UVSOR アンジュレータ 低エネルギービームラインの現状

BL5U: 汎用VUV-ARPES (施設利用)
BL7U : 先端VUV-ARPES (施設利用)
BL3U : 軟X線光化学 (所内専用)
BL6U : 軟X線気体・固体・表面 (所内専用)

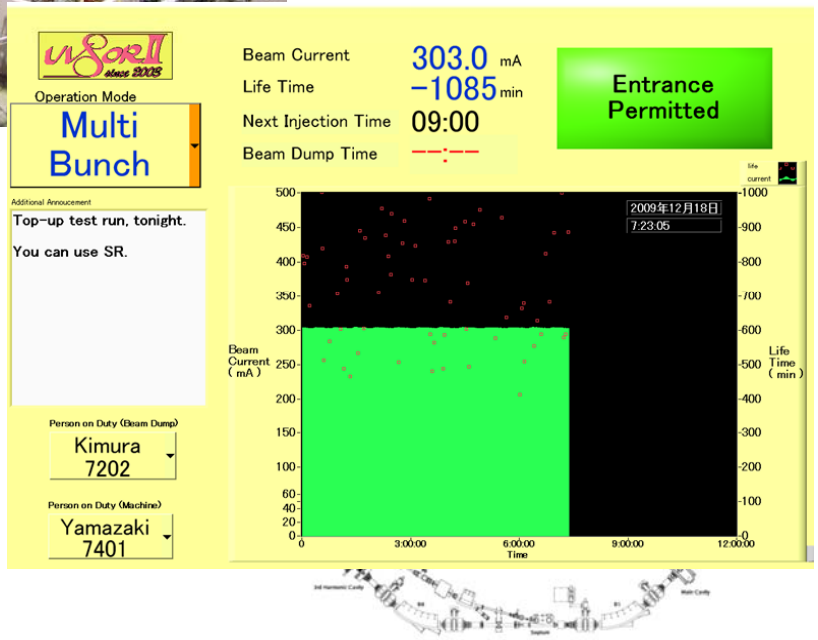
木村真一
分子研UVSOR施設，総研大物理

Light source of UVSOR-II

Electron Energy	750 MeV
Circumstance	53.2 m
Emittance	27nm-rad
Straight Sections	4mx4+1.5mx4
Filling Beam Current	350 mA (multi-bunch)
Injection Interval	6 hours
Top-up operation is partly started.	

since 2003

since 2008



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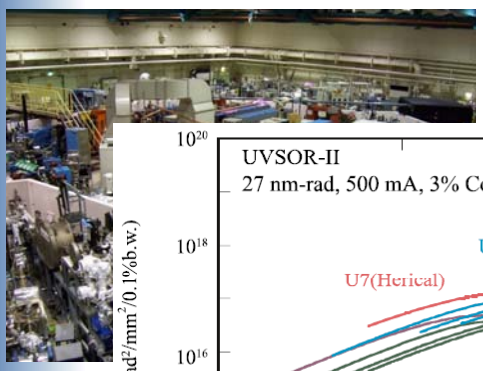
Institute for Molecular Science

Light source of UVSOR-II



Electron Energy	750 MeV
Circumstance	53.2 m
Emittance	27nm-rad
Straight Sections	4mx4+1.5mx4
	(multi-bunch)

urted.

Reserved for
Future Undulator

2m In-vacuum
Undulator

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13 Beamlines at UVSOR-II (Dec. 18, 2009)

Beam-line	Monochromator, Spectrometer	Energy Region (eV)	Experiments
1A	Double-Crystal	600 eV – 4 keV	Solid (Absorption)
1B	1m Seya-Namioka	2 eV – 30 eV	Solid (Reflection, Absorption)
2B*	18m Spherical Grating (Dragon)	24 eV – 205 eV	Gas (Photoionization, Photodissociation)
3U*	Varied-Line-Spacing Plane Grating (Monk-Gillieson)	60 eV – 800 eV	Gas, Liquid, Solid (Absorption, Photoemission, Photon Emission)
4B*	Varied-Line-Spacing Plane Grating (Monk-Gillieson)	25 eV – 1 keV	Gas (Photoionization, Photodissociation) Solid (Photoemission)
5U	Spherical Grating (SGM-TRAIN*)	5 eV – 250 eV	Solid (Photoemission)
5B	Plane Grating	6 eV – 600 eV	Calibration Solid (Absorption)
6U*	Variable-Included-Angle Varied-Line-Spacing Plane Grating	30 eV – 500 eV	Gas (Photoionization, Photodissociation) Solid (Photoemission)
6B	Martin-Puplett FT-FIR Michelson FT-IR	0.1 meV – 2.5 eV	Solid (Reflection, Absorption)
7U	10m Normal Incidence (Modified Wadsworth)	6 eV – 40 eV	Solid (Photoemission)
7B	3m Normal Incidence	1.2 eV – 25 eV	Solid (Reflection, Absorption)
8B1	15m Constant Deviation Grazing Incidence	30 eV – 800 eV	Solid (Absorption)
8B2	Plane Grating	1.9 eV – 150 eV	Solid (Photoemission)

