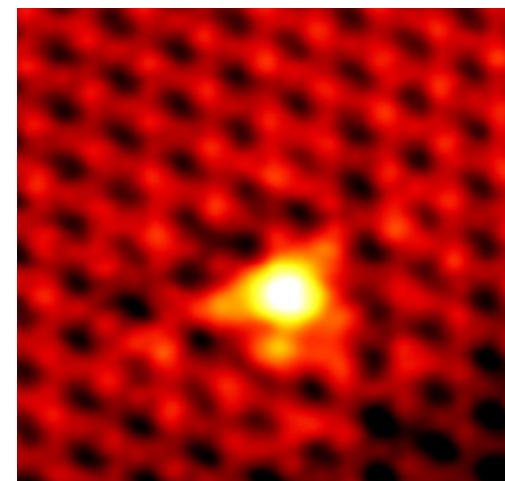
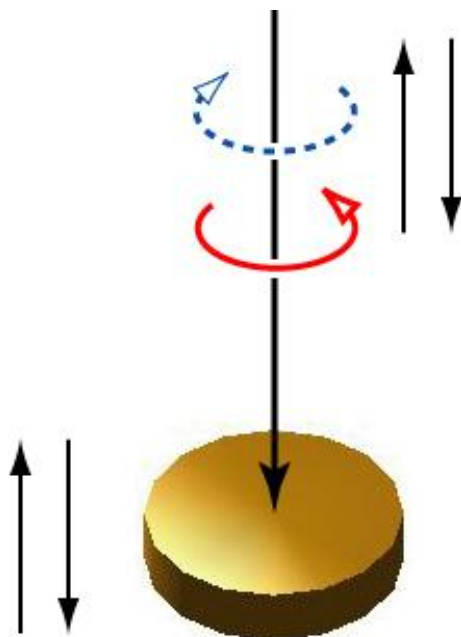
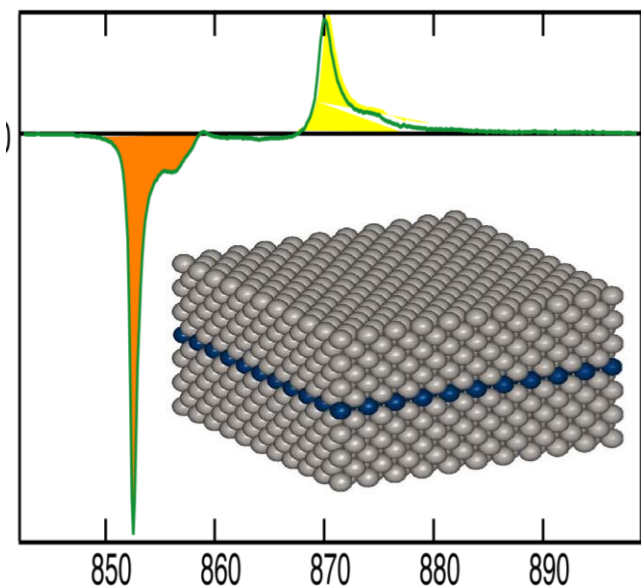


スピントロニクス材料の軟X線 内殻吸収磁気円二色性

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PMA in Pd/Co(1ML)/Pd(001)

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澤田正博、島田賢也、生天目博文

Fe 3d moments in Fe₄N film, Magnetic impurity on 3D topological ins. -- Co/Bi₂Se₃ --

- ◆ 筑波大学 伊藤啓太、原田一範、末益崇
- ◆ 産総研 秋永広幸
- ◆ 日本原子力研究機構 (JAEA) 竹田幸治、斎藤祐児
- ◆ 広島大学大学院理学研究科
叶茂 (Co/Bi₂Se₃)、黒田健太、岡本和晃、谷口雅樹

