Research lines and facilities on Nanolithography in Zaragoza

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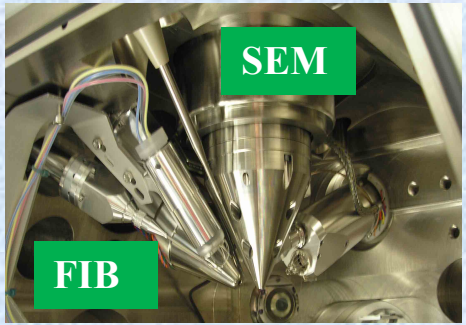
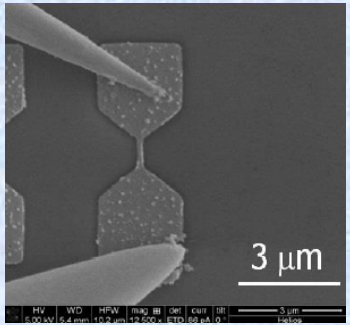
LABORATORIO DE MICROSCOPIAS AVANZADAS (LMA) ICTS-ELECMI





Universidad Zaragoza
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NANOMIDAS GROUP
Nanofabrication and Advanced Microscopies
CSIC-University of Zaragoza (Spain)

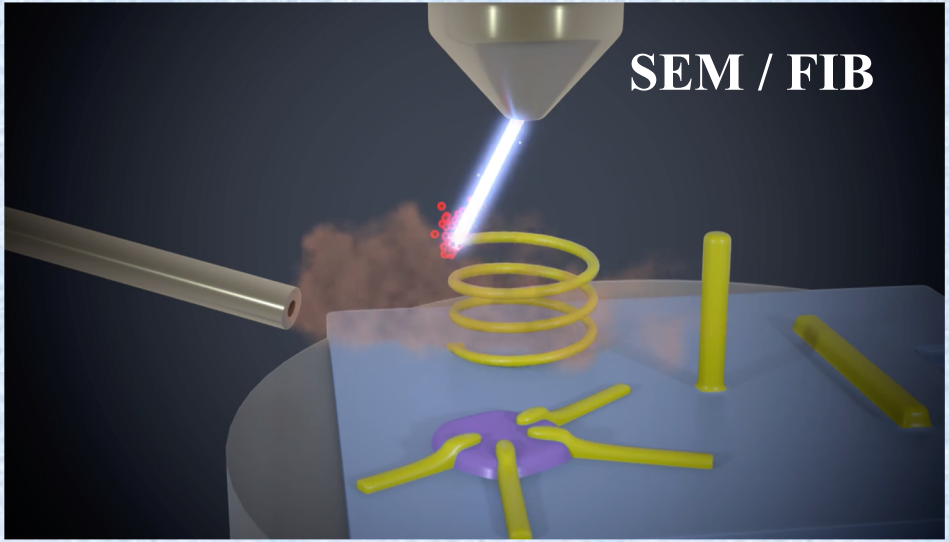
Nanofabrication team

https://nanofab-deteresa.com

OVERVIEW OF CURRENT RESEARCH LINES

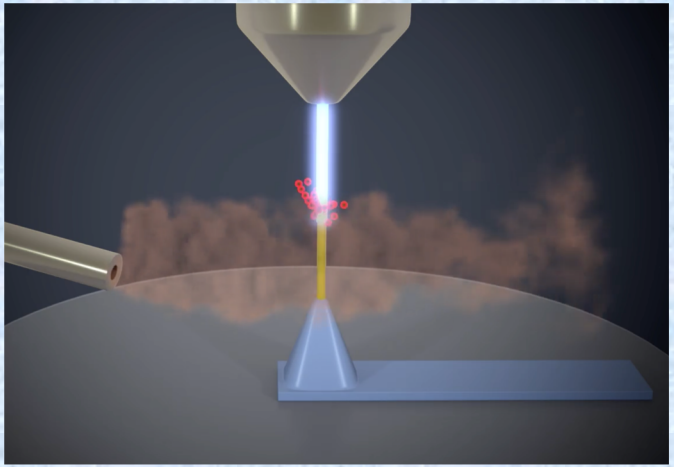
1. Metallic nanostructures by Focused Ion Beam Induced Deposition (FIBID) and Cryo-FIBID
2. Magnetic nanostructures by Focused Electron Beam Induced Deposition (FEBID) and FIBID
3. Superconducting nanostructures and devices by FIBID

FOCUSED ELECTRON/ION BEAM INDUCED DEPOSITION (FEBID/FIBID)



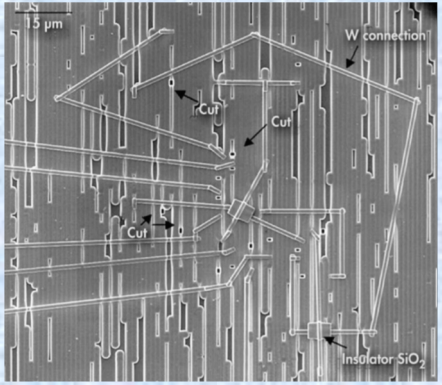
COMPETITIVE ADVANTAGES:

