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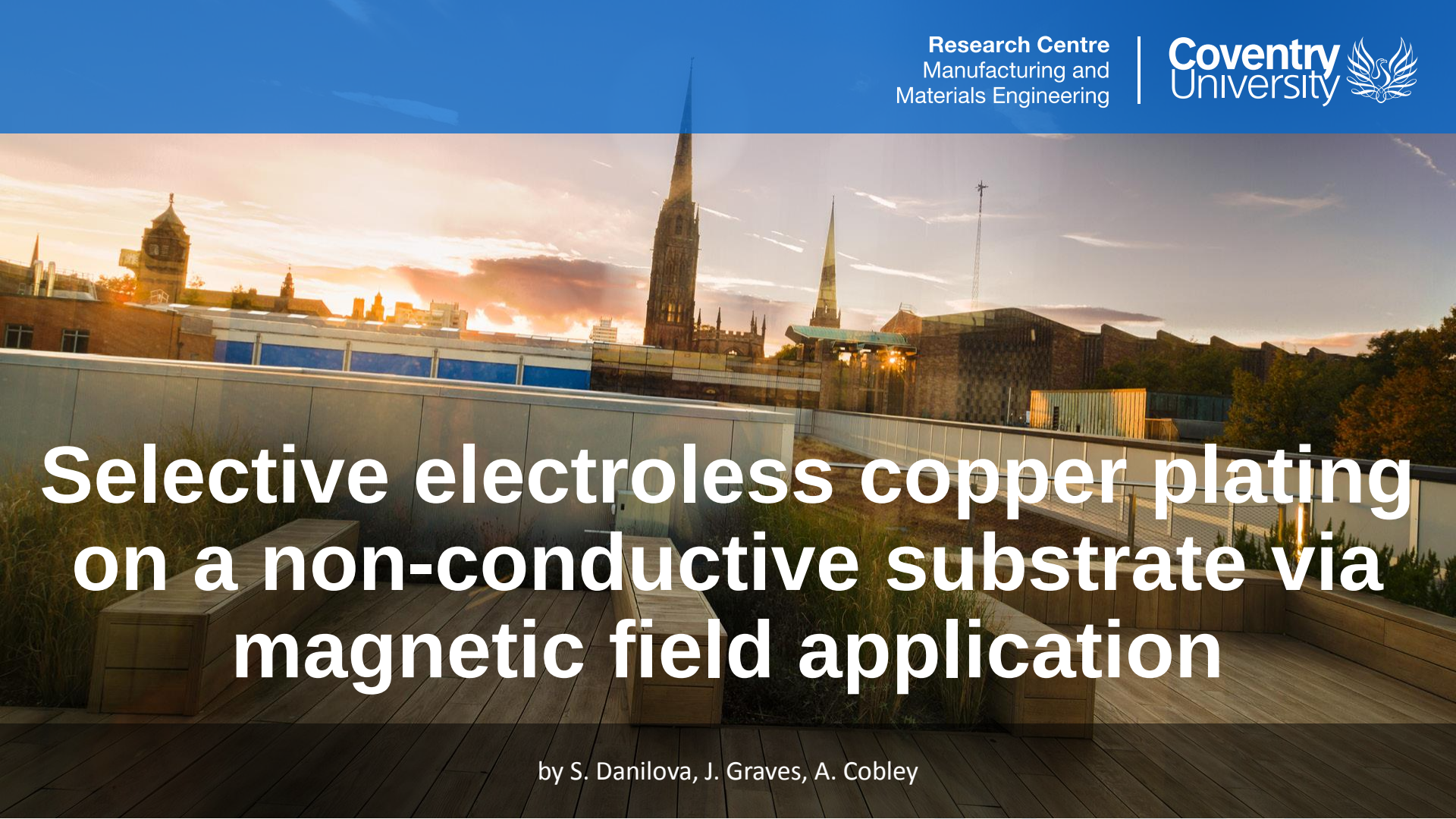

Selective electroless copper plating on a non-conductive substrate via magnetic field application

by S. Danilova, J. Graves, A. Cobley

The Importance of Selective Metallisation in the Electronics Sector

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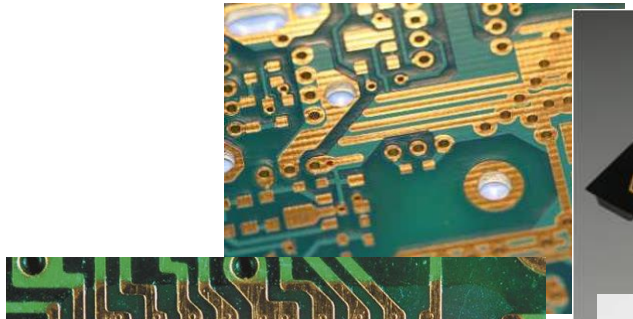
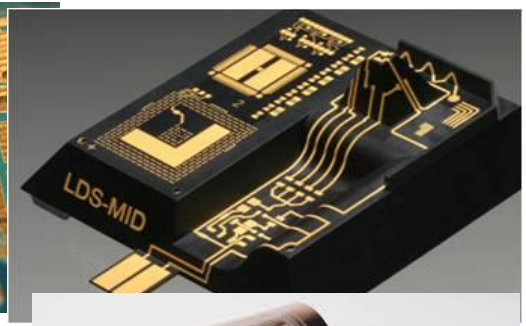
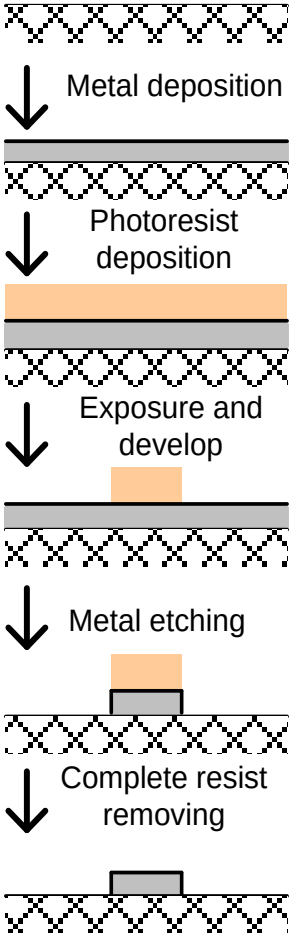
- Printed Circuit Boards
- Molded Interconnect Devices
- Micro-electronics
- Printed Electronics
- Wearable Technology
- RFIDs
- ……and many more





Photolithography



30-40% of total electronic device manufacturing cost is due to photolithography!