内殻吸収磁気円二色性(XMCD)分光

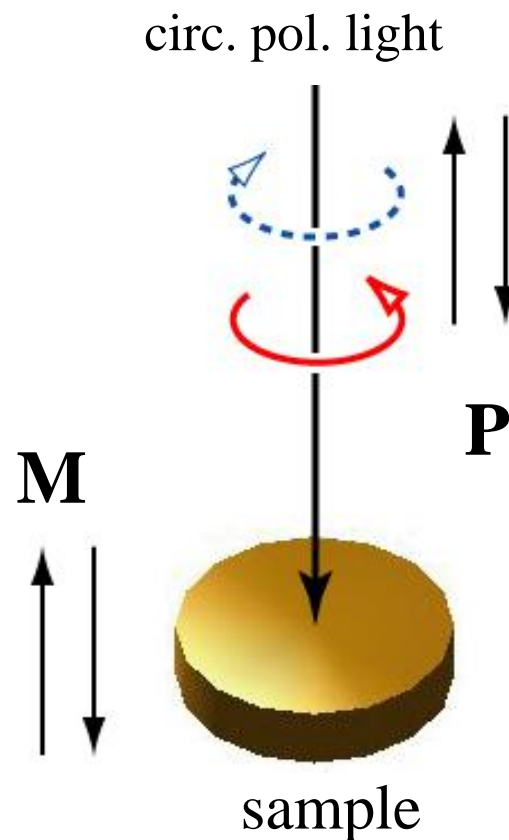
内殻吸収磁気円二色性(XMCD)分光

- 内殻吸収
- 元素選択的なスピン・軌道磁気モーメントの定量評価

磁性体の磁気モーメントを探る標準ツール

円偏光スイッチングの利点

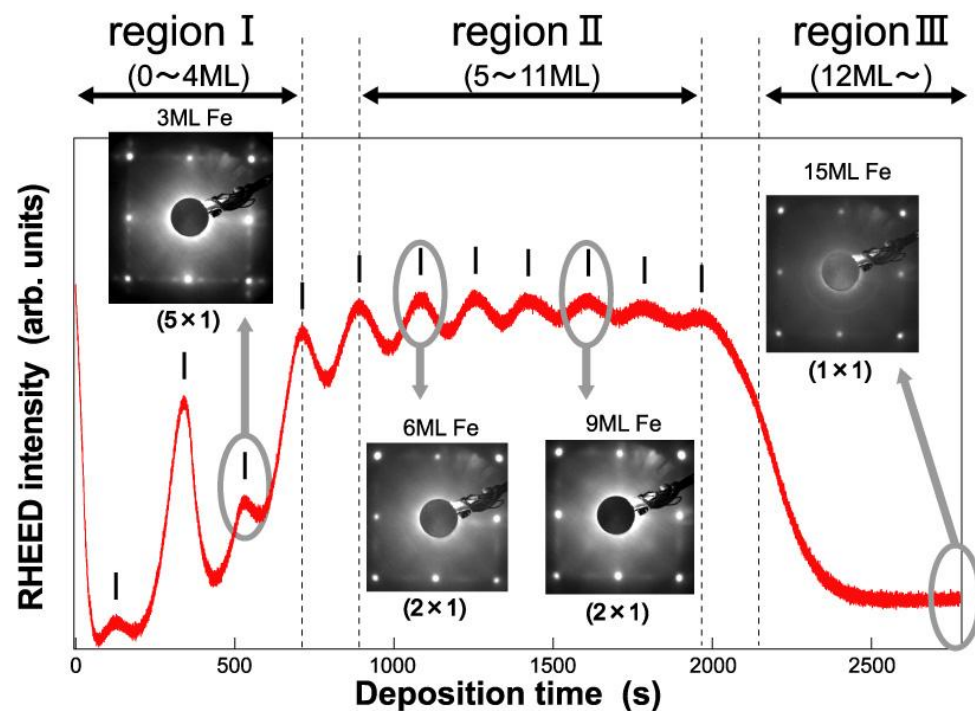
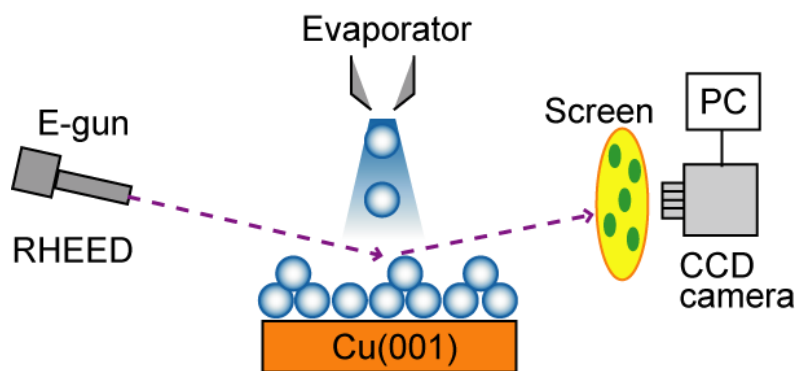
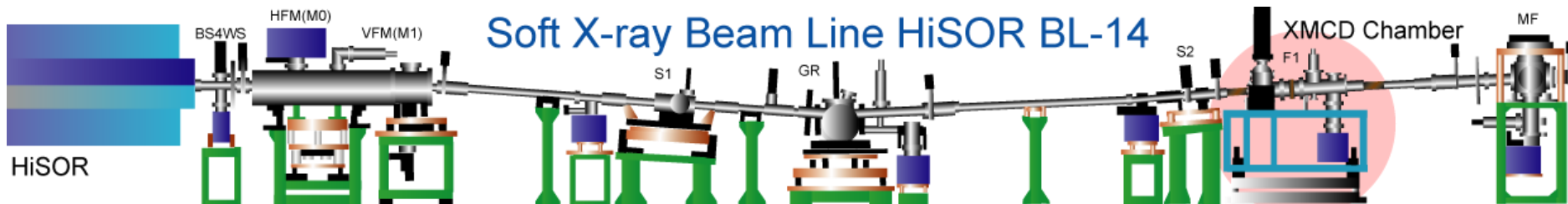
- 測定精度の向上
- 微小磁気モーメント(微小磁性体, 非磁性元素)
- マクロな磁化が無い磁性体への適用