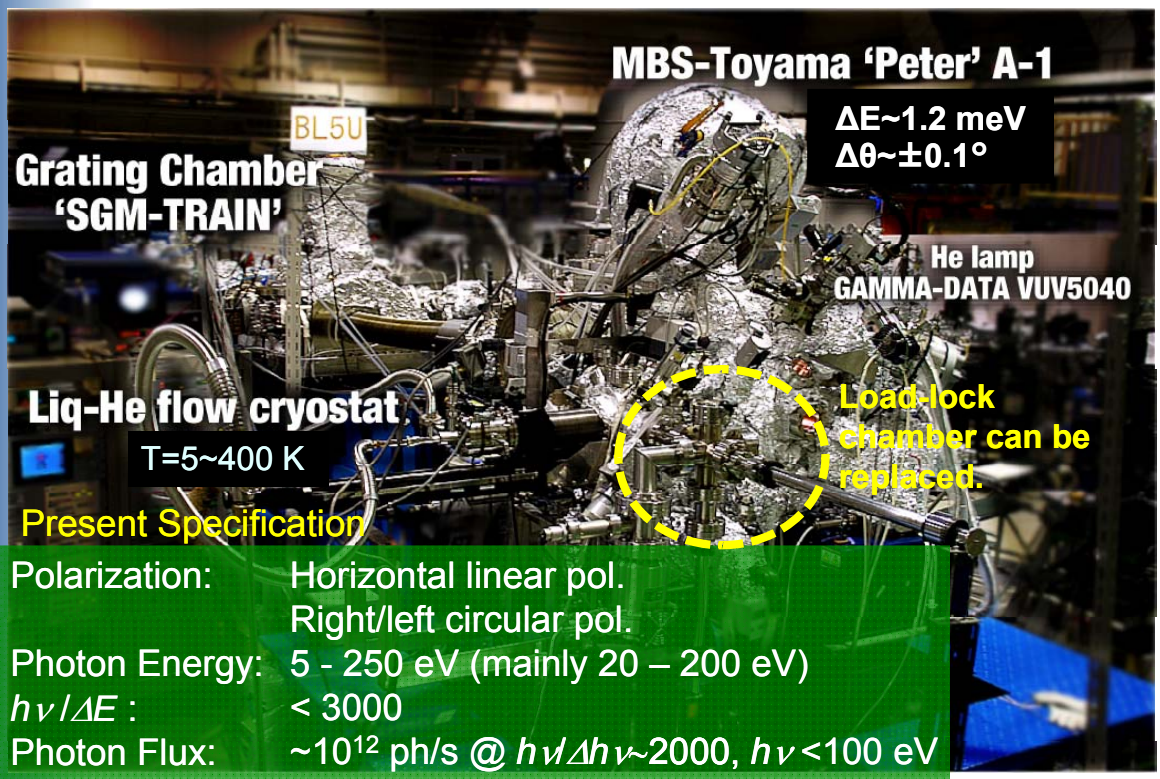
- Move to BL2A in FY2011.
- To be replaced to a 2.5-m-NIM at BL3B in FY2011.

THz-CSR + VUV-CHG BL from FY2011.

- Shutdown in 2010.

BL5U@UVSOR-II (since 2004)

[T. Ito et al., AIP Conf. Proc. 879 (2007) 587.]



Present Specification

Polarization:	Horizontal linear pol. Right/left circular pol.
Photon Energy:	5 - 250 eV (mainly 20 – 200 eV)
$h\nu/\Delta E$:	< 3000
Photon Flux:	~10^{12} ph/s @ $h\nu/\Delta h\nu$~2000, $h\nu$ <100 eV
Max. θ of A-1:	± 7.5° → ± 18° from FY2010

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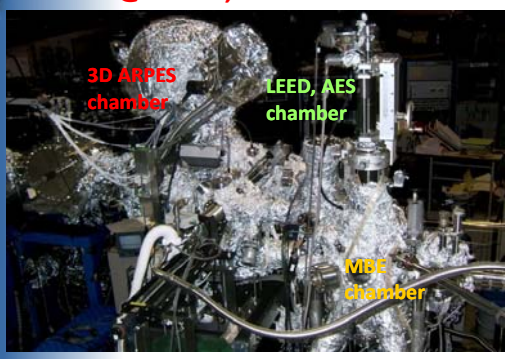
Electronic structure and magnetic transition of a ferromagnetic semiconductor EuO

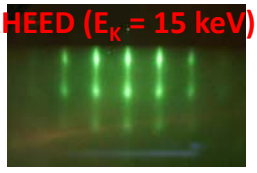
in-situ 3D-ARPES apparatus @ BL5U, UVSOR-II