Photolithography steps:

- spinning photoresist,
- pre-bake,
- exposure,
- development,
- post bake,
- etch,
- photoresist strip

Main disadvantages of photolithography:

- requires heating;
- use hazardous chemicals;
- requires qualified staff;
- high material waste due to entire surface coating
- high cost
- long process

Novel technology

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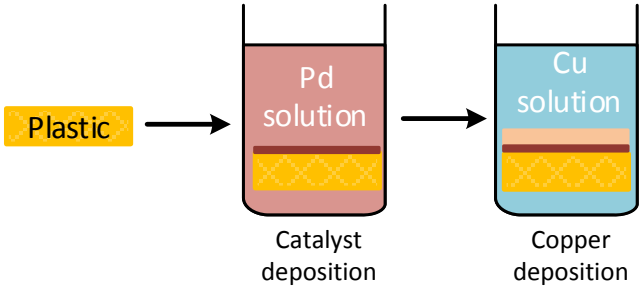
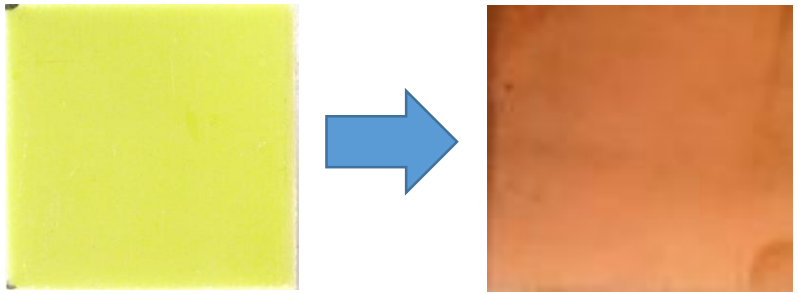
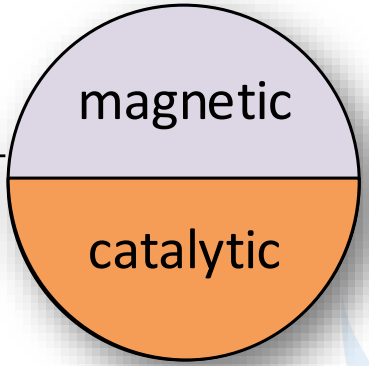
Standard process



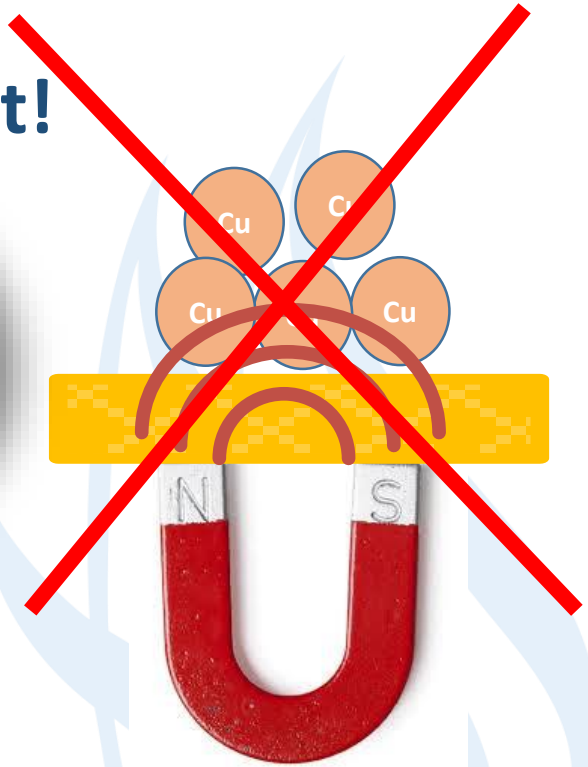
$$Cu^{2+} + 2HCHO + 4OH^{-} \rightarrow Cu + 2HCOO^{-}$$



Novel catalyst!