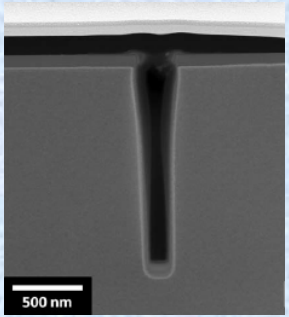
- ONE-STEP LITHOGRAPHY
- ON ANY SUBSTRATE
- 3D GROWTH
- HIGH RESOLUTION

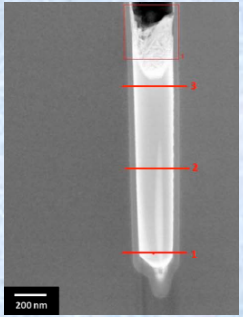


SOME APPLICATIONS OF FEBID/FIBID

Electrical contacts during circuit editing

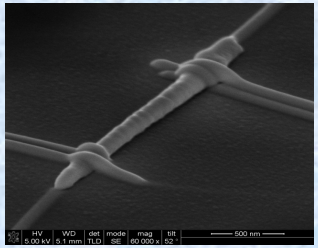




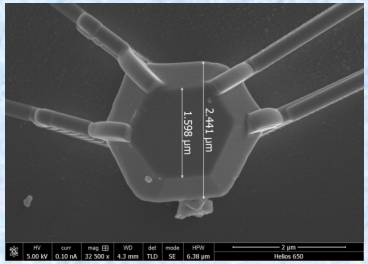


T. Mohiuddin, Electron. Device Fail. Anal. 16 (2014) 20
Y. Drezner et al., J. Vac. Sci. Technol. B 29 (2011) 011026

Electrical contacts to nano-objects

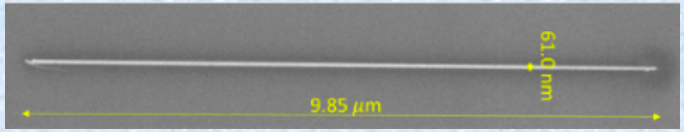


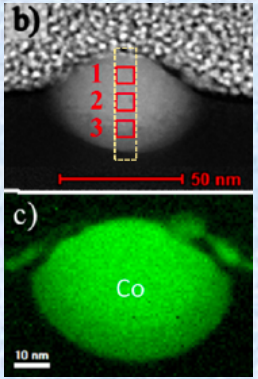
Bismuth single-crystal nanowires, see Marcano et al., Appl. Phys. Lett. 96, 082110 (2010)



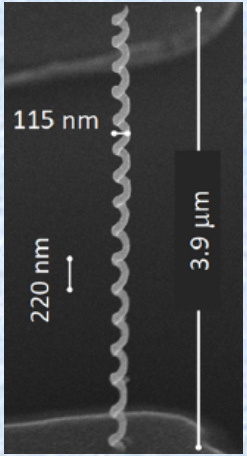
$SrRu_2O_6$ microcrystals, see Hiley et al., Phys. Rev. B 92, 104413 (2015)

Growth of superconducting or magnetic materials





Cobalt magnetic nanowires, see Sanz et al., Nanomaterials 9, 1715 (2019)



W-C superconducting nanowires, see Córdoba et al., Nano Letters 19, 8597 (2019)

1. Metallic nanostructures by Focused Ion Beam Induced Deposition (FIBID) and Cryo-FIBID
2. Magnetic nanostructures by Focused Electron Beam Induced Deposition (FEBID) and FIBID
3. Superconducting nanostructures and devices by FIBID

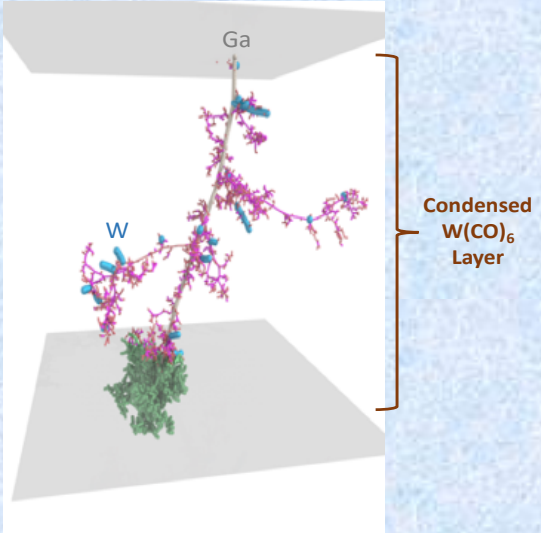
FIBID under cryogenic conditions (Cryo-FIBID)