Fabrication of EuO thin films

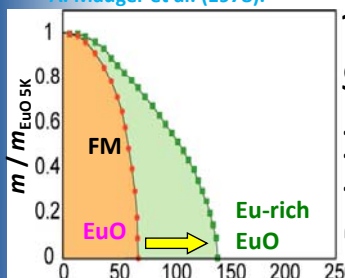
Molecular beam epitaxy method (Vacuum: 2.0 x 10^{-8} Pa)

1. Anneal of $SrTiO_3$ substrate
2. Evaporation of BaO buffered layer(2 nm)
3. Evaporation of EuO (50 nm)



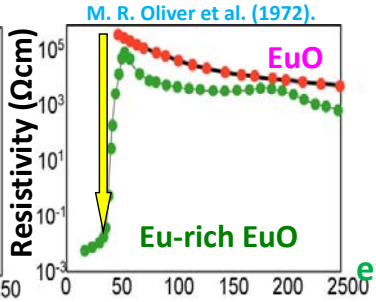
Magnetization

A. Mauger et al. (1978).



Electrical Resistivity

M. R. Oliver et al. (1972).



Temperature (K)

EuO as a next-generation spintronics material

What's the origin of the physical properties?

Direct observation of electronic structure by 3D-ARPES

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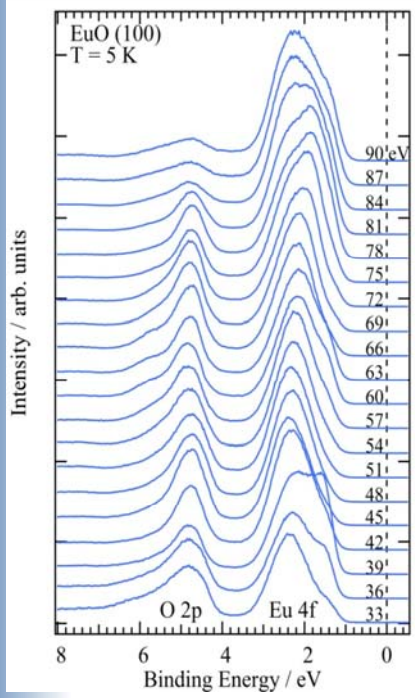
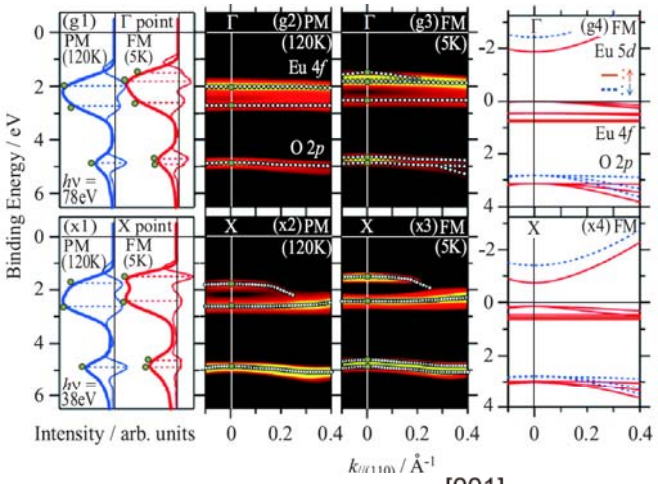
3D-ARPES of single crystalline EuO thin films

[H. Miyazaki, SK et al., *PRL* **102**, 227203 (2009).]

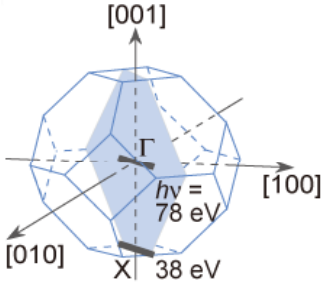
Band dispersion along k_z-direction



Temperature-dependent band dispersion near the Γ and X points.



Brillouin zone of EuO



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A user activity at BL5U, UVSOR-II

A topological metal at the surface of an ultrathin $Bi_{1-x}Sb_x$ alloy film

T. Hirahara,[1,*] Y. Sakamoto,[1] Y. Saisyu,[1] H. Miyazaki,[2] S. Kimura,[2]
T. Okuda,[3,†] I. Matsuda,[3] S. Murakami,[4] and S. Hasegawa[1]

[1] *Department of Physics, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan*
[2] *UVSOR Facility, Institute for Molecular Science, Okazaki 444-8585, Japan*
[3] *Synchrotron Radiation Laboratory, ISSP, University of Tokyo, Kashiwa 277-8581, Japan*
[4] *Department of Physics, Tokyo Institute of Technology, Tokyo 152-8551, Japan*

[submitted.]