The idea



Magnetic catalyst

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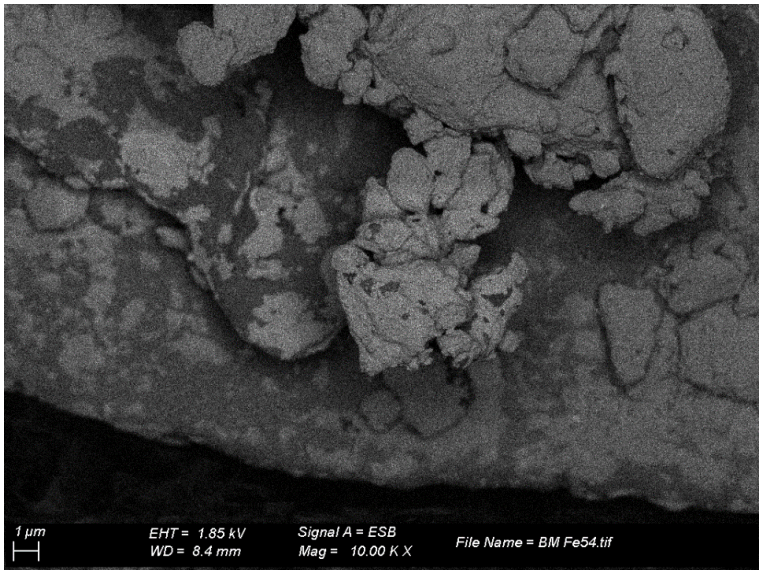
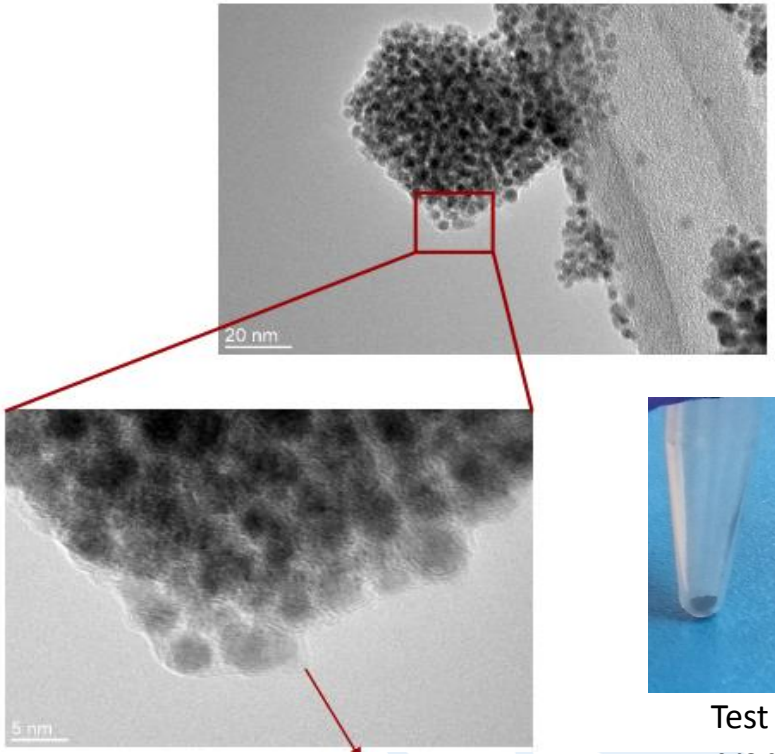
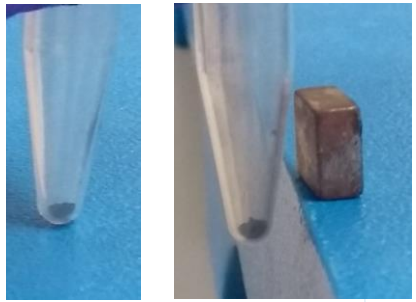
Synthesis 1. Ball milling Fe with Ag



Scanning electron microscopy images of Fe-Ag composite

Synthesis 2. FePd nanoparticles from "Jožef Stefan" Institut, Ljubljana, Slovenia





Test of magnetic properties of particles

Magnetic catalyst

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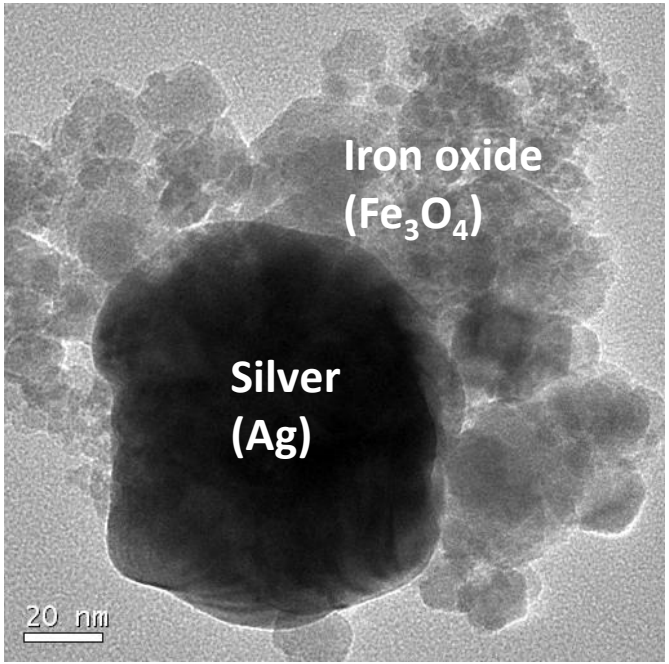
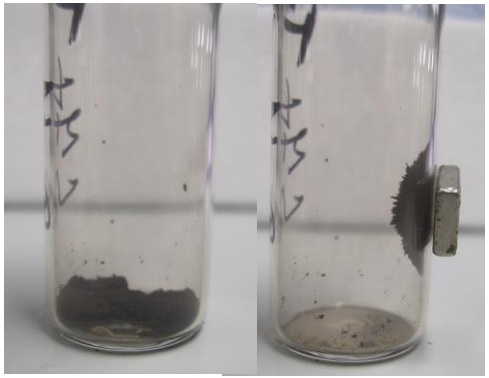
Synthesis 3. Wet-chemical synthesis of Fe_3O_4-Ag composite with arginine as a reducing agent