J. M. De Teresa et al., patent submitted (WO2020021149); R. Córdoba et al., Scientific Reports 9, 14076 (2019)

J. M. De Teresa et al., Micromachines 10, 799 (2019); A. Salvador et al., Nanomaterials 10, 1906 (2020)

A. Salvador et al., manuscript in preparation

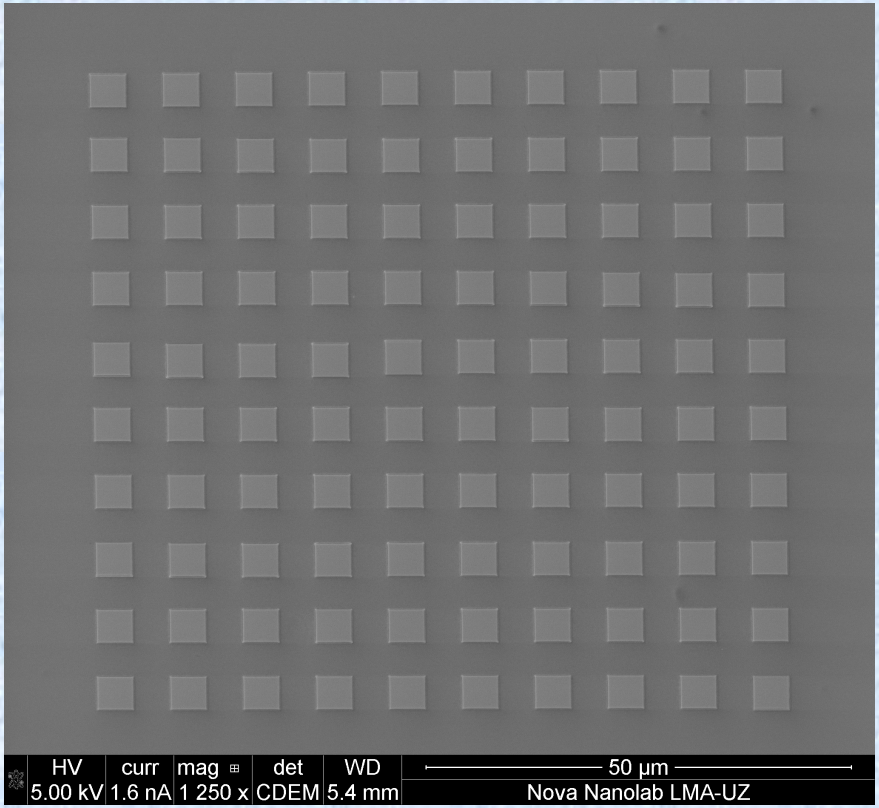
Focused Ion Beam Induced Deposition (FIBID)
in cryogenic conditions (Cryo-FIBID)



SDTRIMSP simulations by
P. Philipp (U. Luxembourg)

Ga^+-FIBID under cryogenic conditions (Cryo-FIBID)

$W(CO)_6$ precursor



ARRAY of 100 SQUARES OF W-C DEPOSITS

-TOTAL AREA= 100 x 25 μm^2

-TOTAL ION IRRADIATION TIME= 85 SECONDS

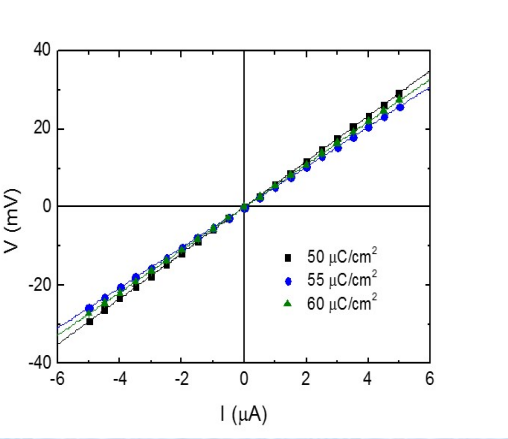
-ION IRRADIATION TIME USING FIBID AT ROOM TEMPERATURE= 14 HOURS

THE PROCESS IS 600 TIMES FASTER BY CRYO-FIBID !

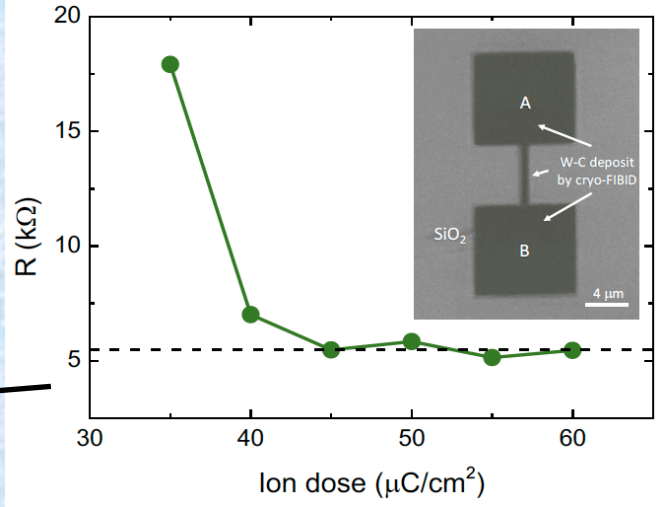
Ga⁺-FIBID under cryogenic conditions (Cryo-FIBID)