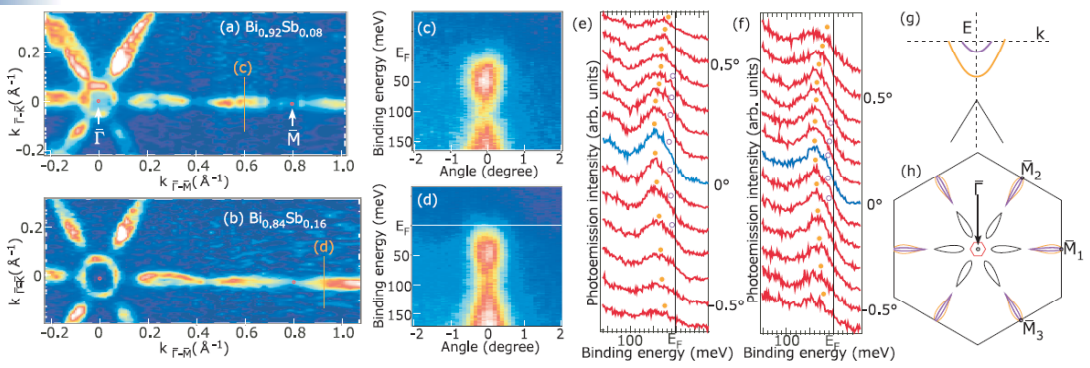


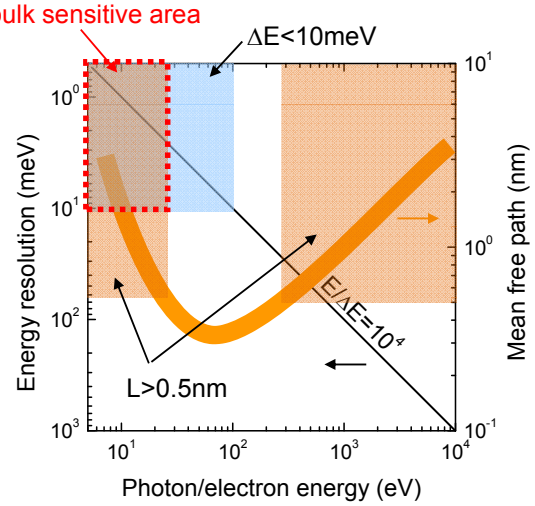
FIG. 2: (Color online) (a, b) Fermi surfaces of 43 Å thick $Bi_{0.92}Sb_{0.08}$ (a) and 39 Å thick $Bi_{0.84}Sb_{0.16}$ (b) ultrathin films. (c, d) $E-\theta$ band dispersions for the cuts shown in (a) and (b), respectively. (e, f) Energy distribution curves for the images shown in (c) and (d), respectively. (g) Schematic drawing of the band dispersion of (c)-(f). (h) Schematic drawing of the Fermi surface shown in the surface Brilloiun zone. The photon energy was $h\nu = 29$ eV.

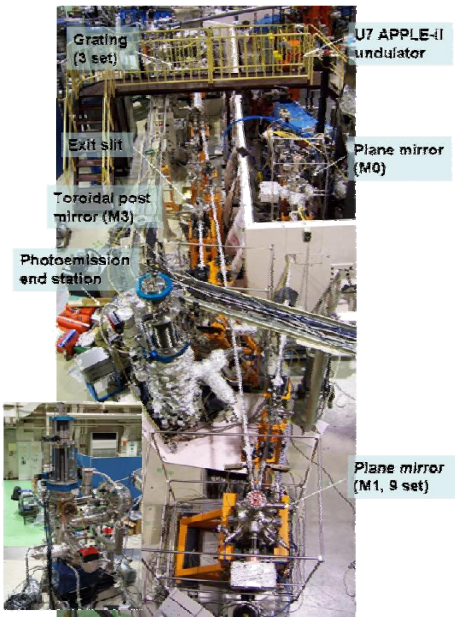
VUV-ARPES beamline BL7U at UVSOR-II

(SAMRAI: Symmetry And Momentum Resolved electronic structure Analysis Instrumentation)

[S. Kimura et al., to be submitted;
S. Kimura et al., AIP Conf. Proc. **879**, 527-530 (2007).]

High resolution and bulk sensitive area





Tunable photon⊗high flux⊗high resolution⊗variable polarization⊗ARPES
⇒ Determination of three-dimensional electronic structure and Fermi surface
⇒ elucidation of the mechanism of transport and magnetic properties.

(Future) Real space imaging of electronic structure using micro-optics
⇒ Direct observation of phase separation of materials.