$$\mathbf{M}\uparrow\mathbf{P}\uparrow \equiv \mu_+$$

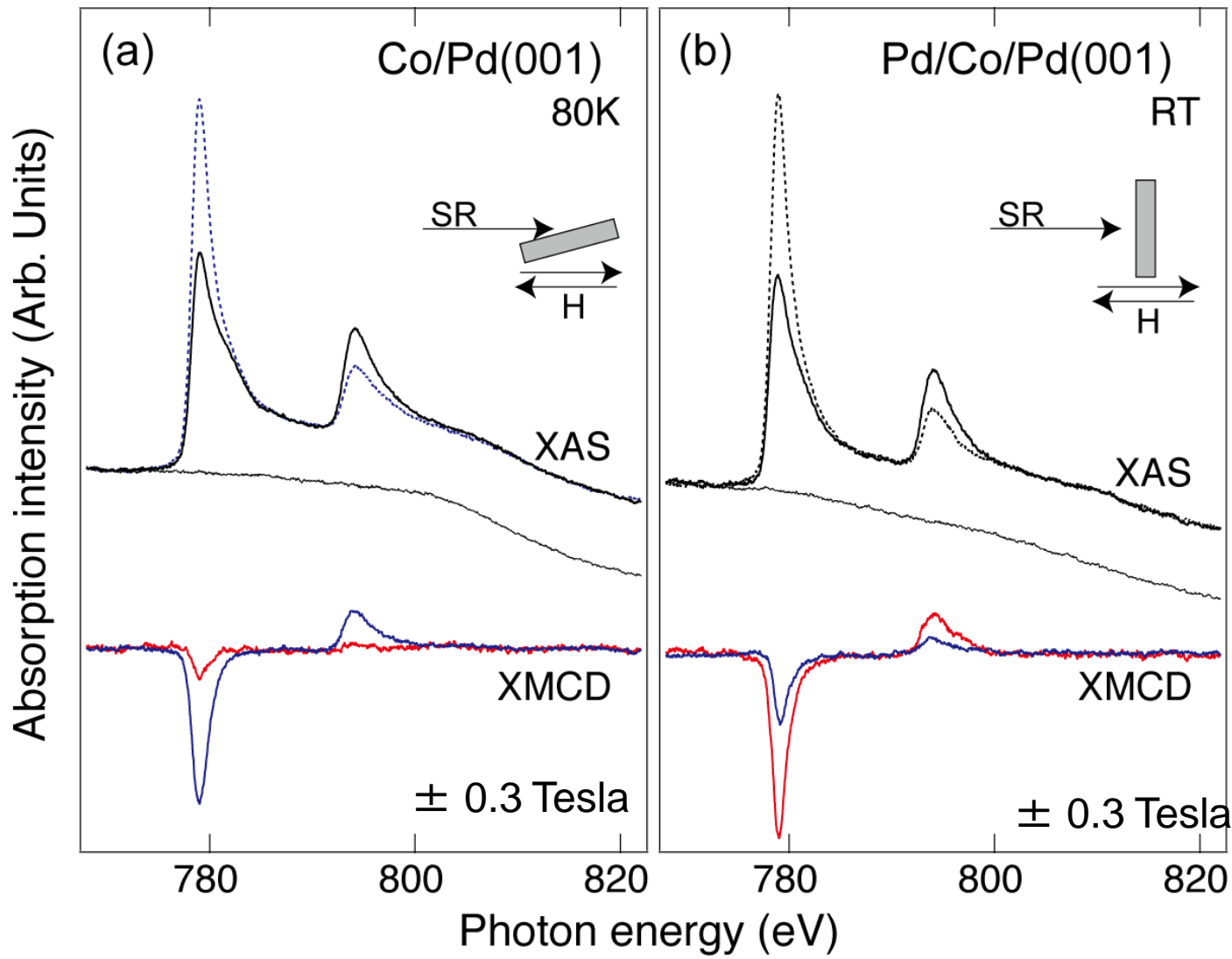
$$\mathbf{M}\downarrow\mathbf{P}\uparrow \equiv \mu_-$$

HiSOR BL14: Science for Nanomagnetism



澤田正博(放射光科学研究センター)