Transport experiments at room temperature

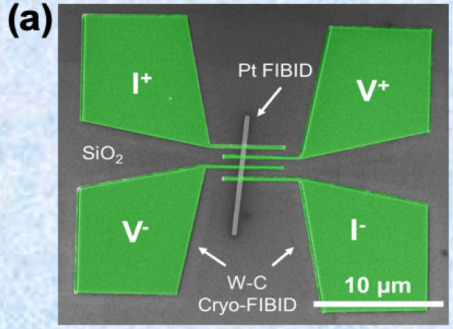
W(CO)$_6$ precursor

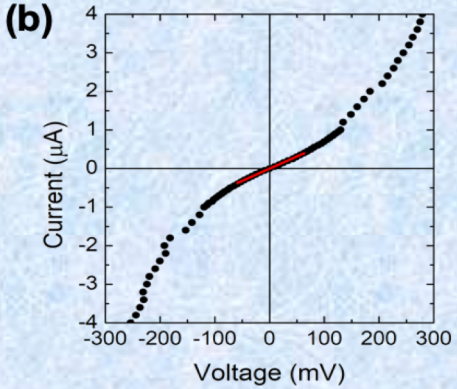


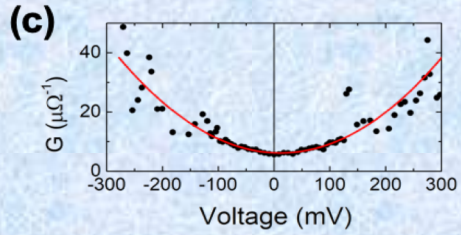
Linear I vs V: Metallic behaviour



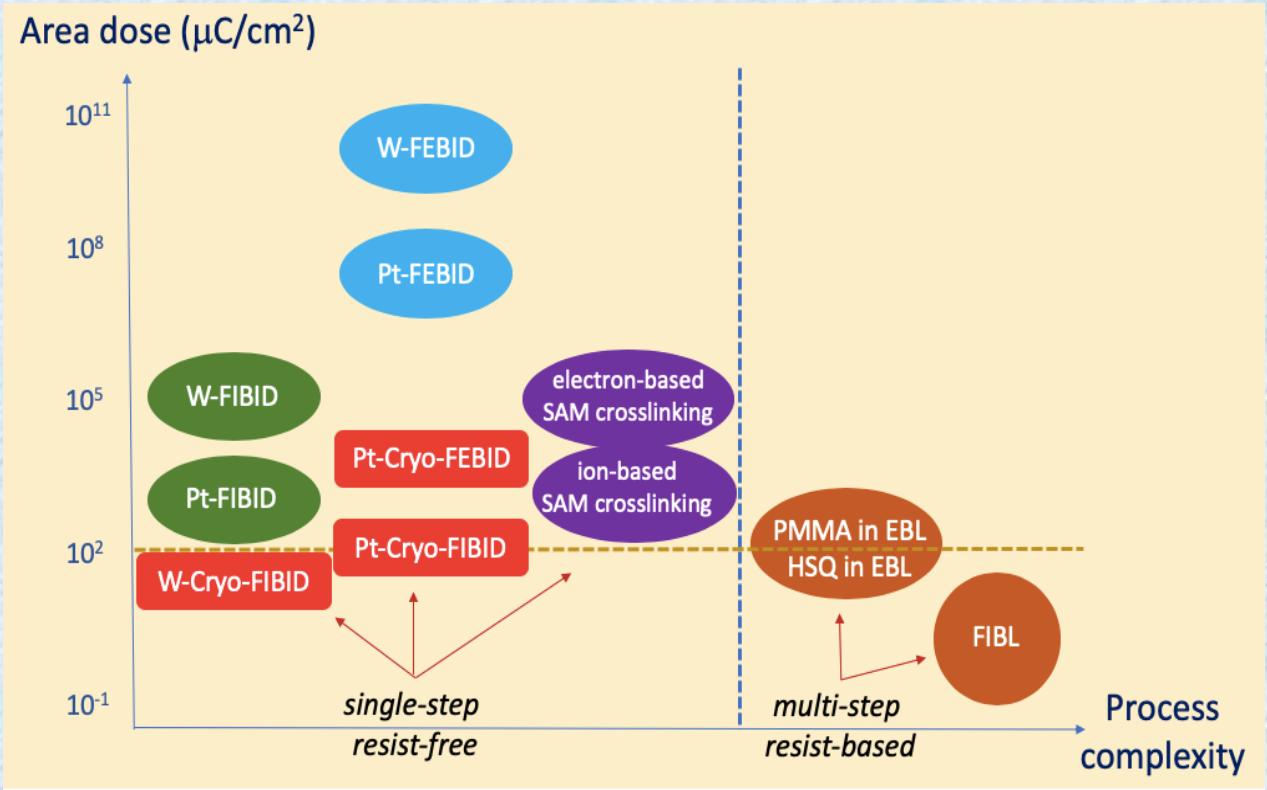
Resistivity of 800 μΩcm

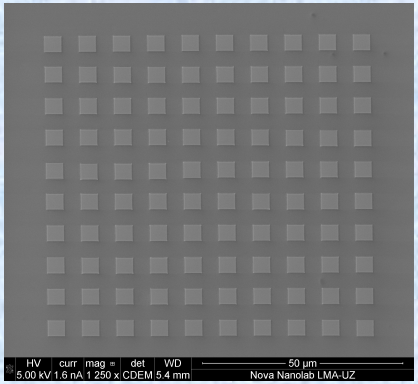




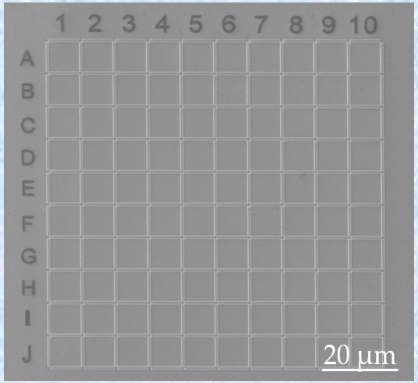


Comparison of RT FIBID and Cryo-FIBID





(W-C deposits by Cryo-FIBID, 85 s irradiation, instead of 14 h)



(Pt-C deposits by Cryo-FIBID, 43 s irradiation instead of 2.5 h)

