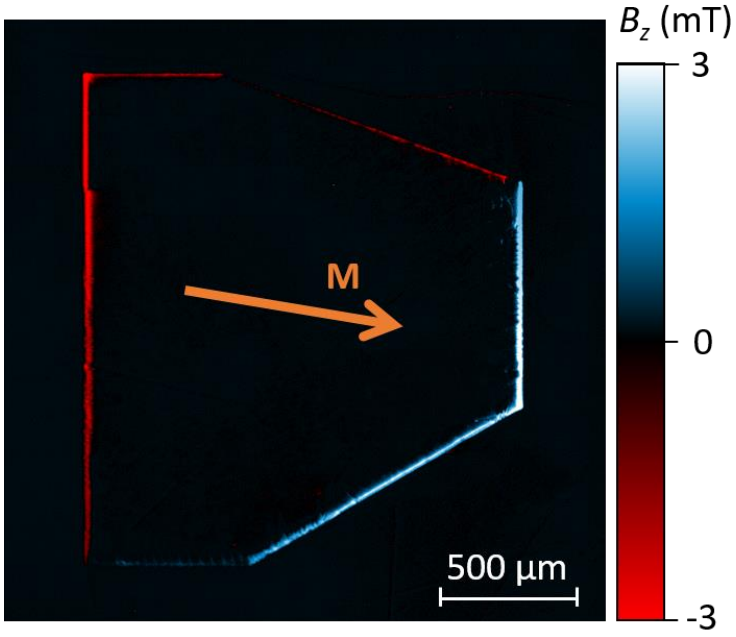
G. Shaw, J. Brisbois, L. Pinheiro, *et al.*, *unpublished*

Preparation initial magnetic state

The direction of magnetization is easily controlled…



In-plane saturation field ~ 2 mT

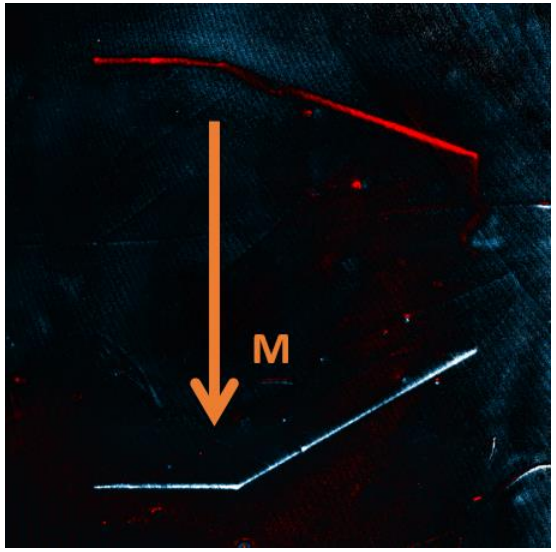


… and easily reversed!

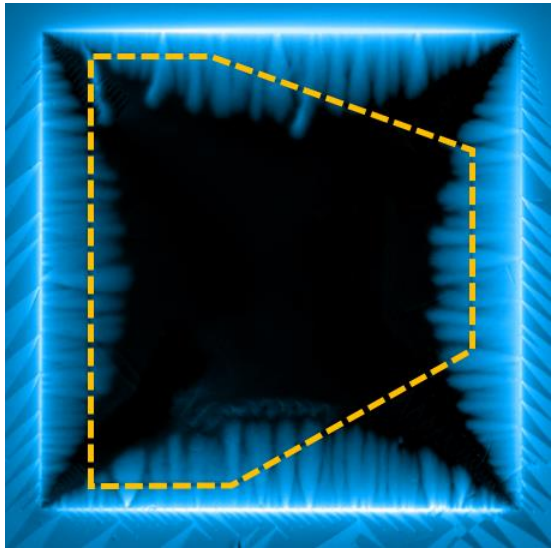
J. Brisbois *et al.*, *Sci. Rep.* **6**, 27159 (2016).