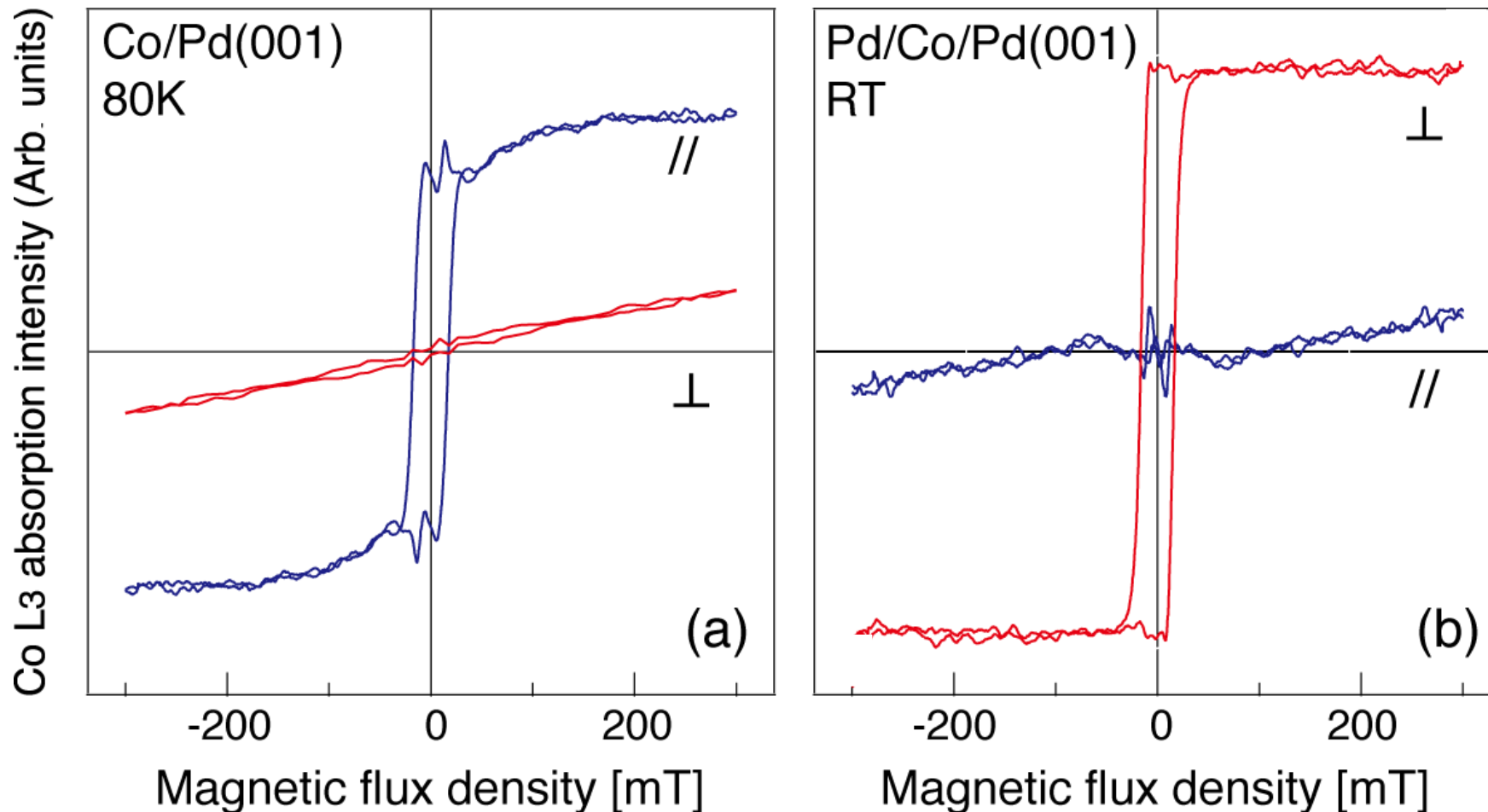
XAS & XMCD spectra of Co/Pd and Pd/Co/Pd



Sum-rule analysis for Pd/Co(1ML)/Pd(001)

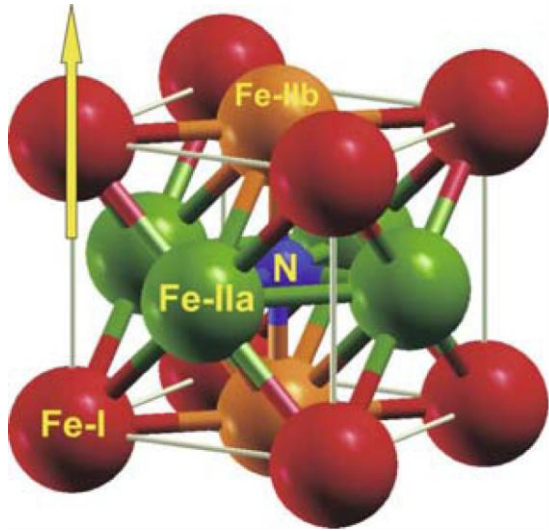
$m_{\text{spin}} = 2.16 \pm 0.12 \mu_B$ $m_{\text{orb}}^z = 0.46 \pm 0.05 \mu_B$ ($n_h = 2.49$)