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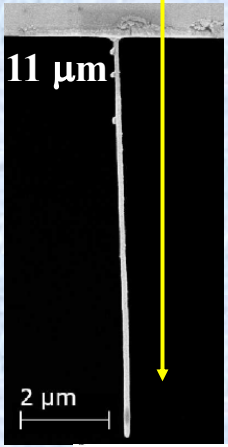
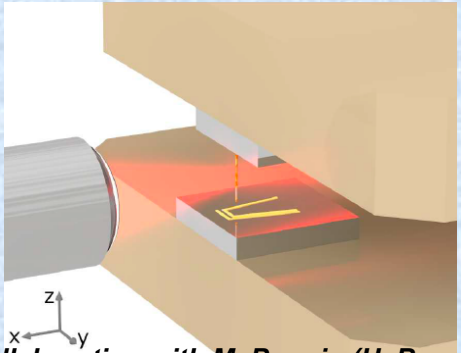
Fe and Co magnetic nanowires for MFM tips

Very long Co tips can be grown for highly-sensitive magnetic force sensors

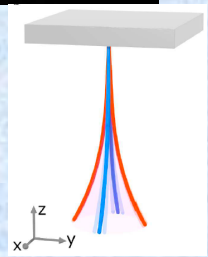
$Co_2(CO)_8$

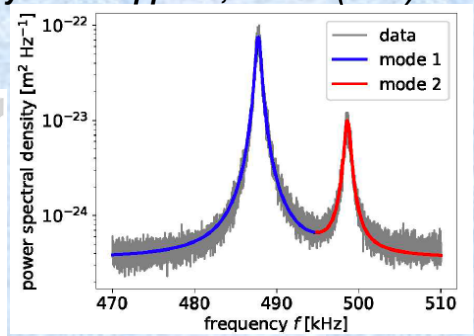




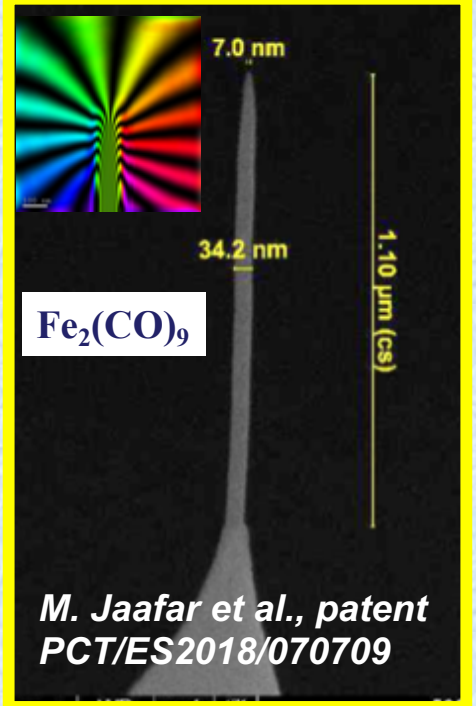
Collaboration with M. Poggio (U. Basel)

Phys. Rev. Appl. 13, 044043 (2020)





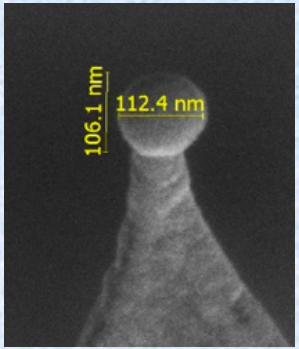
Very sharp tips can be grown for high-resolution MFM measurements