Imprinting the smooth flux penetration

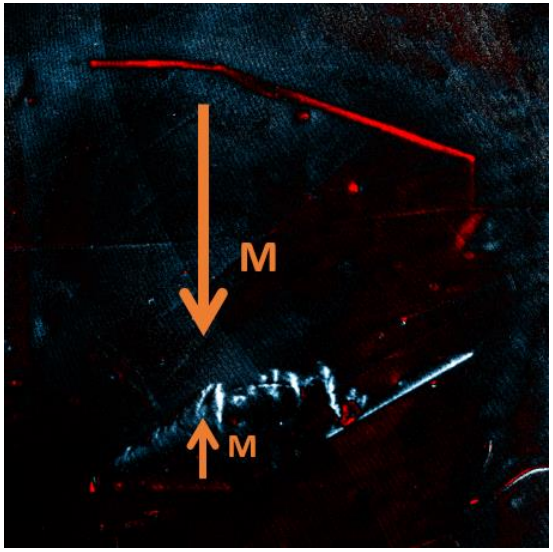
Before, 10 K



4.8 mT, 5 K



After, 10 K

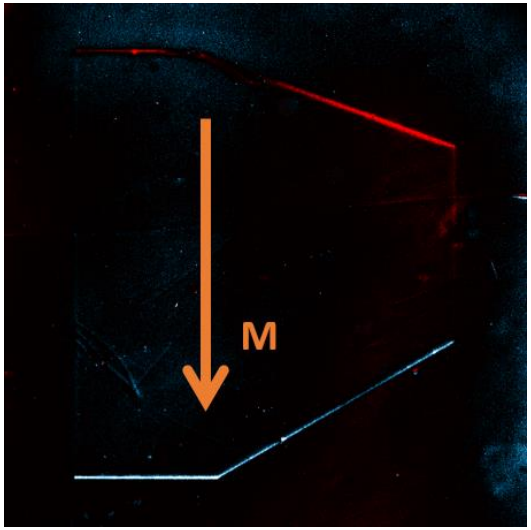


The reversal of the in-plane magnetization leaves a head-to-head domain wall with out-of-plane field.

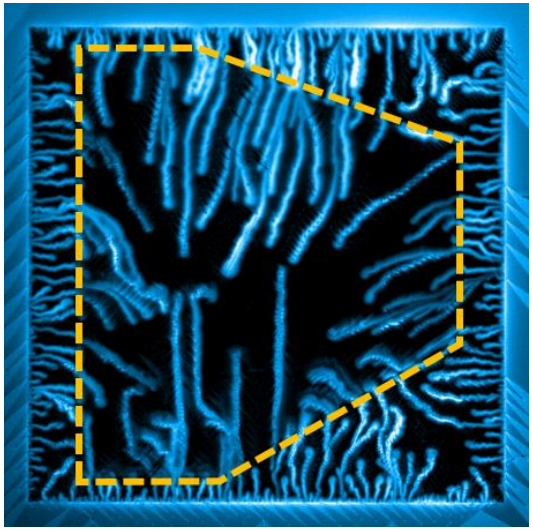
J. Brisbois *et al.*, *Sci. Rep.* **6**, 27159 (2016)