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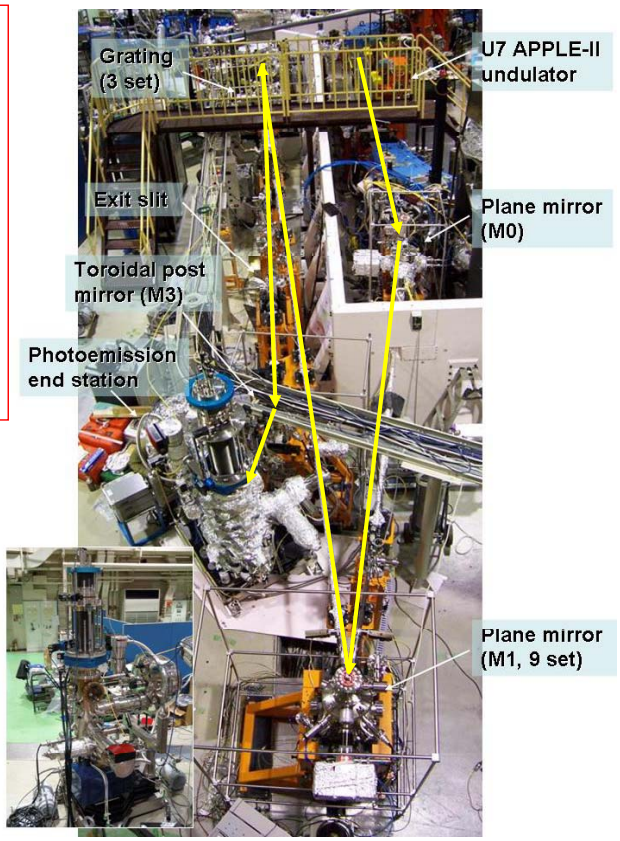
BL7U (SAMRAI) @ UVSOR-II (since 2007)

$h\nu$ = 6 ~ 40 eV
N_{ph}>10^{12}~10^{11} ph/s on sample
⊗
$E/\Delta E$>10^4 (<1meV @ 10 eV)
⊗
Polarization: PL(H/V)+CL(L/R)
⊗
$\Delta E_{ARPES} \leq$ 1meV, 3D-ARPES, low temperature (< 12 K).

- APPLE-II type undulator
- Wadsworth type monochromator
- MB Scientific A-1 analyzer
- R-dec i-GONIO 6-axes manipulator with cryostat



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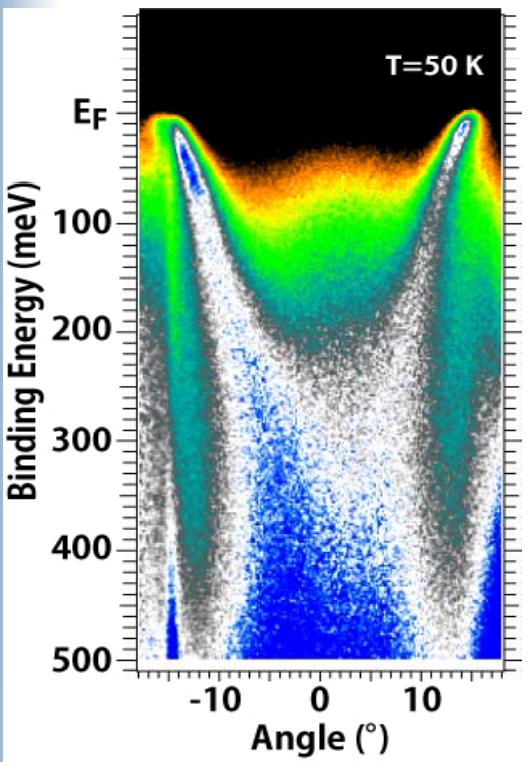
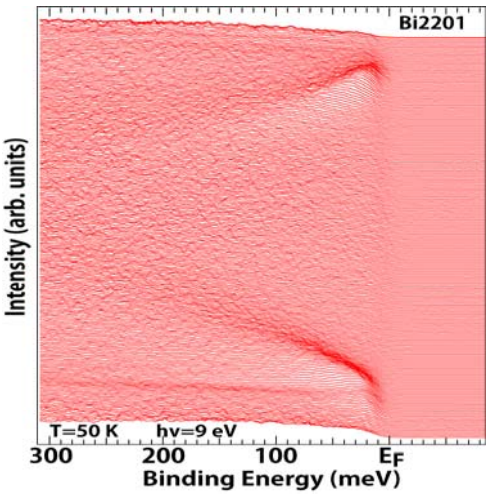
Recent ARPES result: Bi2201 (OP31K)

Takeuchi Group @ Nagoya Univ.