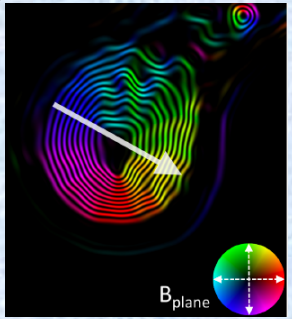
$Fe_2(CO)_9$

M. Jaafar et al., patent PCT/ES2018/070709

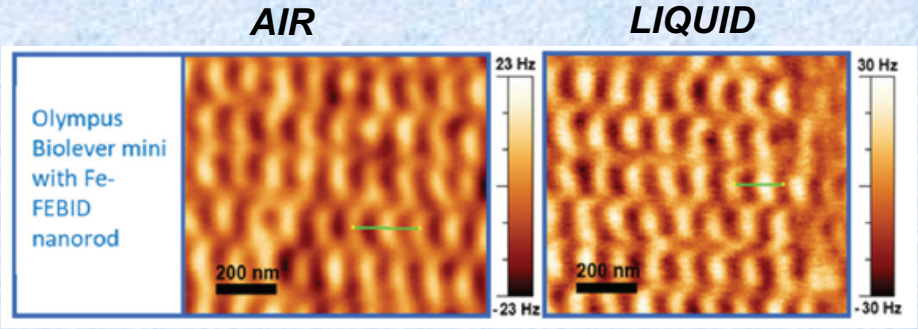
Magnetic nanospheres for FMRFM



Sangiao et al., BJNANO 8, 2106 (2017)

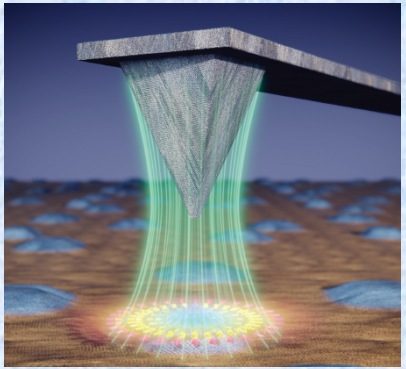


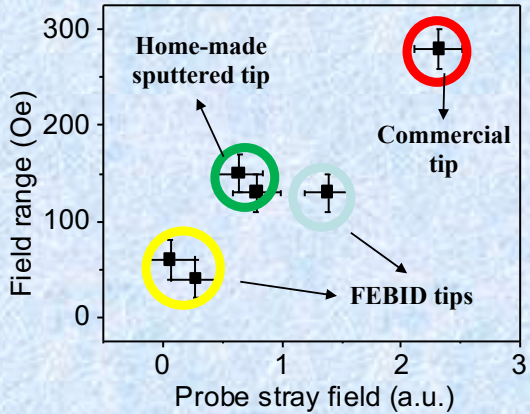
MFM tips for use under liquid environment



M. Jaafar et al., Nanoscale 12, 10090 (2020)

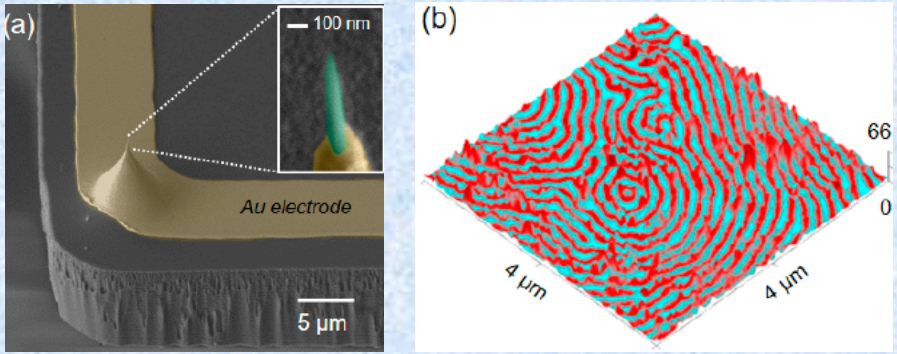
MFM tips for use on soft magnetic structures





E. Berganza et al., Nanoscale 12, 18646 (2020)

MFM tips for AFSEM



H. Plank et al., Micromachines 11, 48 (2020)

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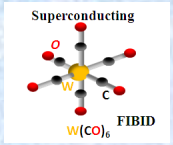
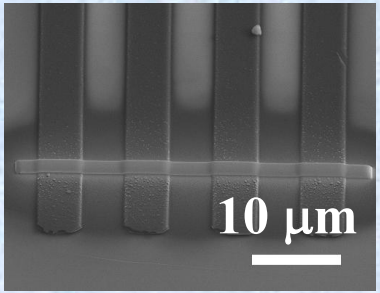
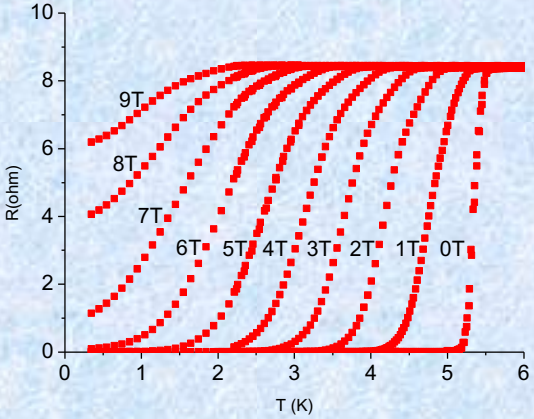
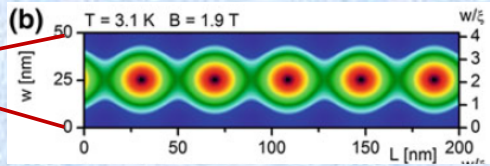
W-C superconducting nanostructures and devices by Ga⁺-FIBID



