Hybrid Spinterfaces for Organic Antiferromagnetic Spintronics

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SINFONIA

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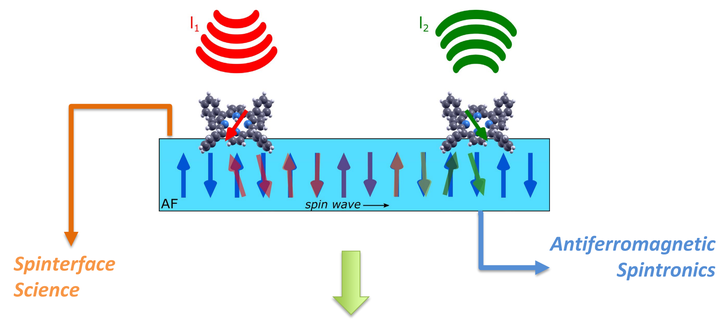
SINFONIA - Selectively activated INFOrmation technology by hybrid Organic Interfaces

SINFONIA is an interdisciplinary research project that envisions a technology allowing to store and transport information on the nanometer length scale and at operational frequencies in the THz regime



Conversion of an optical stimulus in a spin wave (and vice versa) with extreme spatial and temporal resolutions

Objective

*Exploitation of the hybridized states created at the interface between a **molecular system** and an **antiferromagnet** to **entangle light** with **spin waves***

essential breakthroughs

The use of AntiFerromagnets (AF)
THz magnonics
No stray fields
No charge currents when using insulators

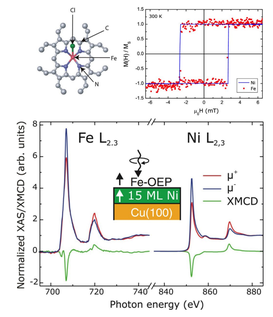
The versatility of molecules
Several molecules → functionalities (both at the interface and w.r.t. interaction with light) → tailoring
Possibly small amount of materials/production costs

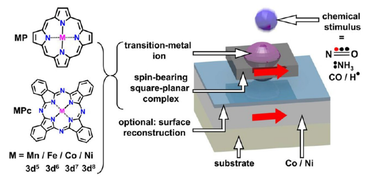
The realization of optically controlled devices
No electrical contacts
Exploiting the local nature of the coupling (molecular level) to obtain downscaling

Metal Porphyrins and magnetism

- ✓ Metal porphyrins/phtalocyanines can show a magnetic ordering when coupled to ferromagnetic substrates
- ✓ The magnetic response can be tuned by using **coordination-chemistry**
  → interaction with the substrate or with adsorbed molecules

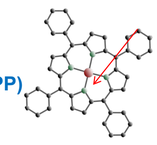
Fe-OEP on Ni - H. Wende JESRP **189** (2013) 171





Ballav *et al.* J. Phys. Chem. Lett. **4** (2013) 2303

our case study

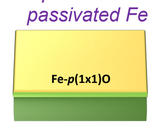


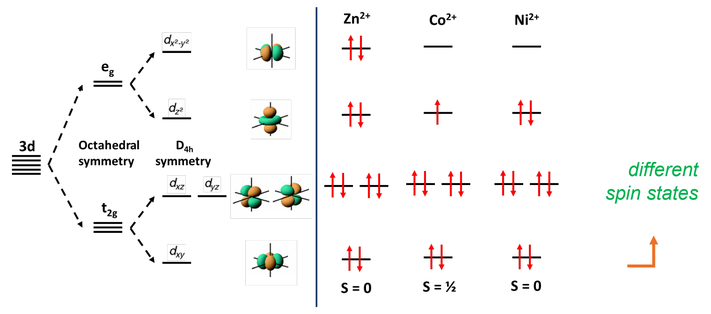
Zn^{2+}, Co^{2+}, Ni^{2+}…

Metallo-Tetraphenyl Porphyrins (M-TPP)

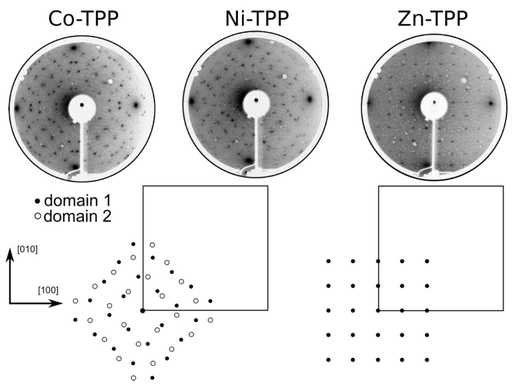
- Flat morphology: macrocycle + 4 phenyl groups
- Central metal ion with 2+ valence state

