

Electrodeposited nanowires for composite bonded magnets: scaling-up the synthesis process

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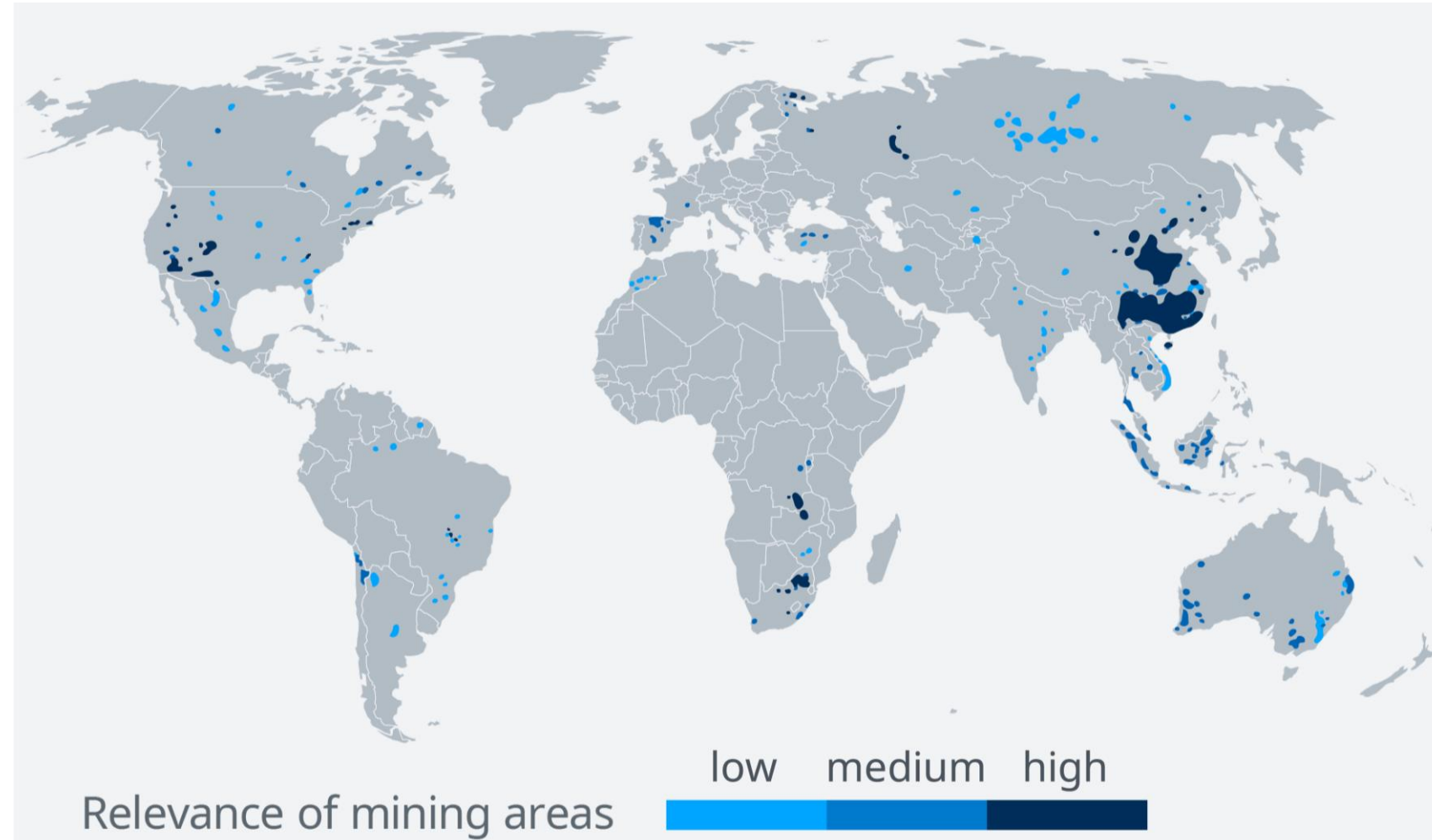
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Application of permanent magnets