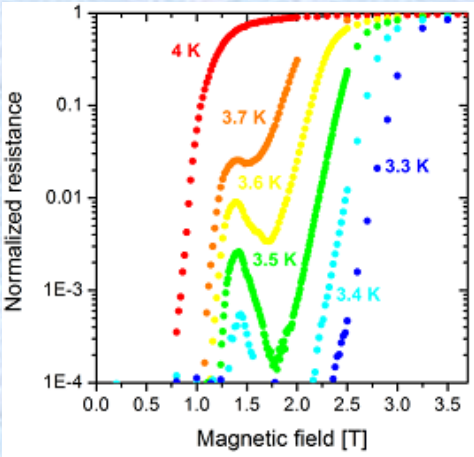


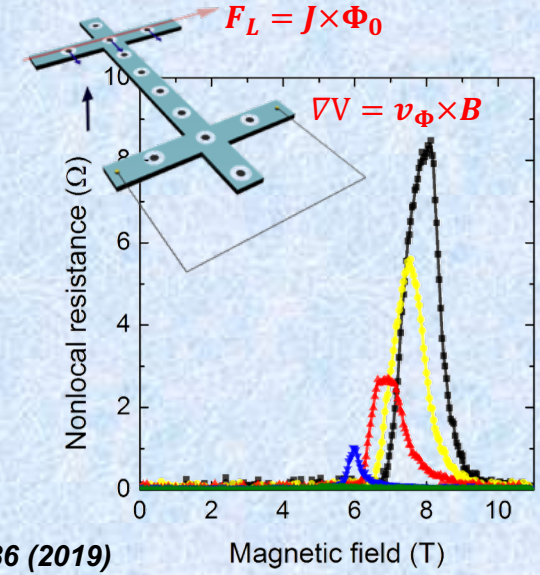


De Teresa et al., MRS proceedings 1180, 1180-CC04-09 (2009)



R. Córdoba et al., Nature Commun. 4 (2013) 1437

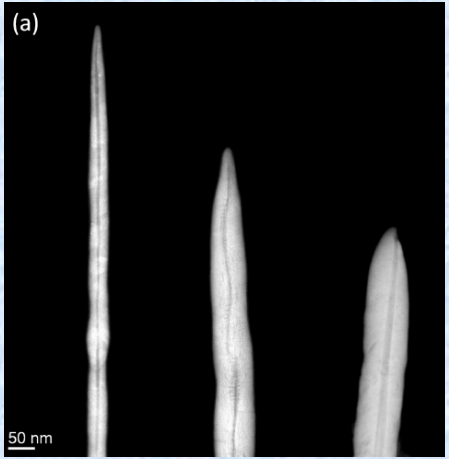


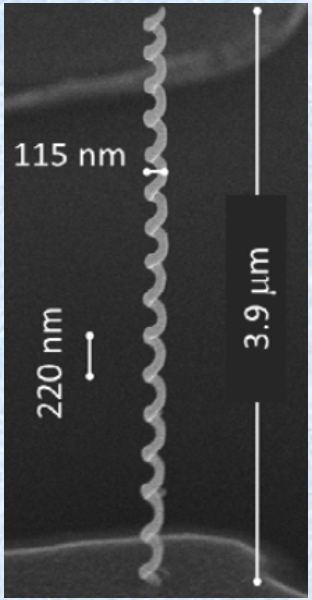


R. Córdoba et al., Sci. Rpts. 9, 12386 (2019)

W-C superconducting nanostructures and devices by He^+-FIBID

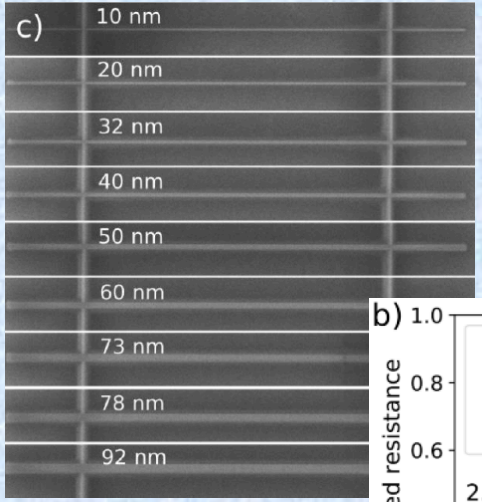
out-of-plane linear nanowires (grown at HIM in Paris)

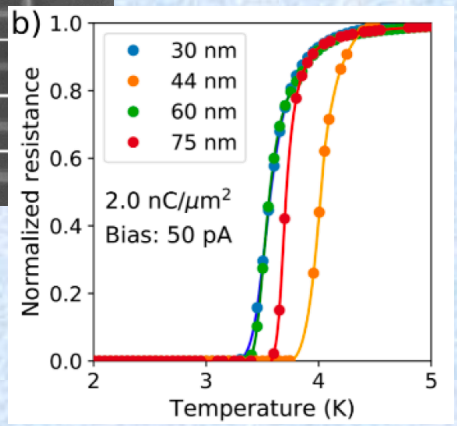




R. Córdoba et al., Nano Letters 18, 1379 (2018); Nano Letters 19, 8597 (2019); BJNANO 11, 1198 (2020)

in-plane nanowires (grown at HIM in Dresden)