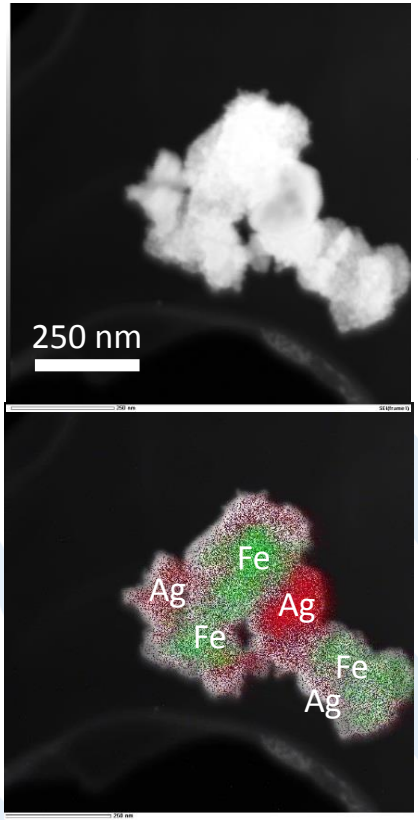


Transmission electron microscopy image of novel catalyst



Test of magnetic properties of particles

Synthesis 4. Wet-chemical synthesis of Fe_3O_4-SiO_2-Ag composite with tin as a reducing agent



Scanning transmission electron microscopy image of novel catalyst with energy dispersive X-ray spectroscopy data of elements distribution

- Silver (Ag)
- Iron (Fe)

Proof of concept

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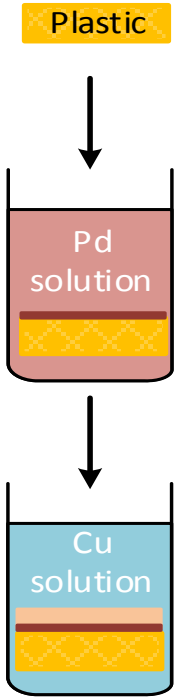
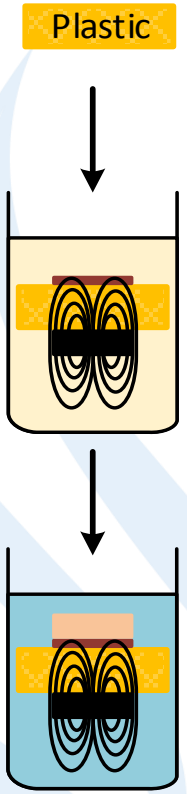
Standard procedure



Video

Modified procedure



Optimisation of catalyst deposition

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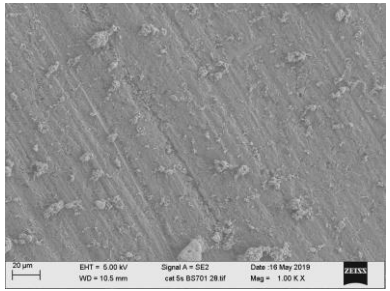
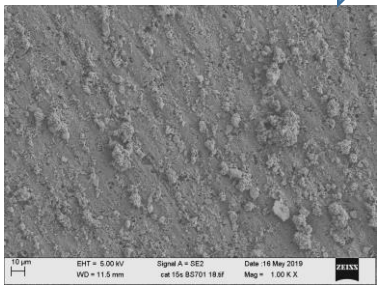
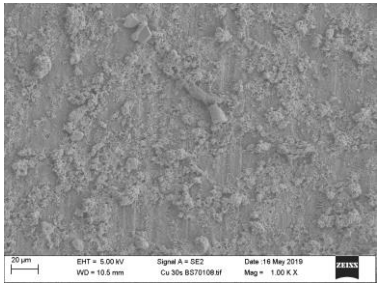
Time of catalyst deposition