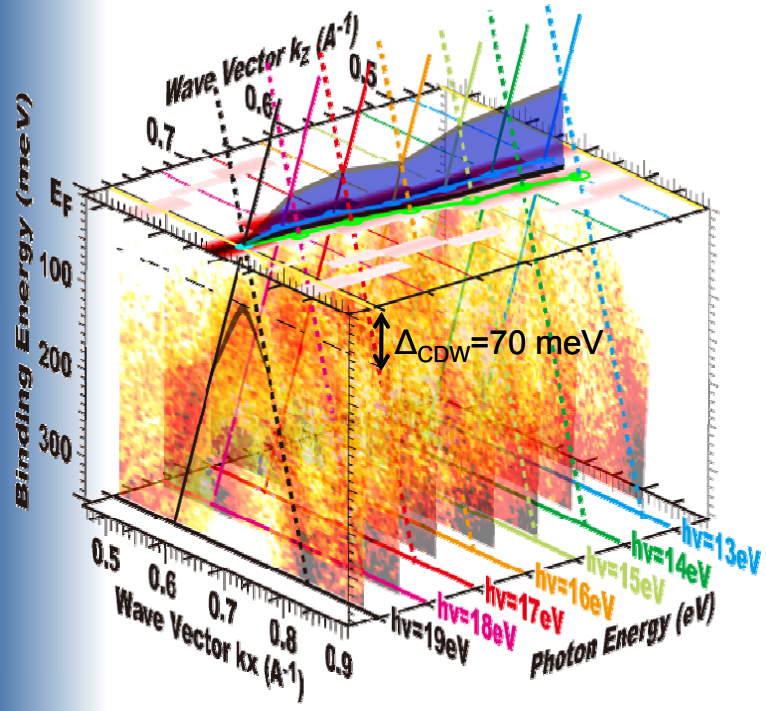


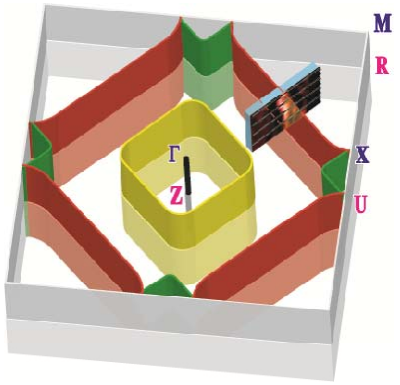
hv = 9 eV
ΔE ≤ 5 meV
5min/1 picture !

3D-band structure of $CeTe_2$

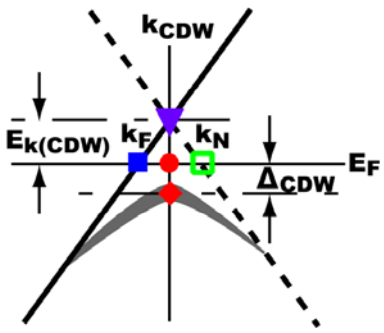
k_z dependence of CDW gap

T. Ito @ UVSOR → Nagoya Univ.





Hole FS@M point
Δ_{CDW}=70 meV



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Institute for Molecular Science

Beamlines at UVSOR-II (Dec. 11, 2009)

Beam-line	Monochromator, Spectrometer	Energy Region (eV)	Experiments
1A	Double-Crystal	600 eV – 4 keV	Solid (Absorption)
1B	1m Seya-Namioka	2 eV – 30 eV	Solid (Reflection, Absorption)
2B*	18m Spherical Grating (Dragon)	24 eV – 205 eV	Gas (Photoionization, Photodissociation)
3U*	Varied-Line-Spacing Plane Grating (Monk-Gillieson)	60 eV – 800 eV	Gas, Liquid, Solid (Absorption, Photoemission, Photon Emission)
4B*	Varied-Line-Spacing Plane Grating (Monk-Gillieson)	25 eV – 1 keV	Gas (Photoionization, Photodissociation) Solid (Photoemission)
5U	Spherical Grating (SGM-TRAIN*)	5 eV – 250 eV	Solid (Photoemission)
5B	Plane Grating	6 eV – 600 eV	Calibration Solid (Absorption)
6U*	Variable-Included-Angle Varied-Line-Spacing Plane Grating	30 eV – 500 eV	Gas (Photoionization, Photodissociation) Solid (Photoemission)
6B	Martin-Puplett FT-FIR Michelson FT-IR	0.1 meV – 2.5 eV	Solid (Reflection, Absorption)
7U	10m Normal Incidence (Modified Wadsworth)	6 eV – 40 eV	Solid (Photoemission)
7B	3m Normal Incidence	1.2 eV – 25 eV	Solid (Reflection, Absorption)
8B1	15m Constant Deviation Grazing Incidence	30 eV – 800 eV	Solid (Absorption)
8B2	Plane Grating	1.9 eV – 150 eV	Solid (Photoemission)

In-house beamline (Kosugi group, Shigemasa group)

- In-vacuum undulator
- VLG monochromator
- Mainly use for chemical-physics

BL3U at UVSOR-II

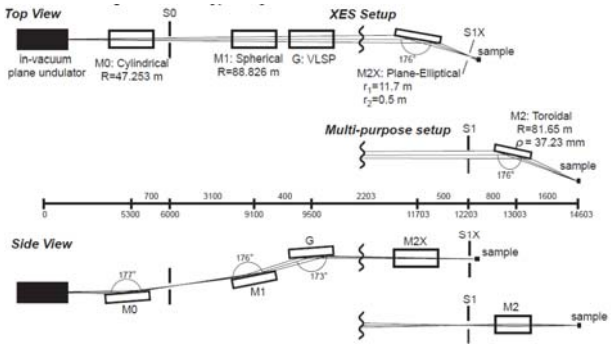
軟X線アンジュレータビームライン
(40 – 800 eV)