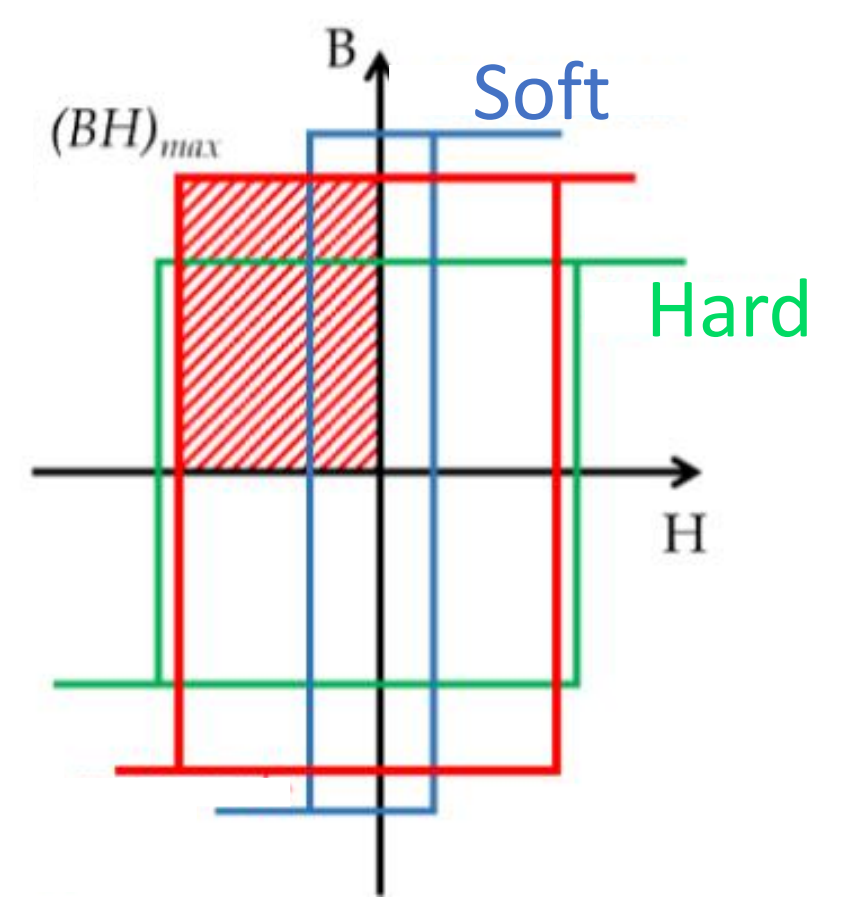
Problems with the rare earths:

The most important mining areas of critical raw materials^[1]



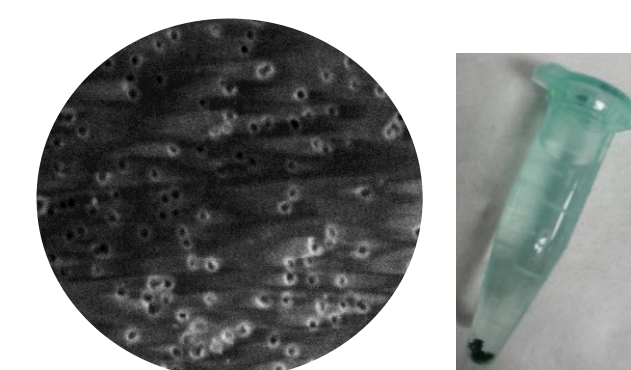
- High prices in the order of 100.000 €/metric ton
- Their extraction causes environmental damages

Possible solution ? Composite materials



Why is this solution unexplored?

Lab NW production



0.01mg NWs/ cm²

We need 4 orders of magnitude more!!

Industrial applications

Lab procedure for NW synthesis

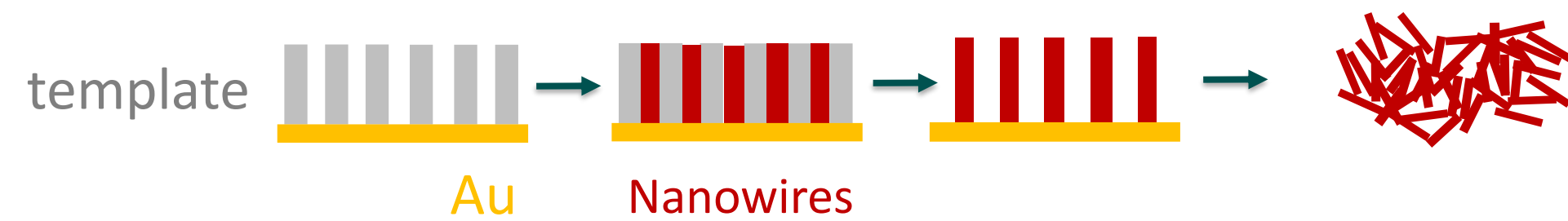
With template assisted electrodeposition we can control ...