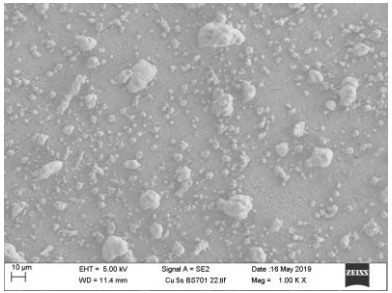
Catalyst

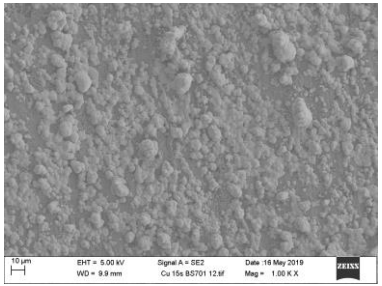
Electroless copper

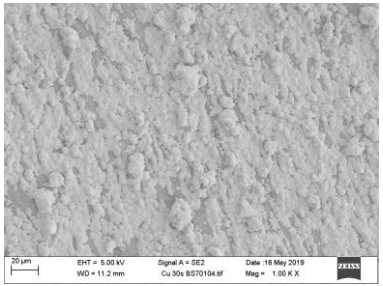




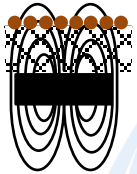




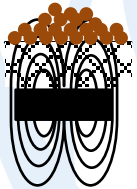


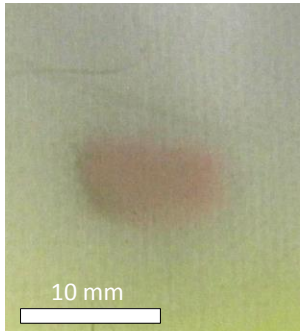


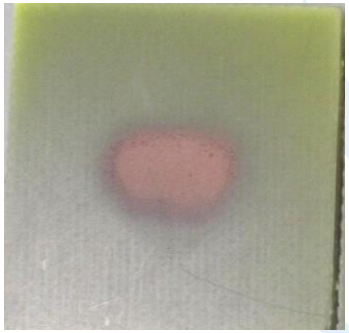
Desired catalyst deposition



Excessive catalyst deposition







Optimisation of catalyst deposition

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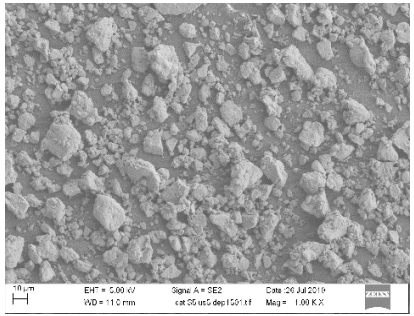
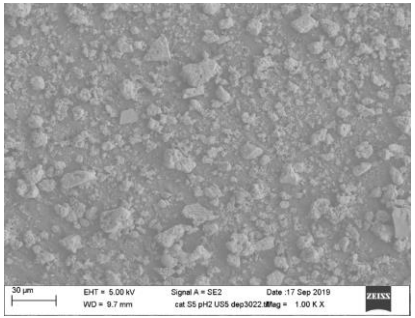
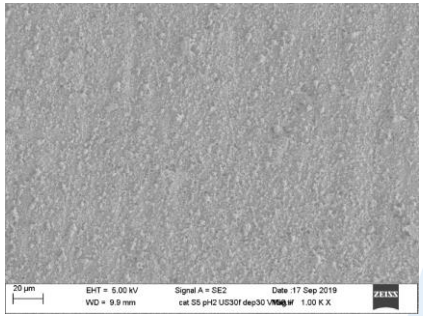
pH=7 | pH=2 | pH=2 with filtration

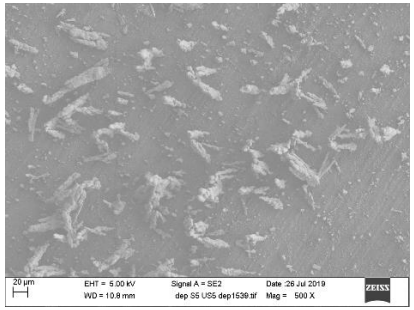
Catalyst

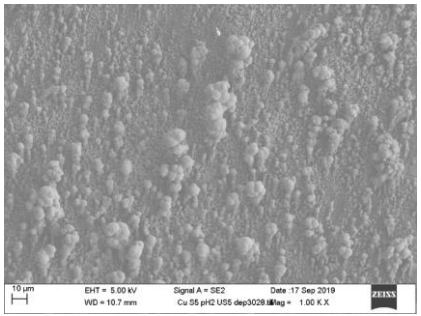


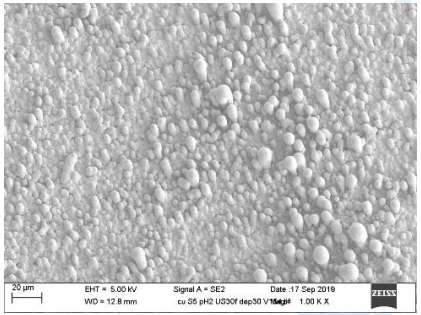




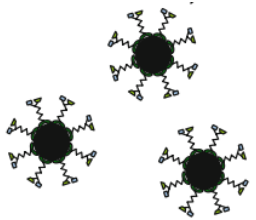
Electroless copper



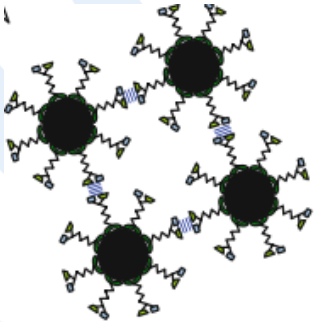




pH=2



pH=7



Magnetic template fabrication

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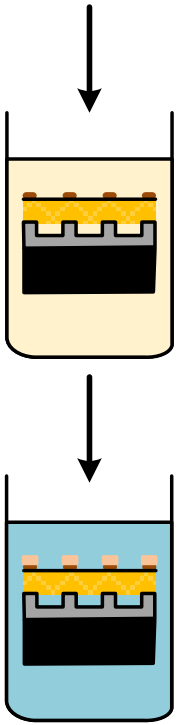
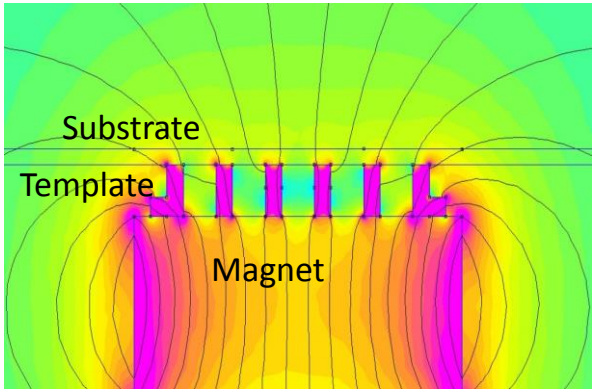
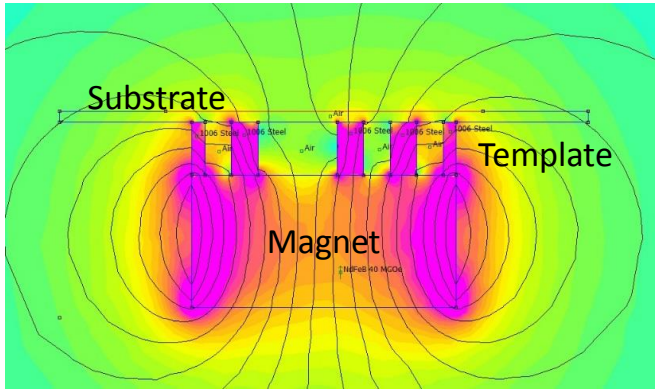
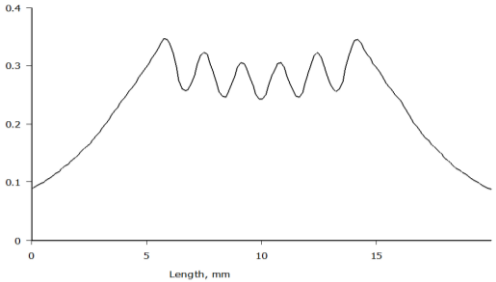
Plastic