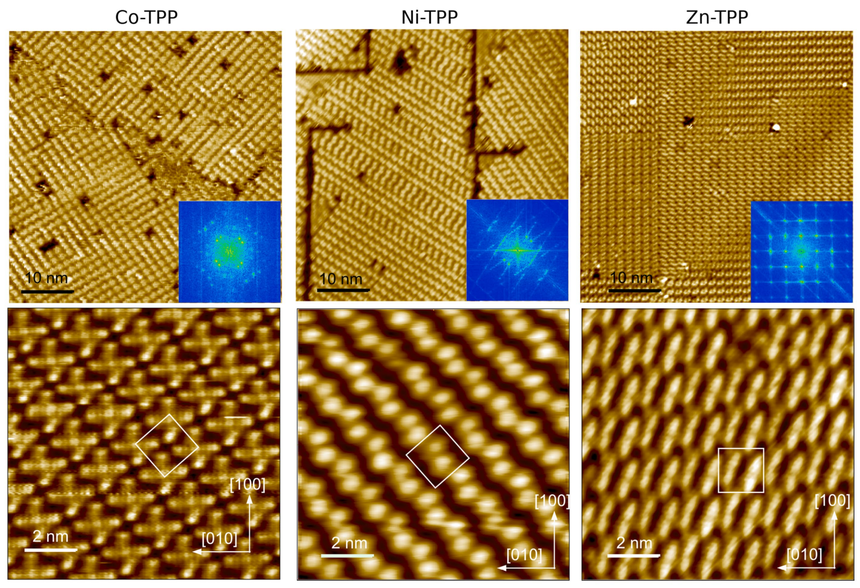
…deposited over passivated Fe





Growth of different porphyrins on Fe-*p*(1x1)O





LEED patterns (beam energy 55 eV) for 1 ML of Co-TPP (left), Ni-TPP (middle) and Zn-TPP (right) deposited on Fe(001)-*p*(1 × 1)O.
The intense spots visible in the screens' periphery arise from the Fe(001)-*p*(1 × 1)O surface.

2 (5x5) domains oriented at ± 37°

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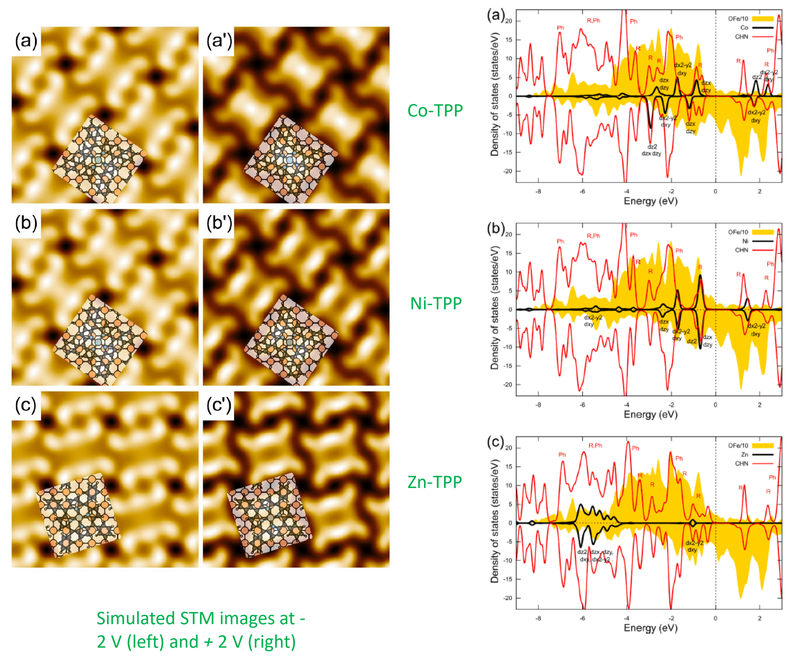
(5x5) reconstruction

G. Albani et al. Micromachines (2021) **12**, 191

G. Fratesi et al. Appl. Surf. Sci. **530** (2020) 147085

A. Calloni et al. Appl. Surf. Sci. **505** (2020) 144213

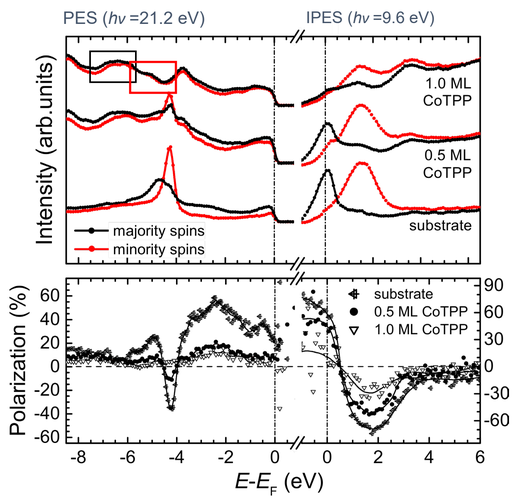
Simulations of M-TPP/Fe-*p*(1x1)O interfaces