M. Sawada et al., J. Elec. Spectrosc. Relat. Phenom **184** (2011) 280.

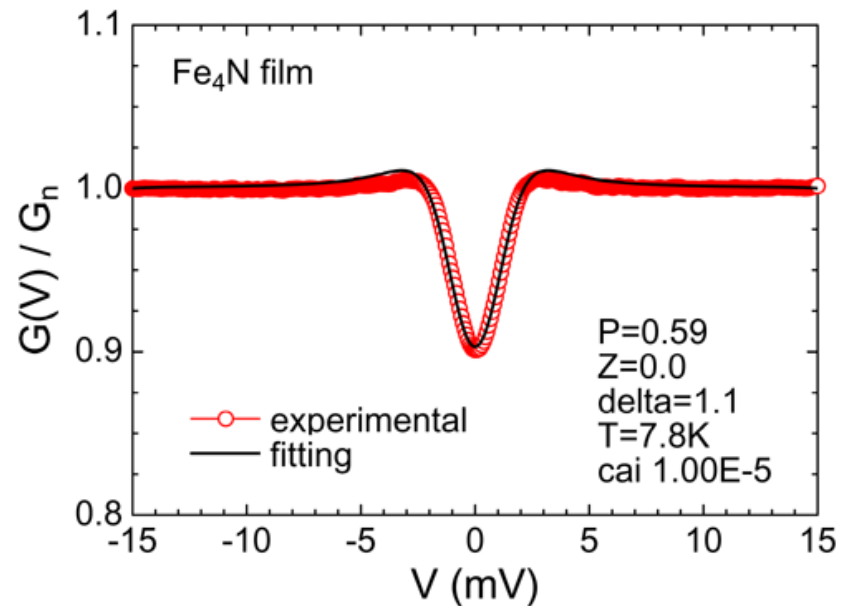
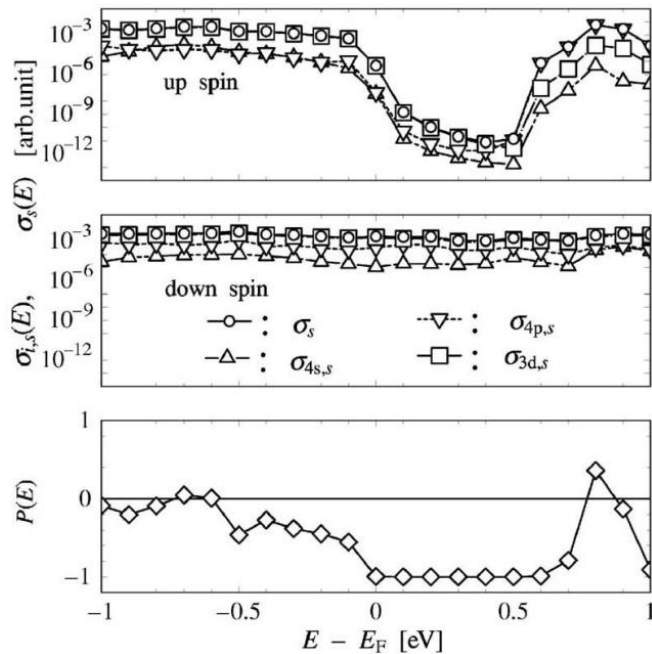


PMA is stable at RT for Pd/Co/Pd(001)