Imprinting flux avalanches

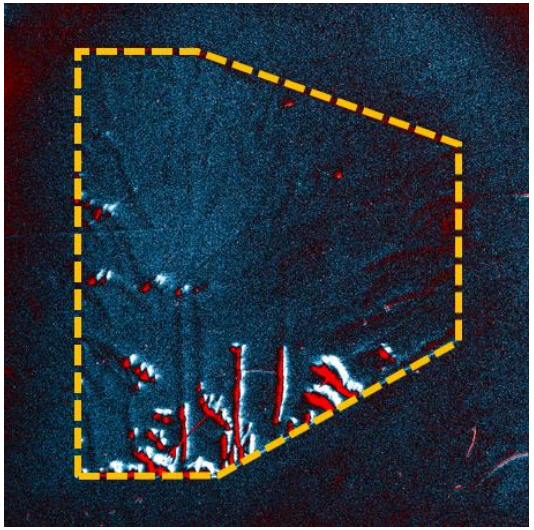
Before, 10 K



5 mT, 2.5 K

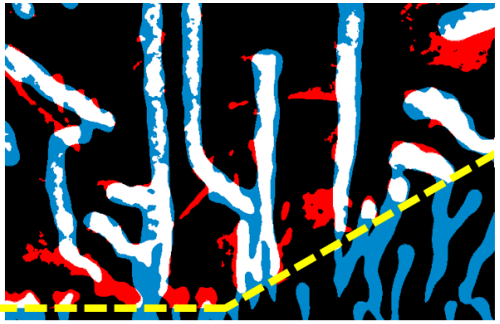


After, 10 K



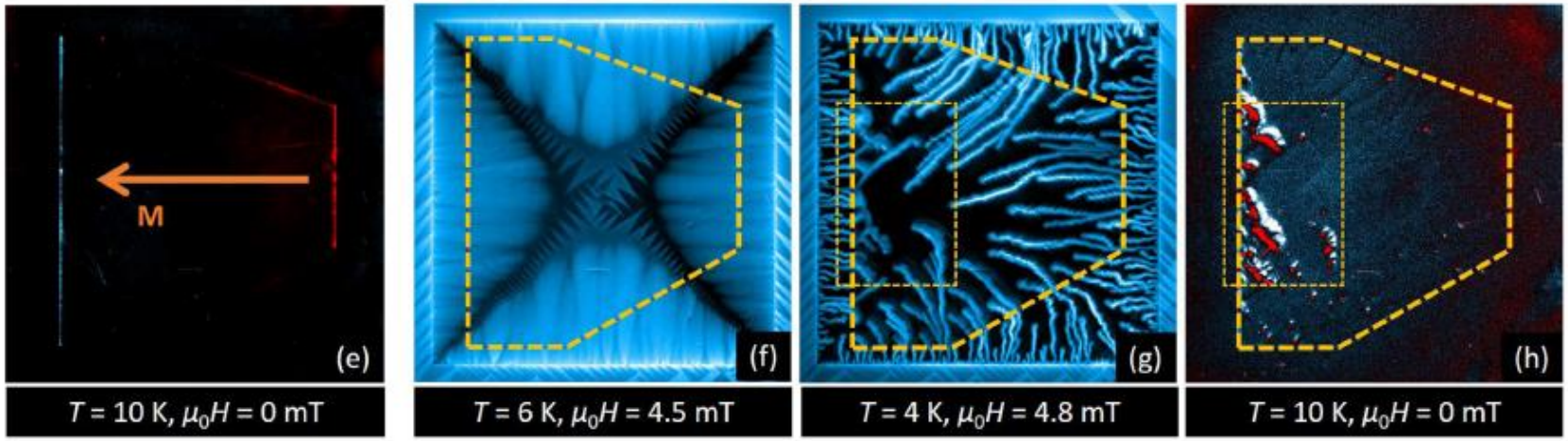
Guiding along the direction of magnetization

Printings are stable, even up to room temperature!