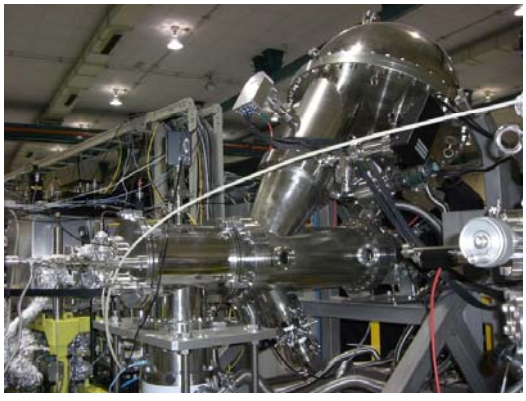
エネルギー分解能E/ΔE = 10000

クラスター実験用の高分解半球型電子分光器(SCIENTA SES-200 + MBS A-1)

透過回折格子を用いた高分解能発光分光器

液体の透過型軟X線吸収分光装置





クラスター装置

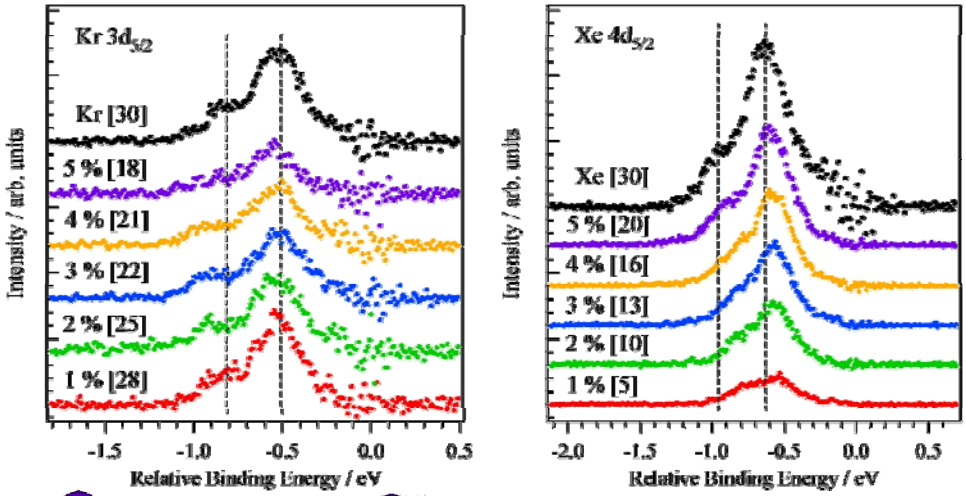
透過型発光分光器

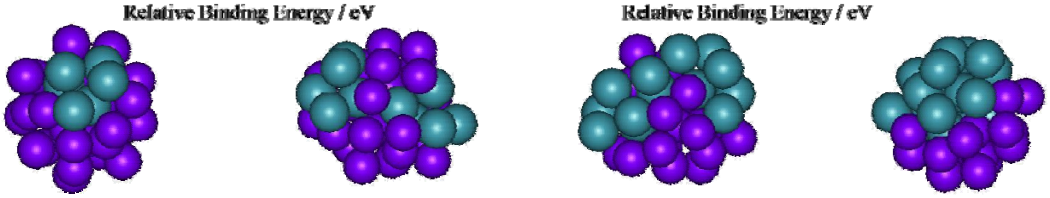
M. Nagasaka

Kr/Xe混合クラスターの表面構造の解明

異なる比率の混合クラスターの表面構造をXPSを用いて測定

分極理論による計算との比較により表面構造を調べた



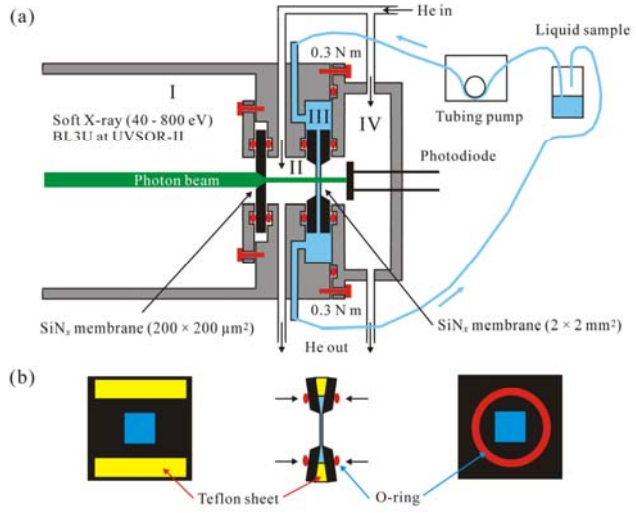


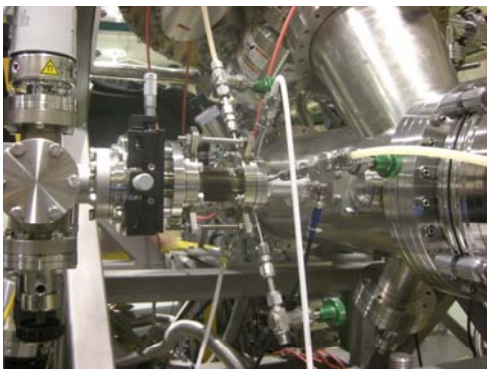
Xe_6Kr_{29} (1 %)　$Xe_{10}Kr_{25}$ (2 %)　$Xe_{13}Kr_{22}$ (3 – 4 %)　$Xe_{19}Kr_{16}$ (5 %)

異なる比率の混合クラスターの特徴的な表面構造を明らかにした

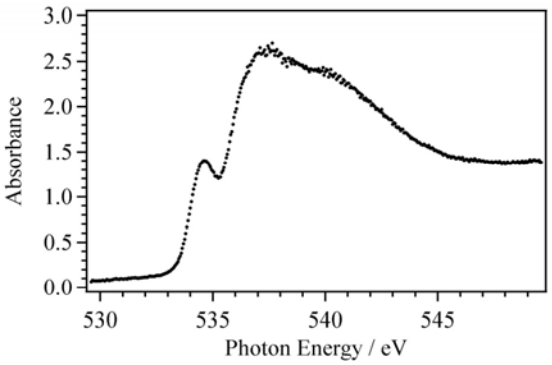