γ' -Fe₄N as a promising highly spin pol. material

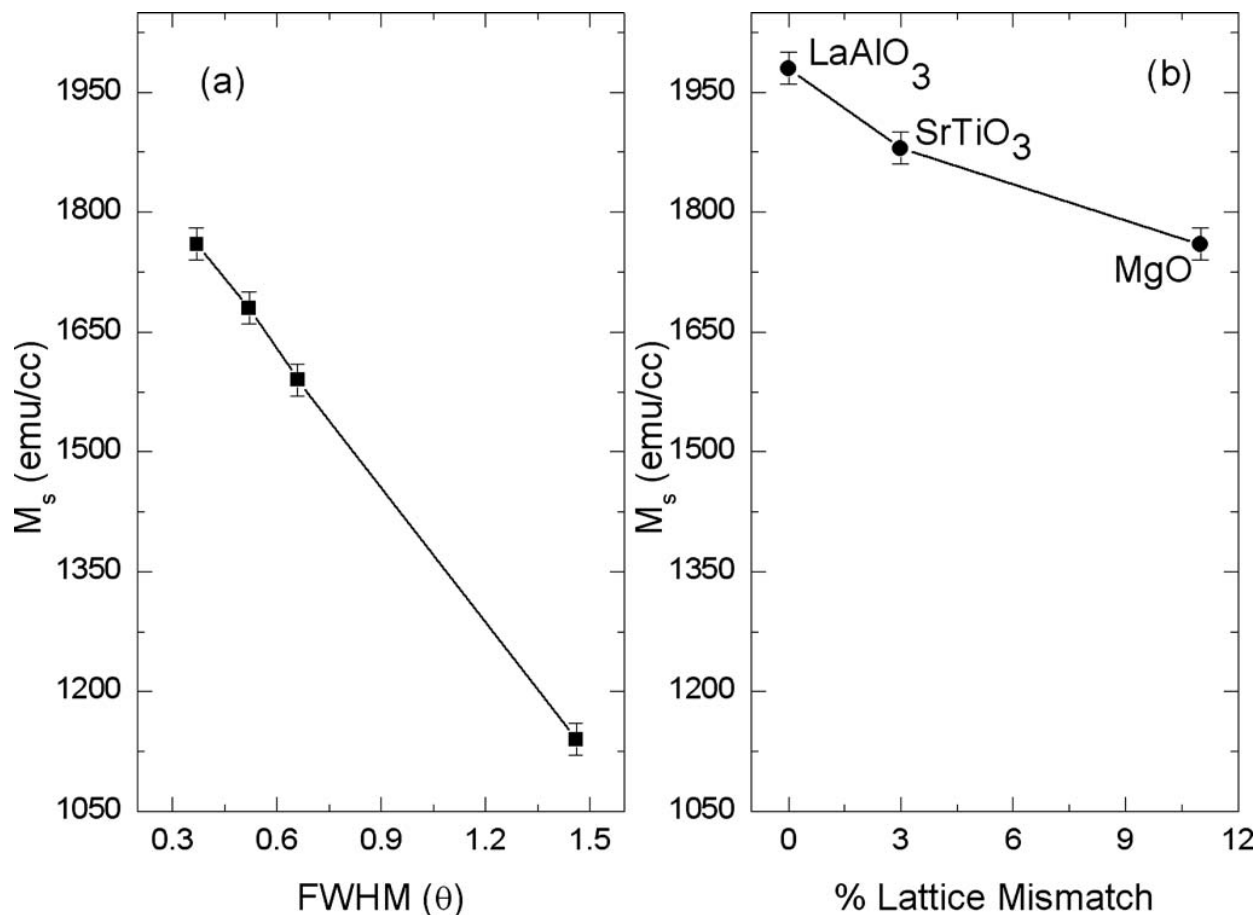


- Cubic perovskite ($a=0.3795\text{nm}$)
Small mismatch with Si (1.3%)
- Ferromagnetic below $T_c=767\text{K}$
Large negative spin polarized conductance is predicted and PCAR shows a finite spin pol.

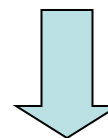


M_S v.s. lattice mismatch for γ' -Fe₄N (VSM)

S. Atiq *et al.*, Appl. Phys. Lett. **92** (2008) 222507.



55nm Fe₄N/LaAlO₃,
 $M_S > 1900$ emu/cc



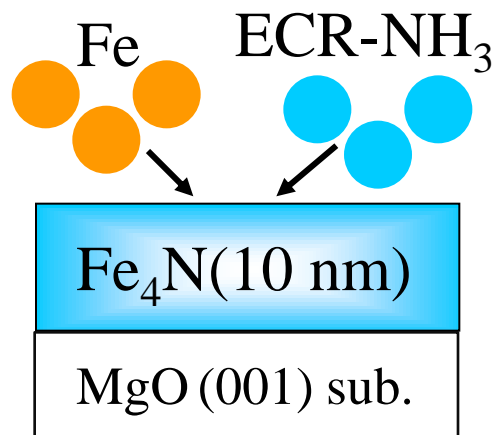
$$2.9\mu_B/\text{Fe}$$

True?

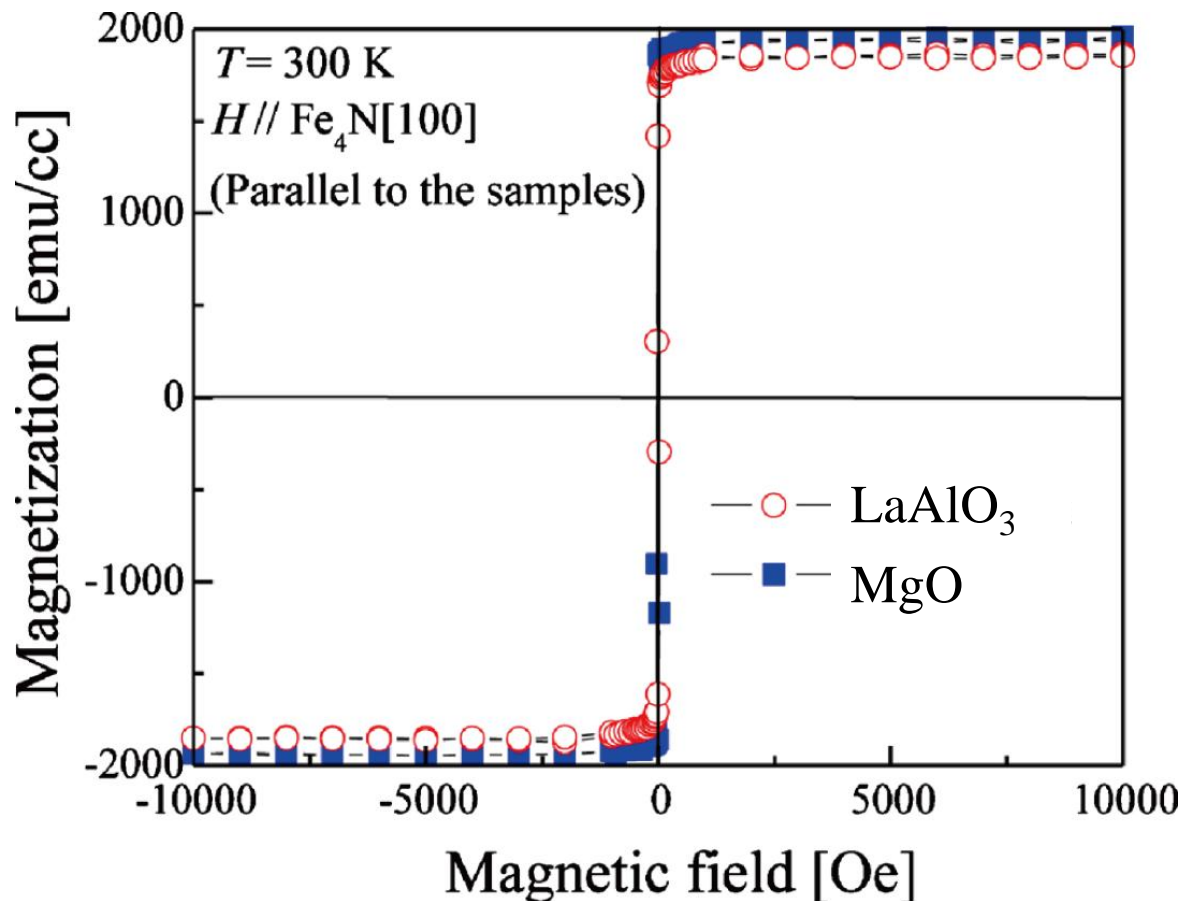
Magnetic volume error
would be easily involved
in evaluation of M_S .