... diameter: template pore diameter

... length: time of electrodeposition

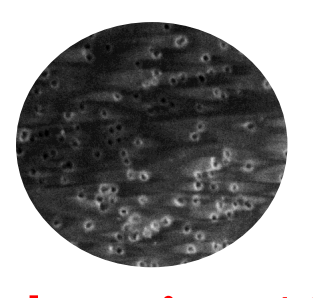
... morphology and structure: potential

... composition : electrolyte composition and applied potential



Templates

POLYCARBONATE



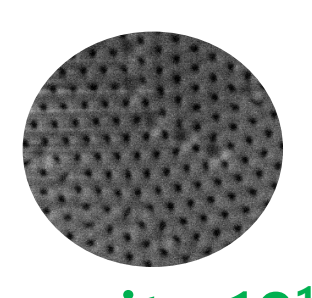
pore density 10⁸ cm⁻²

thickness (6µm)

0.01 mg NW/cm²

€€€

COMMERCIAL ALUMINA



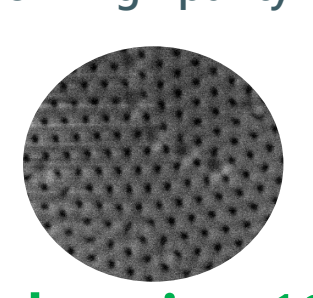
pore density 10¹⁰ cm⁻²

thickness (60µm)

xx mg NW/cm²

€€€€

LAB-MADE ALUMINA
(from high purity Al)



pore density 10¹⁰ cm⁻²

thickness (190µm)

1.2 mg NW/cm²

€€€€

TWO-STEP anodization



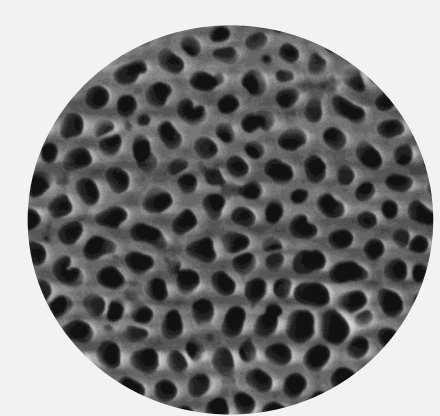
2-3 days / template
Need of cooling



New synthesis process

Reduction of costs

LAB-MADE ALUMINA
from RECYCLED WASTE Al



pore density 10¹⁰ cm⁻²

thickness (190µm)

1.2 mg NW/cm²

free

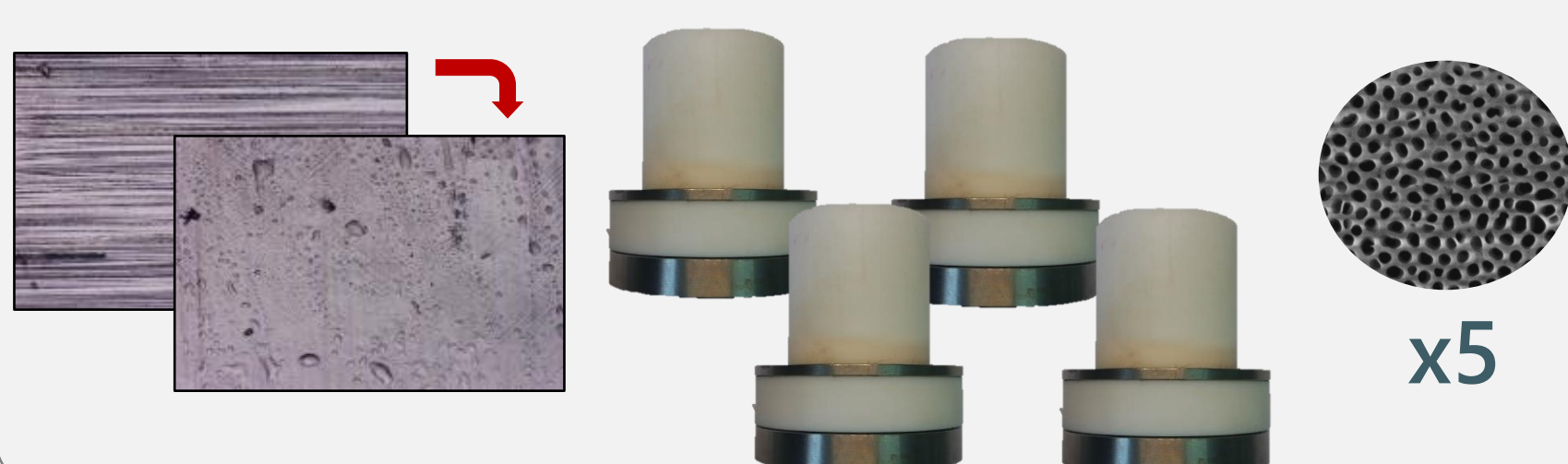
Changing high purity Al for recycled waste Al, we obtain:

↑↑ Pore density

↓↓ Price

Time reduction

SINGLE-STEP multiple anodization

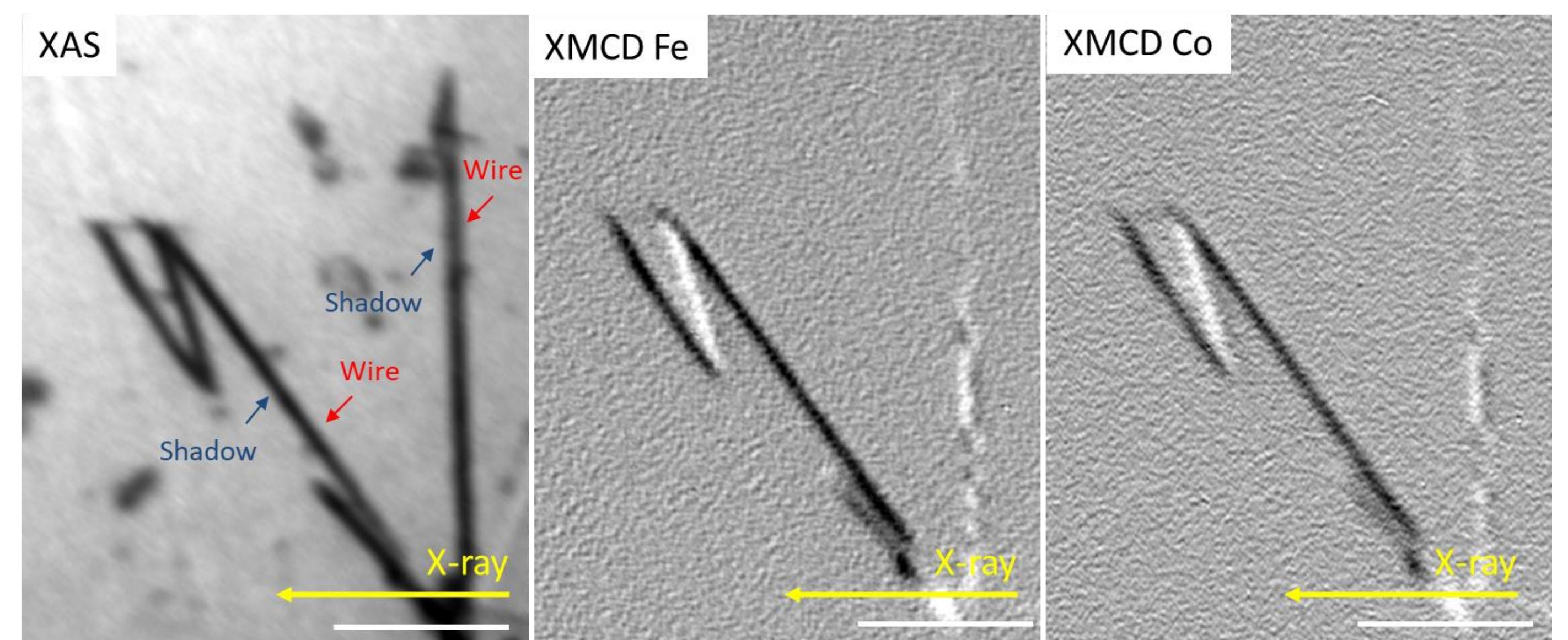


5 templates / day
No need of cooling

x5

Magnetic configuration

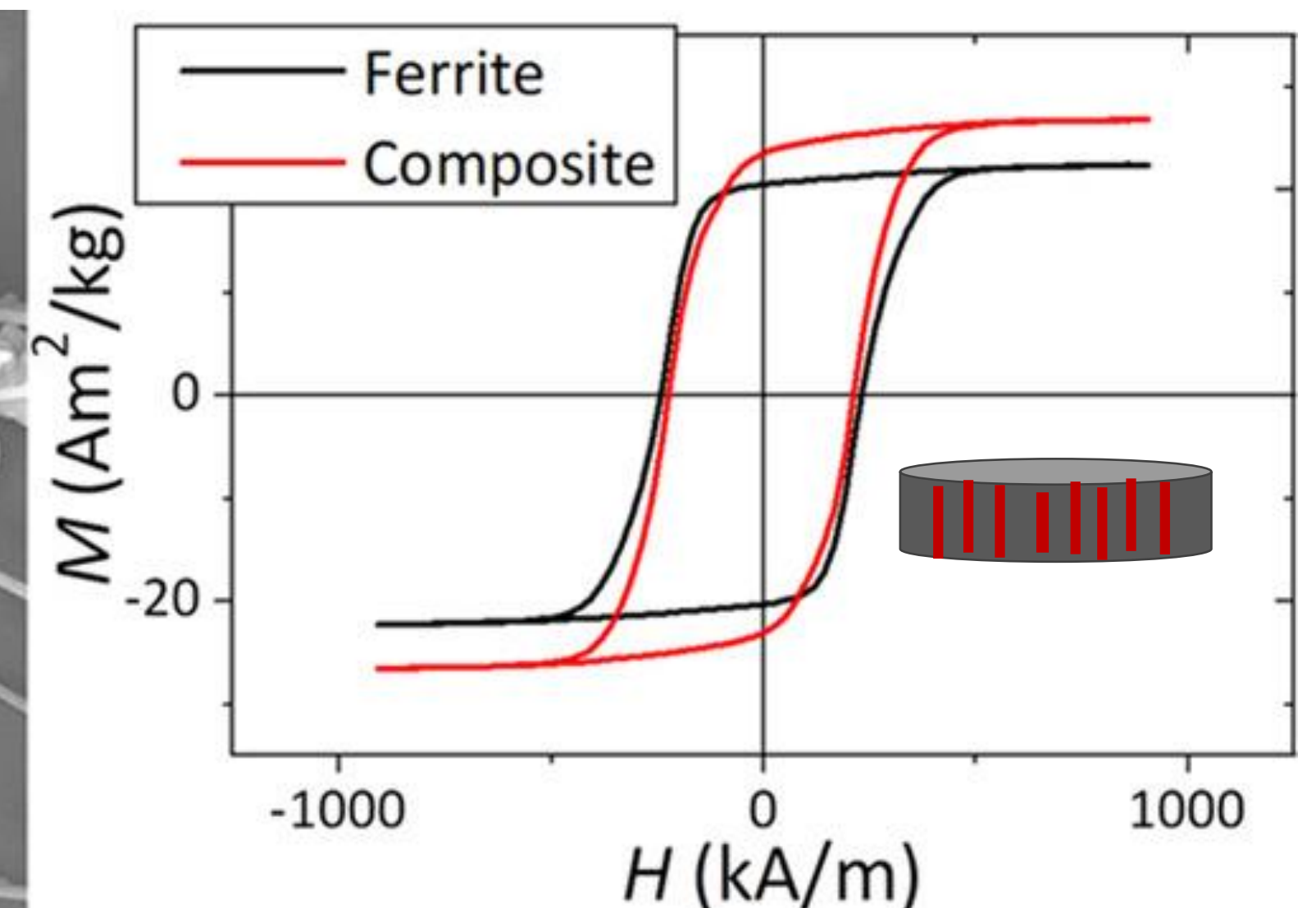
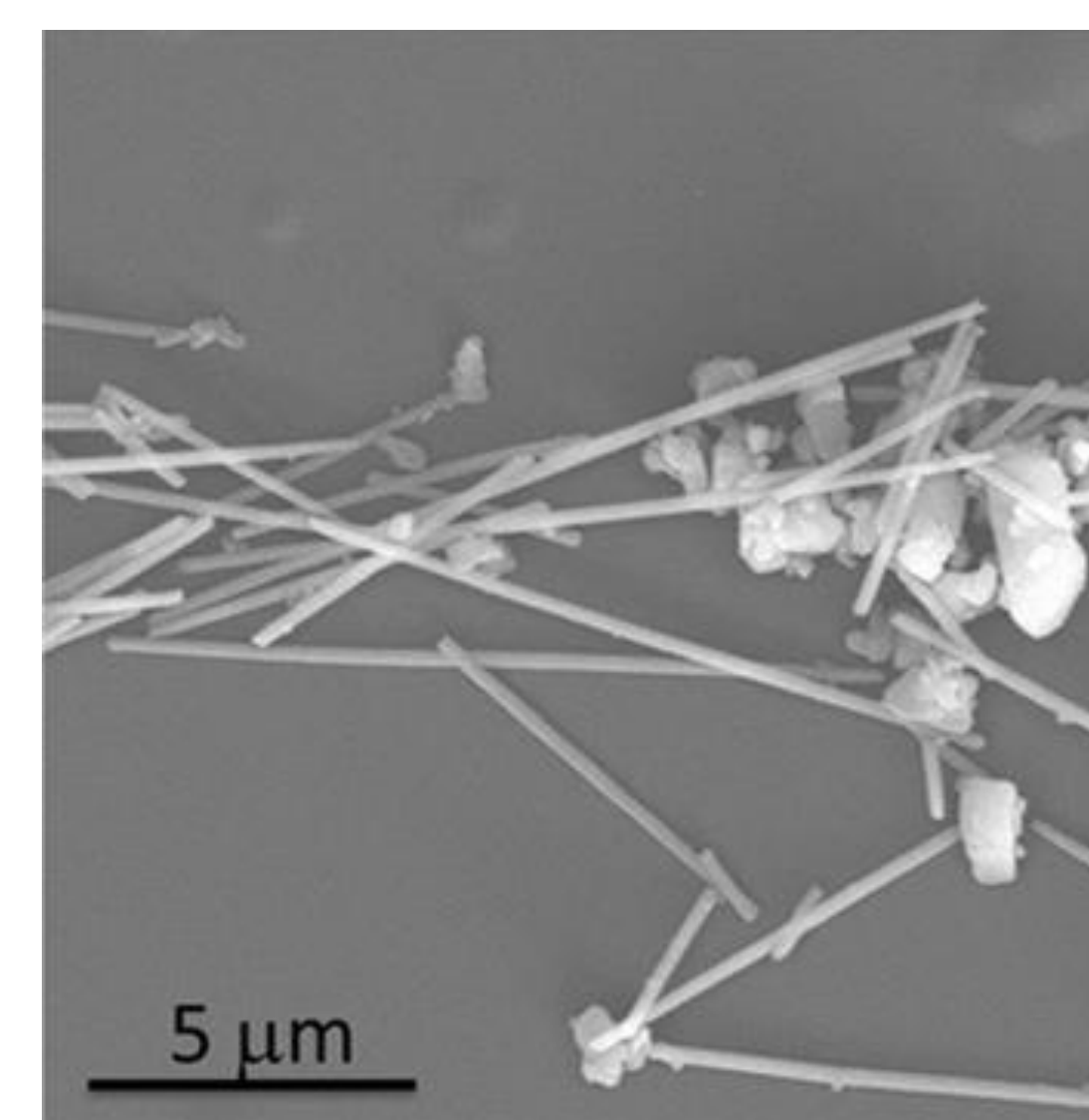
Shadow XMCD-PEEM microscopy^[2]



Magnetization mostly along nanowire axis

Small vortex or curling component forming magnetic domains

Fe-Co Nanowire – Strontium Ferrite bonded magnet with improved energy product



J.C Guzmán-Mínguez & A. Quesada^[3]

↑ 20% M_{rem}
48% B_{max}

Conclusions

- Production capacity has been increased in three orders of magnitude
- Time and costs of the production have been reduced.
- Prototype of bonded magnet has been synthesized with an improvement of 48% in the energy product (BH_{max})

References

[1] EU Commission, US Geological Survey. Methodology: github.com/dw-data/crm.

[2] S. Jamet et al. Phys. Rev B (2015) 92, 144428.

[3] Guzmán-Mínguez et al. ACS Appl. Nano Mat. 3.10 (2020): 9842-9851