J. Brisbois *et al.*, *Sci. Rep.* **6**, 27159 (2016)

Imprinting flux avalanches



The initial magnetization direction is important

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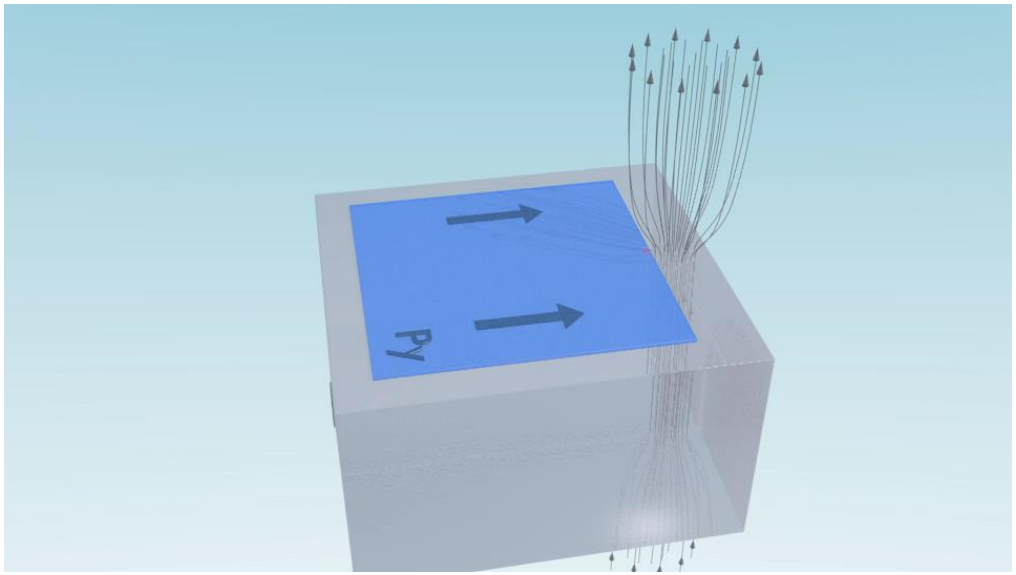
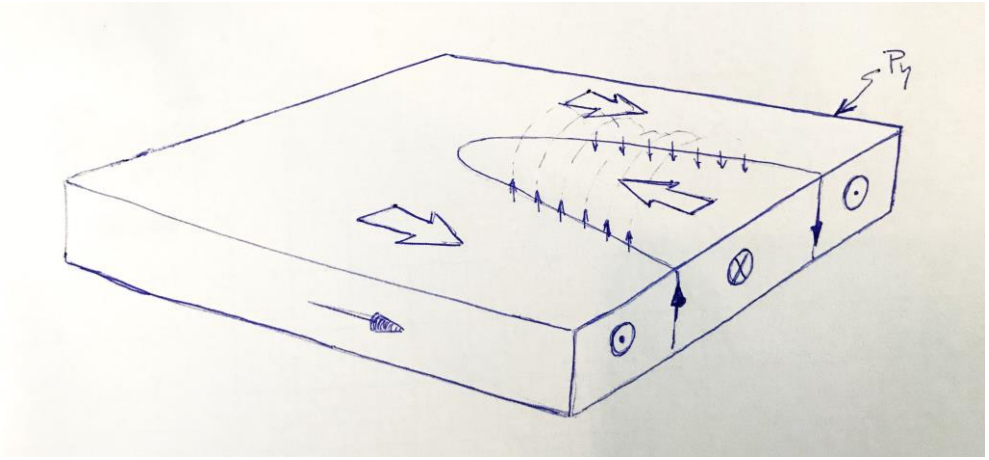
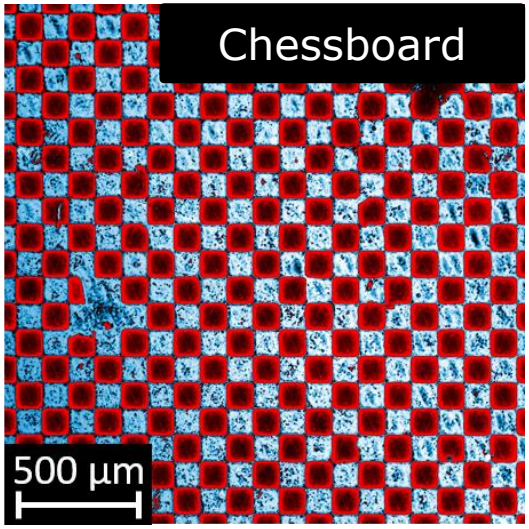
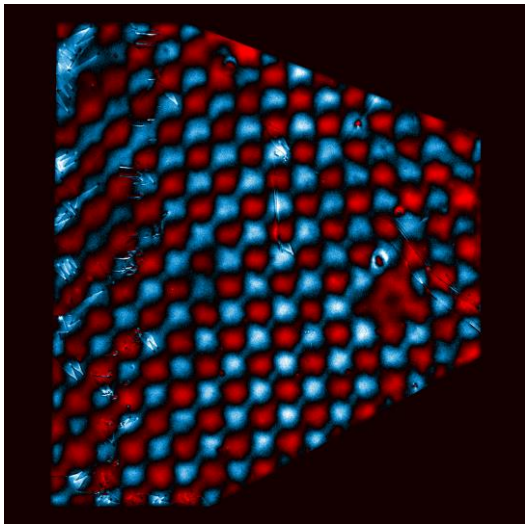
Possible scenario