M_S increases as the lattice mismatch is smaller.

MBE grown high-quality Fe_4N film



Co-deposition of Fe
and ECR- NH_3



Fe_4N (10nm) / LaAlO_3 (001) [0% mismatch]

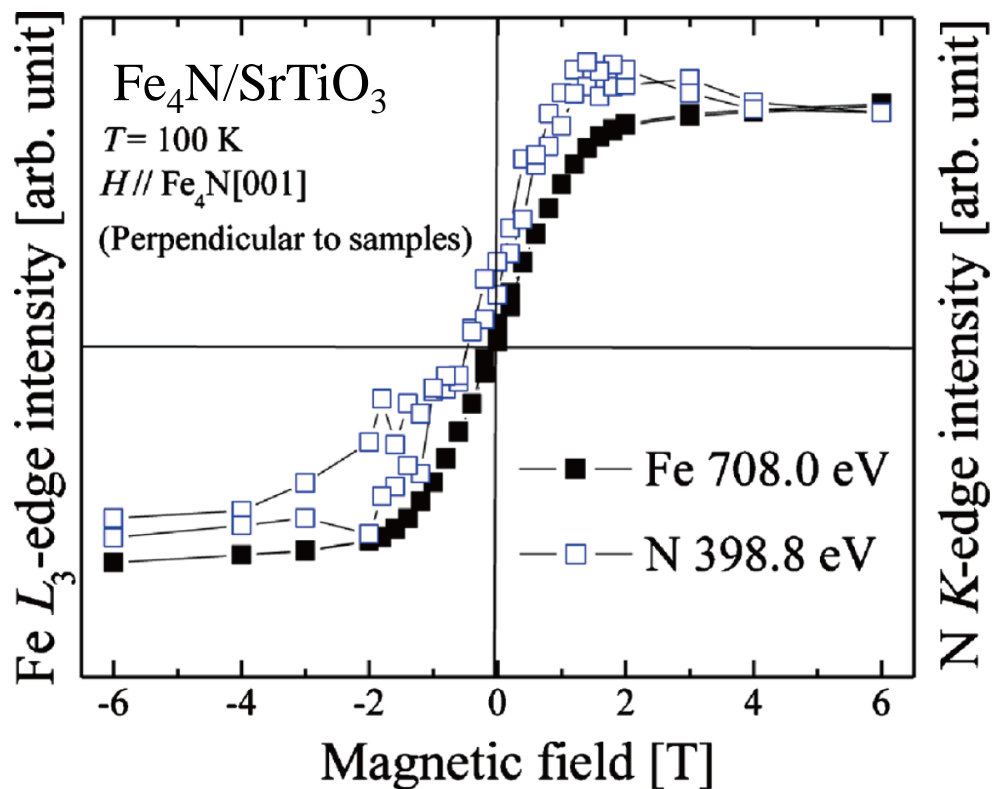
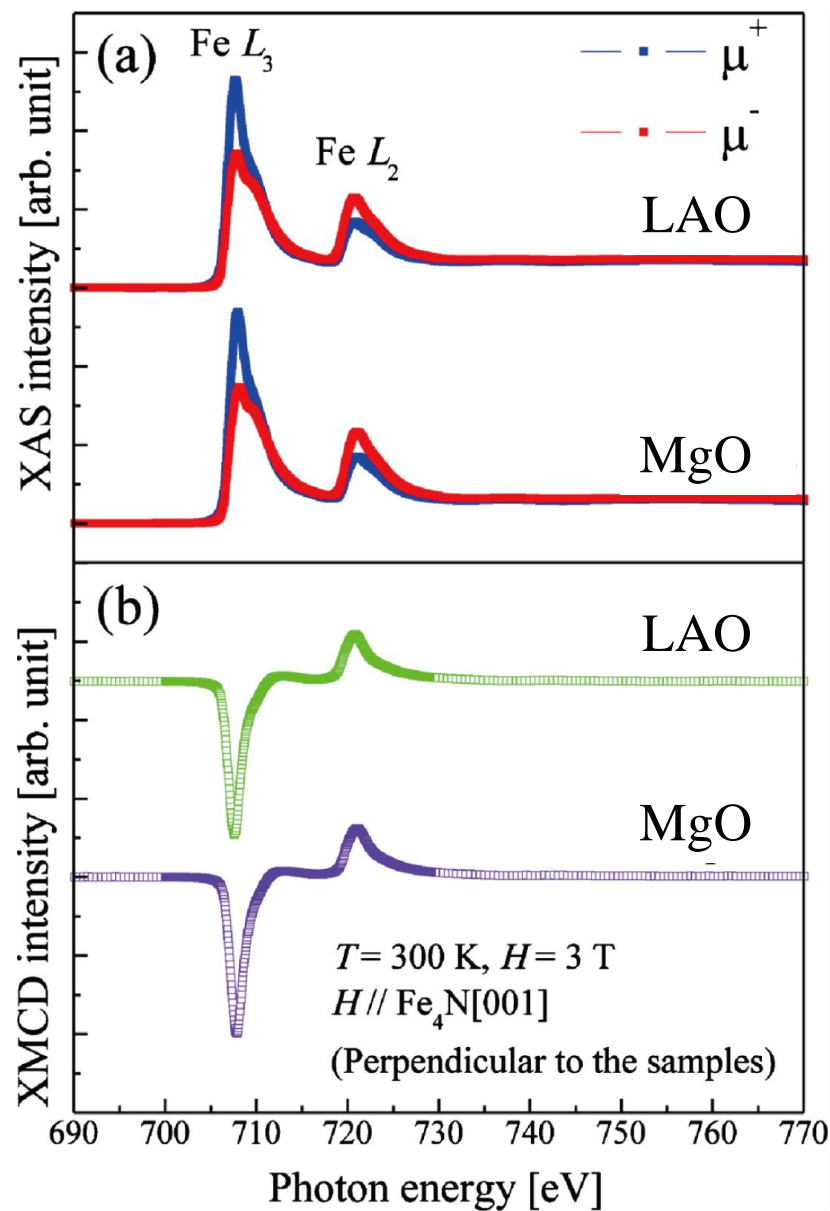
Fe_4N (10nm) / MgO(001) [11% mismatch]