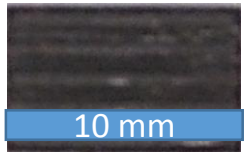


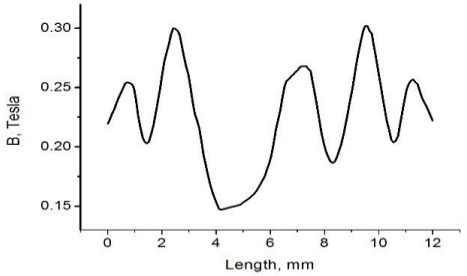
Simulations of magnetic field distributions made in FEMM software

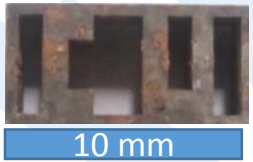












Selective deposition

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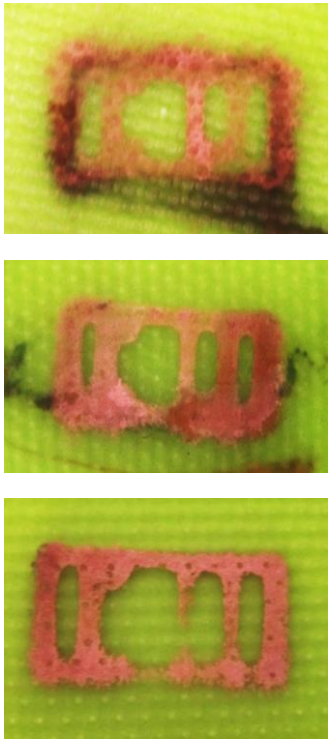
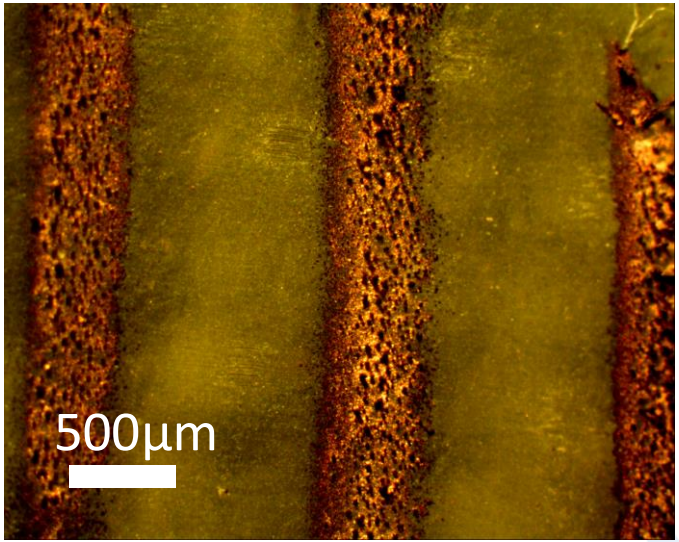
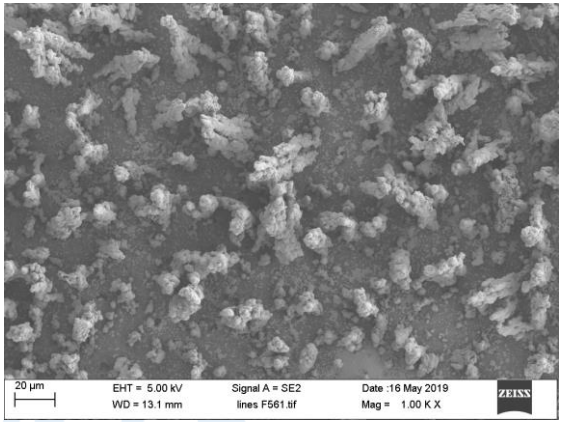
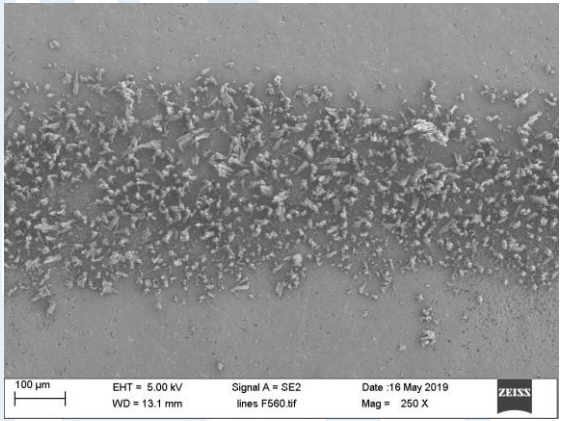
Digital photos of selectively deposited copper



Optical microscopy images of selectively deposited copper







Scanning electron microscopy images of selectively deposited copper

Optimisation of magnetic template

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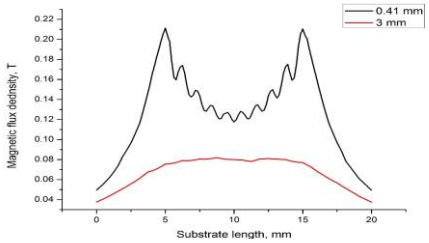
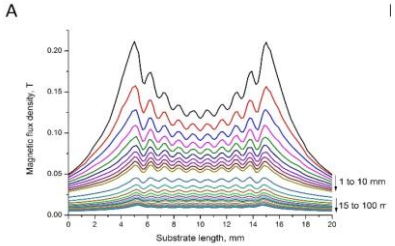
Parameters influence magnetic flux density distribution:

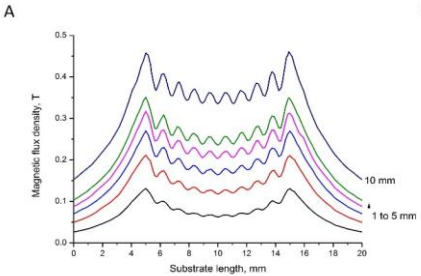
- thickness of the substrate



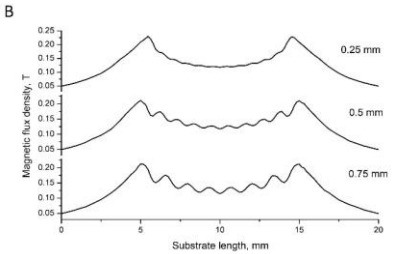
- height of the template

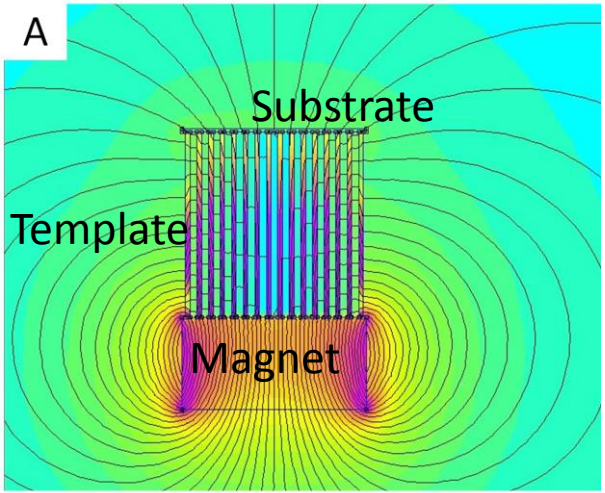


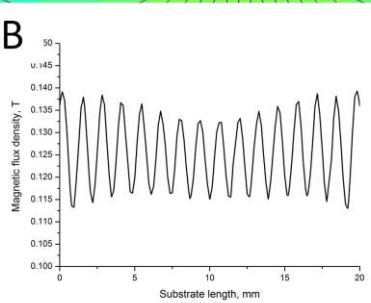
- size of magnet



- distance between lines







20x19.25x19.25 cm;
Lines thickness – 0.5 mm

Selective deposition

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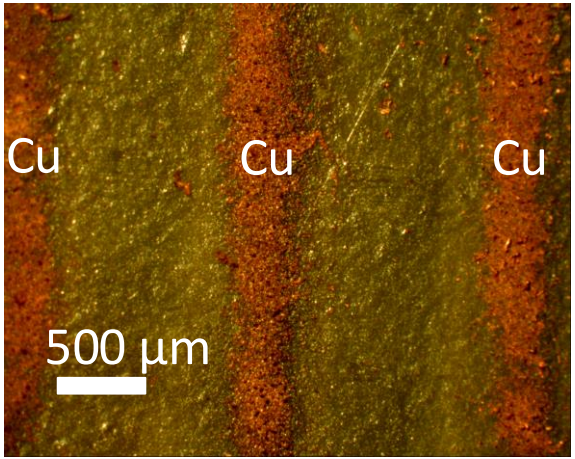