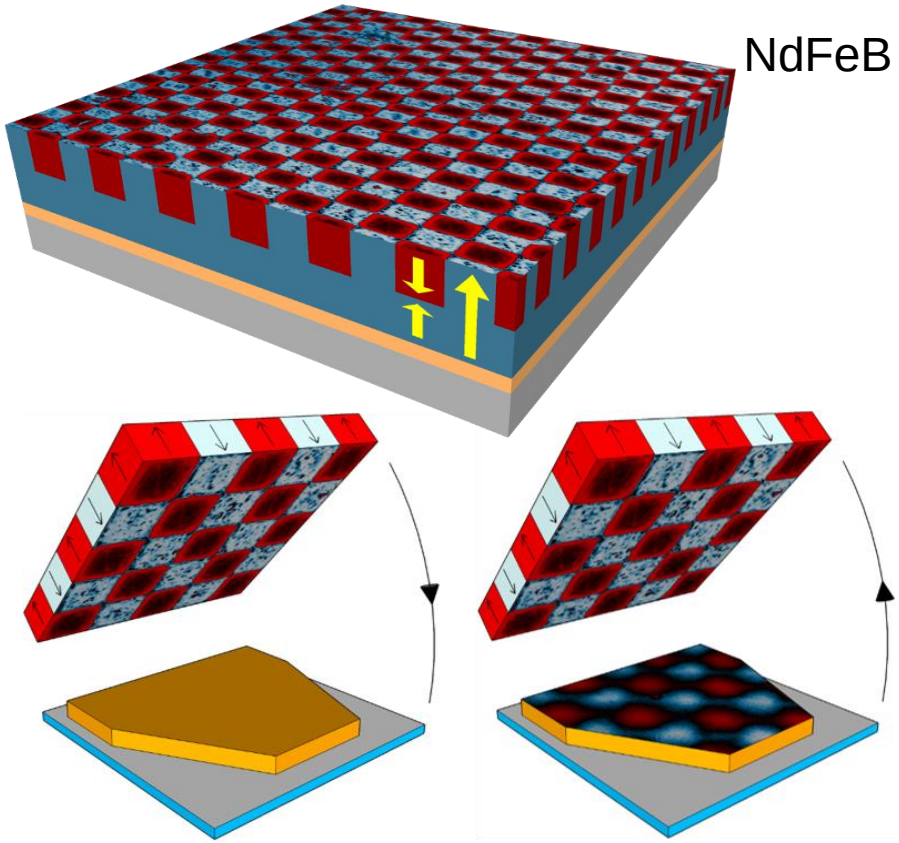




Room temperature printing





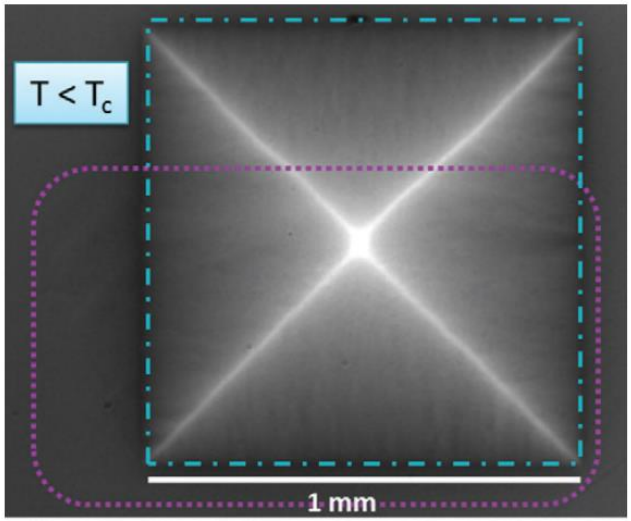


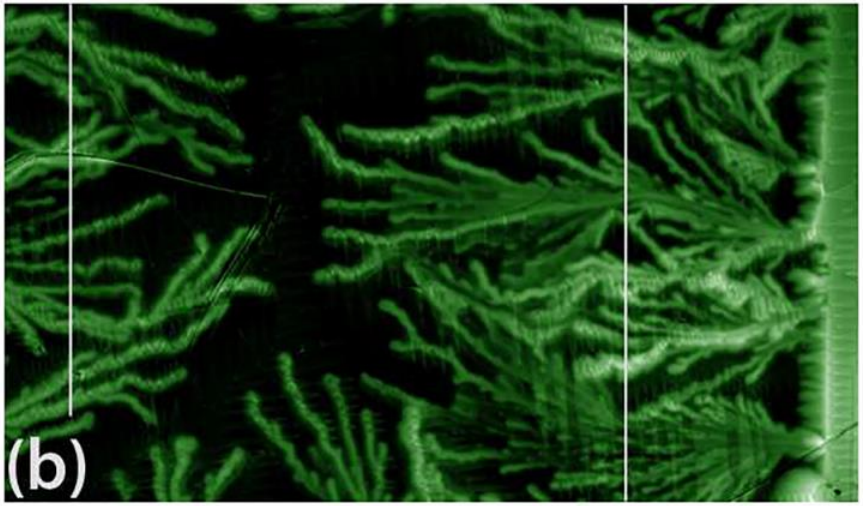
Imprinting works also at room temperature

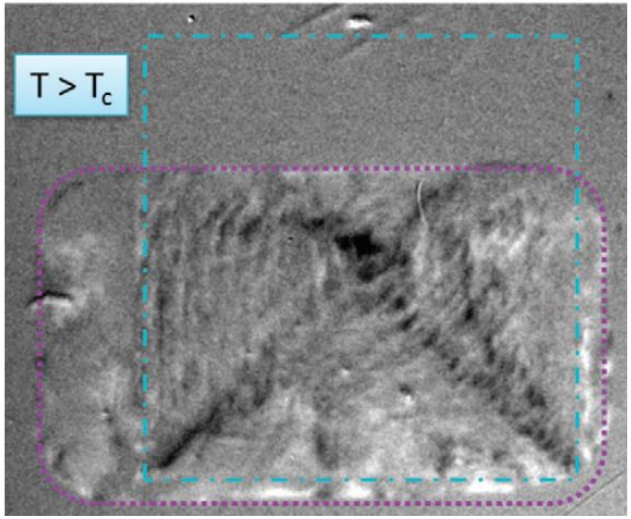
→ tune the magnetic landscape at will

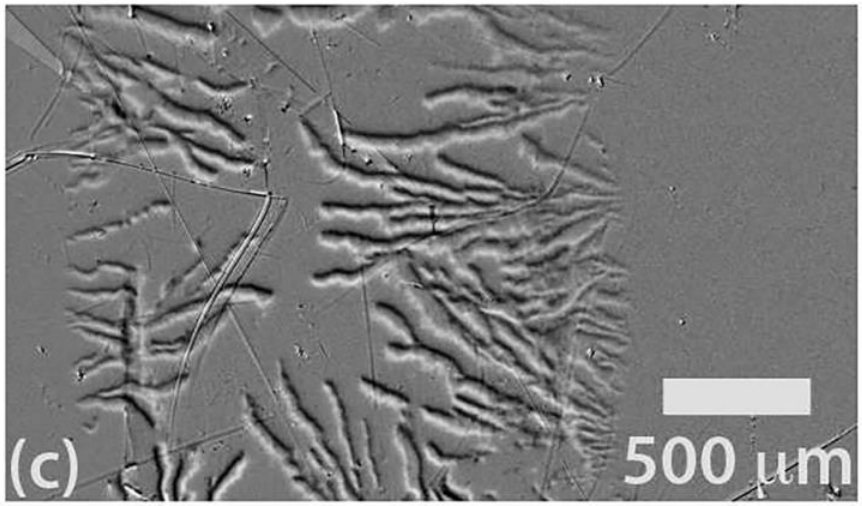
J. Brisbois *et al.*, *Sci. Rep.* **6**, 27159 (2016).

We are not alone …









C. Stahl *et al.*, *EPL* **106**, 27002 (2014)

R. F. Lopes *et al.*, *J. Appl. Phys.* **121**, 13905 (2017)

Conclusion

- ✓ Flux penetration (smooth and avalanches) can be imprinted in a magnetic layer.
- ✓ The printings are stable and can even be observed at room temperature.
- ✓ Enhanced damping due to magnetic layer.

Perspectives:

- ✓ Improve the resolution of magnetic recording of flux penetration
- ✓ Tunable magnetic landscape

Acknowledgements