Both are capped with 3nm thick Au film

伊藤啓太、末益崇(筑波大)

XAS and XMCD spectra of γ' -Fe₄N

K. Ito et al., Appl. Phys. Lett. **98** (2011)102507.



伊藤啓太、末益崇(筑波大)

Sum rule analysis of Fe 3d moments of γ' -Fe₄N

K. Ito et al., Appl. Phys. Lett. **98** (2011)102507.

Fe₄N(10nm) / LaAlO₃(001)

$$m_{\text{spin}} = 2.34 \mu_{\text{B}} \quad m_{\text{orb}}^z = 0.10 \mu_{\text{B}}$$

Fe₄N(10nm) / MgO(001)

$$m_{\text{spin}} = 2.35 \mu_{\text{B}} \quad m_{\text{orb}}^z = 0.12 \mu_{\text{B}}$$

Fe 3d hole number: $n_h=3.88$ cf. Y. Takagi et al., PRB **81** (2010) 035422.

Compounds	Magnetic moment (μ_{B} per Fe atom)		
	m_{orb}	m_{spin}	m_{total}
γ' -Fe ₄ N/LAO	0.102 ± 0.003	2.34 ± 0.06	2.44 ± 0.06
γ' -Fe ₄ N/MgO	0.121 ± 0.003	2.35 ± 0.06	2.47 ± 0.06
γ' -Fe ₄ N	0.068	2.52	2.59
ε -Fe ₃ N	0.040	1.97	2.01
α -Fe	0.086	1.98	2.07
α -Fe	0.046	2.16	2.21

← E. Blanca et al.,
PBE+U cal.

Experimental Fe 3d moment is consistent with PBE+U.

M_{S} values are similar between LAO and MgO substrates.

Summary

Pd/Co(1ML)/Pd(001)

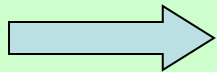
- Perpendicular magnetic anisotropy at RT.
- Large orbital moment perpendicular to plane.
 - M. Sawada et al., J. Elec. Spectrosc. Relat. Phenom **184** (2011) 280.

γ' -Fe₄N film

- Determination of precise values of Fe 3d moments.
- Tiny dependence on substrates (LaAlO₃, MgO).
 - K. Ito et al., Appl. Phys. Lett. **98** (2011)102507..

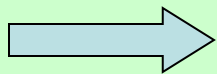
Magnetic impurities on 3D TI Co/Bi₂Se₃

- No long-range ferromagnetic order.



No energy gap opening at Dirac point

M. Ye et al.



QPI due to a strong warping of iso-energy contours