Simulated STM images at -2 V (left) and + 2 V (right)

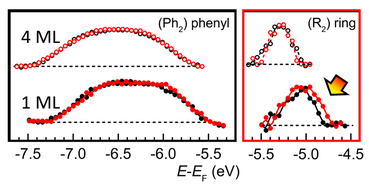
G. Fratesi et al. Appl. Surf. Sci. 530 (2020) 147085

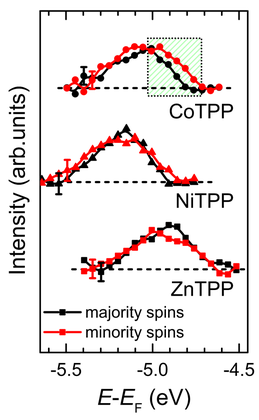
Co-TPP on Fe(001)-*p*(1x1)O – magnetic ordering



- ✓ Spectral polarization is dominated by the presence of the FM substrate
- ✓ We investigate the spin polarization of the molecular states we move away from E_F in a region which is **structureless @ 1ML**

Negative polarization signal on R_2 ⇨ **Magnetic behavior @ RT**





27 Co	28 Ni	29 Cu	30 Zn

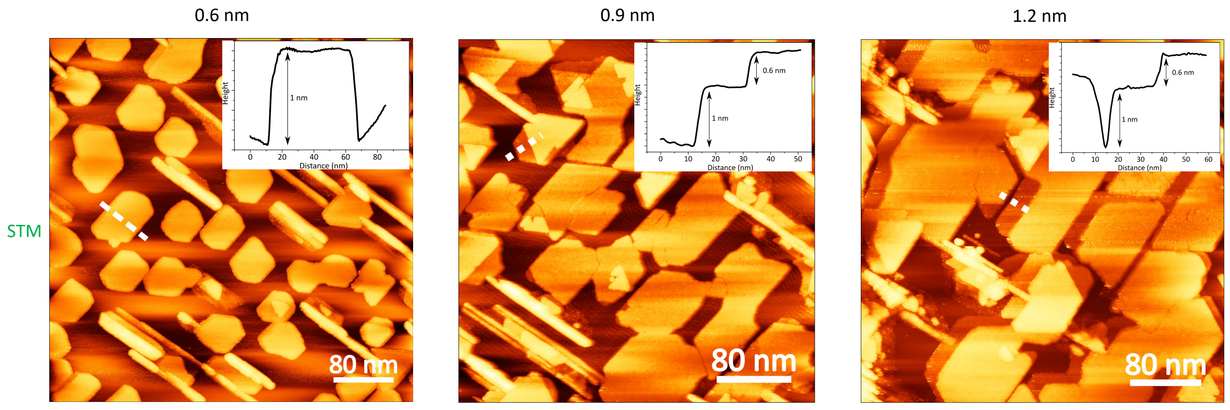
d_{z2} orbital are fully occupied: **S = 0**

3*d* states

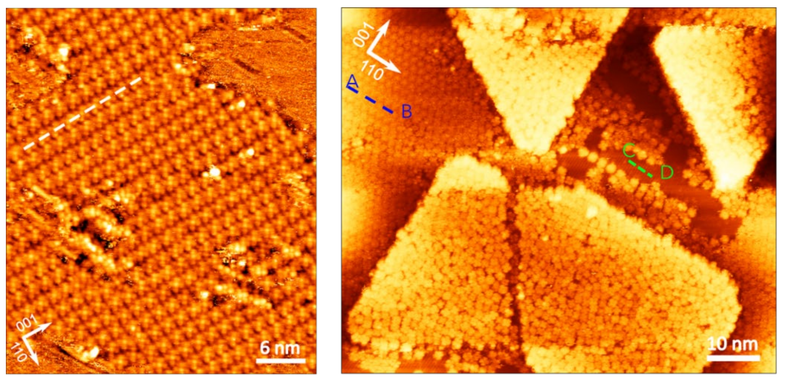
M. S. Jagadeesh et al., Appl. Phys. Lett. **115**, 082404 (2019)

Growth of Cr_2O_3 on Cu(110)

P_{O2} = 1x10^{-6} mbar, T_{growth} = 430 °C



1 ML FePc/ Cr_2O_3/Cu(110): morphology



FePc – Iron phthalocyanine

Ongoing works and perspectives

- Magnetic properties (synchrotron, magneto-optics)
- Porphyrins on NiO
- Study magnon generation and transport in the AF layers

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