P. Orús et al., Nanotechnology 2020, doi: 10.1088/1361-6528/abc91c

FET-OPEN Project kick-off meeting

https://www.fibsuperprobes.com/

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INSTITUTO DE NANOCIENCIA Y MATERIALES DE ARAGÓN

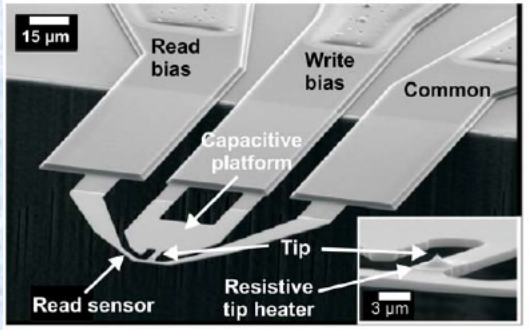
J. M. De Teresa (IP), C. Magén, S. Sangiao, P. Orús

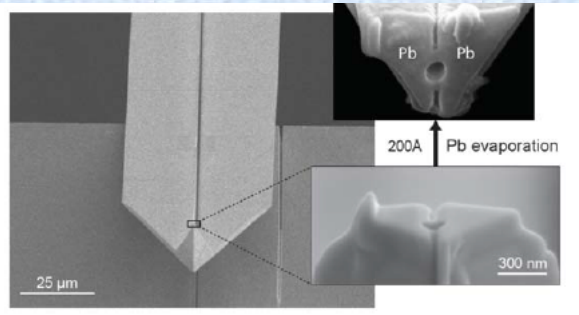
Focused Ion Beam fabrication of superconducting scanning Probes

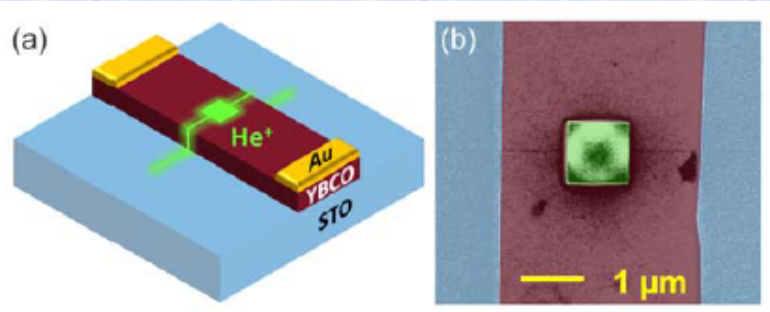
FIBsuperProbes

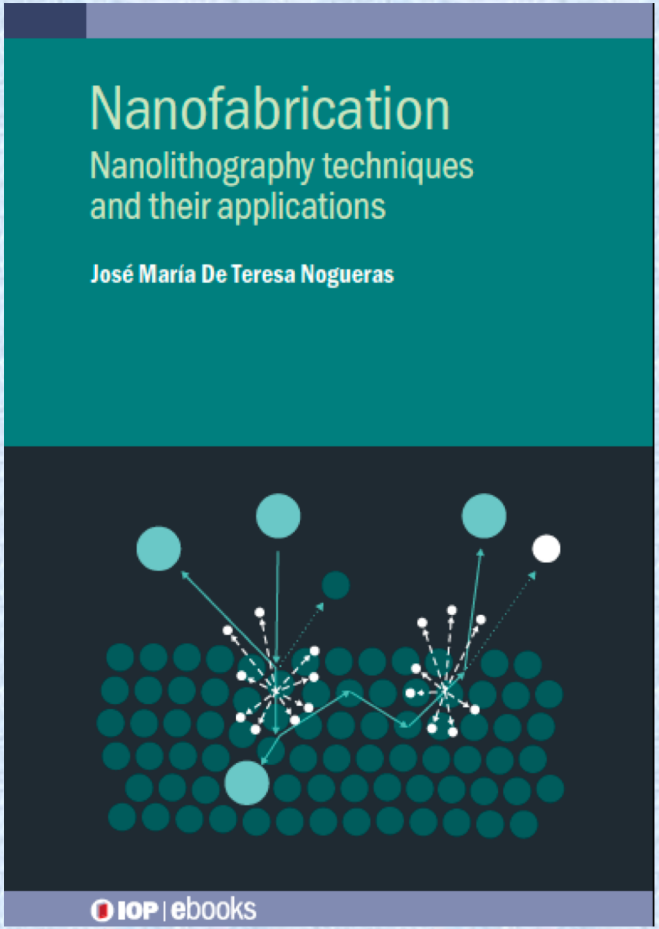
Universität Basel
CSIC
Eberhard Karls Universität Tübingen
IBM

FIBsuperProbes









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