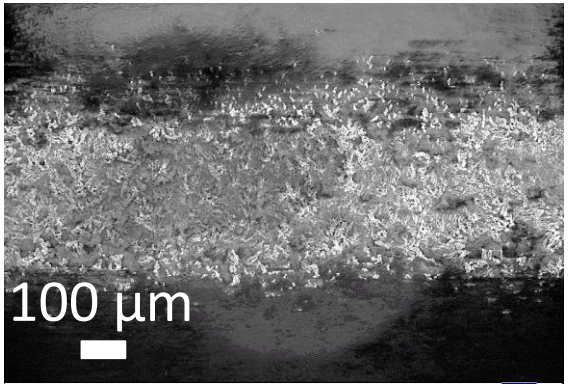

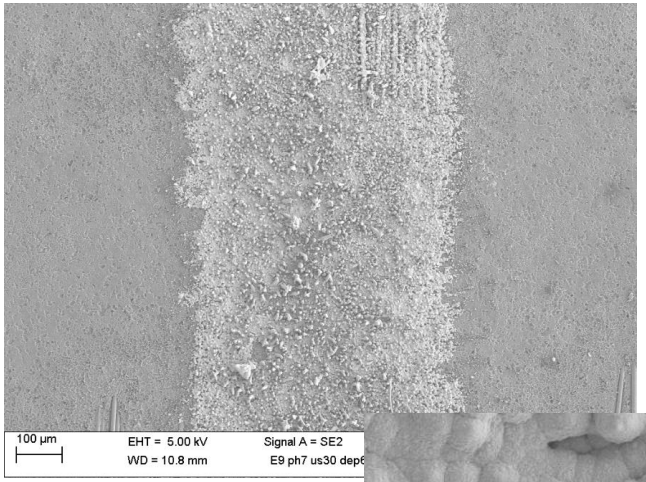

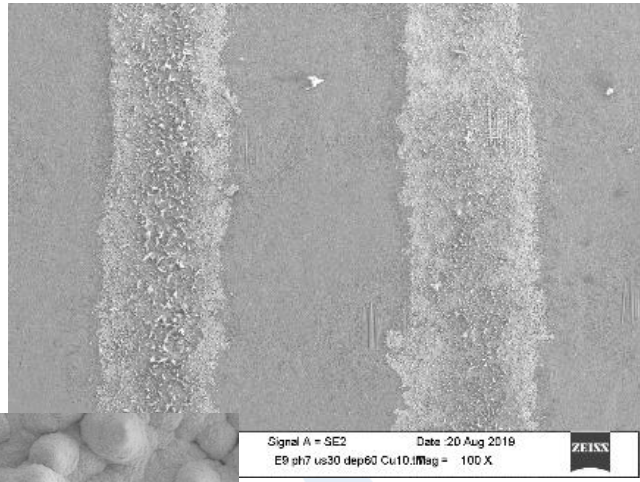

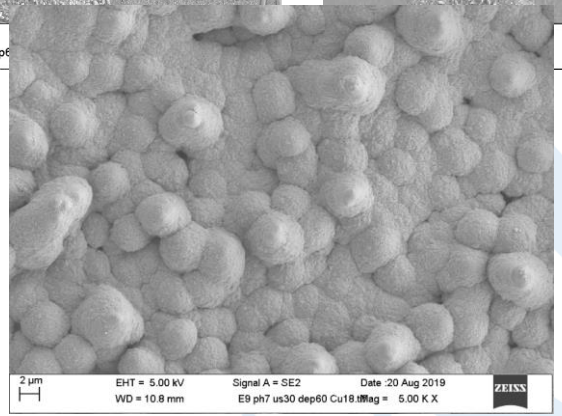

Scanning electron microscopy image of deposited copper line

Conclusions

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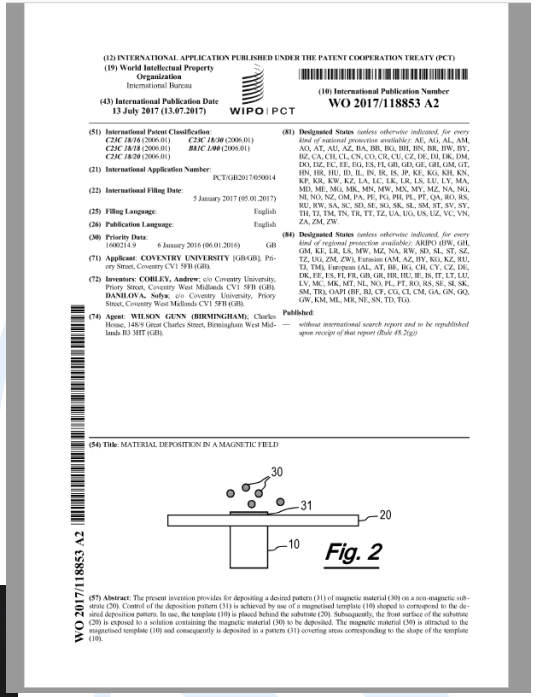
1) In 3 years the research was taken from idea to proof of concept;
2) A novel magnetic catalyst was created;
3) Selective metal deposition was achieved with micron scale features;



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(54) Title: MATERIAL DEPOSITION IN A MAGNETIC FIELD

Fig. 2

(57) Abstract: The present invention provides for depositing a desired pattern (31) of magnetic material (30) on a non-magnetic substrate (20). Control of the deposition pattern (31) is achieved by use of a magnetised template (10) shaped to correspond to the desired deposition pattern. In use, the template (10) is placed behind the substrate (20). Subsequently, the front surface of the substrate (20) is exposed to a solution containing the magnetic material (30) to be deposited. The magnetic material (30) is attracted to the magnetised template (10) and consequently is deposited in a pattern (31) covering areas corresponding to the shape of the template (10).

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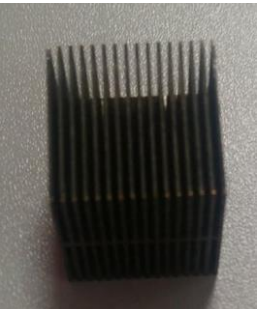

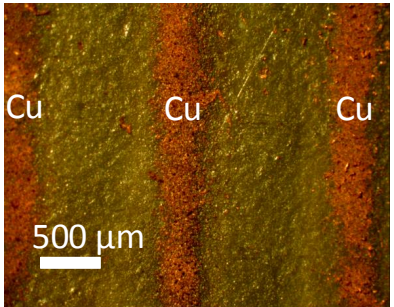

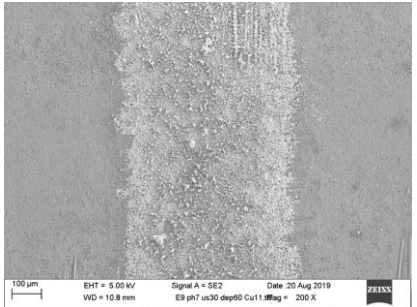

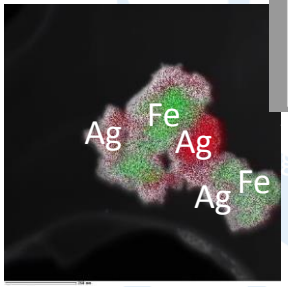

Future work

The main goal – Selectively deposit Cu in sub micron patterns by

1) Create monodispersed magnetic nanoparticles;
2) Continue work on template modelling by using 3D simulation software;
3) Optimisation of catalyst and Cu plating conditions

Conclusions

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	Photolithography	Patterning by magnetic field
"Patterning" temperature	120 C	46 C
High cost equipment	Yes	No
Amount of steps required	7	0 (patterning during metal deposition)
Cost of catalyst in GBP per gram	30	<1
Produced waste	• Organics for photoresist removal • Removed metal during "patterning"	None Catalyst can be recovered by magnets and reused

Patterning by magnetic field can potentially reduce cost by 30% and production time by 50%!!!

Thank you!

Any Questions?