M. Nagasaka

透過法による水の軟X線吸収測定





液体セルの写真



水のO K吸収端のX線吸収スペクトル

2枚のSiNメンブレンを押さえることにより、
100 – 800 nmの液体層を実現

液体を流すことにより、試料を容易に変更可能

温度変化させた測定も可能 (6 – 54 ℃)

O K吸収端における水の3つのピークを確認

M. Nagasaka *et al*. J. Electron Spectrosc. Relat. Phenom., in press.

M. Nagasaka

BL6U：軟X線ビームライン (2008~)

(繁政グループ + 小杉グループ)

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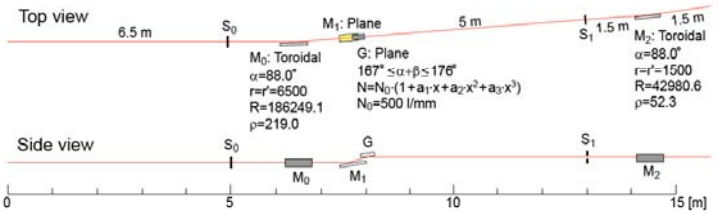
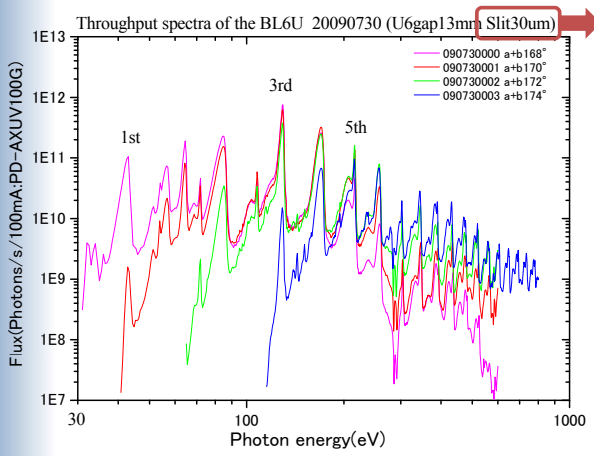
Layout of BL6U

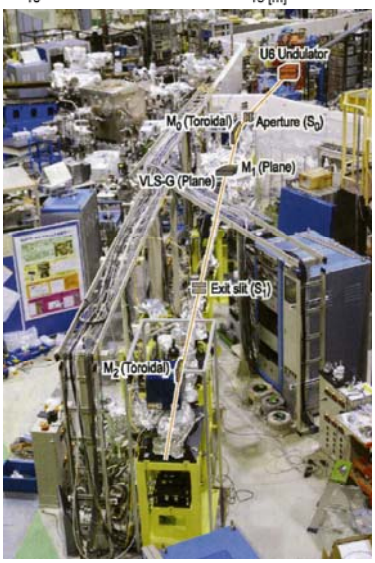


特徴

・偏角可変（一枚の回折格子で広い範囲をカバー）
・入射スリットレス（光強度と分解能の両立）



E/ΔE
=10000
@80 eV

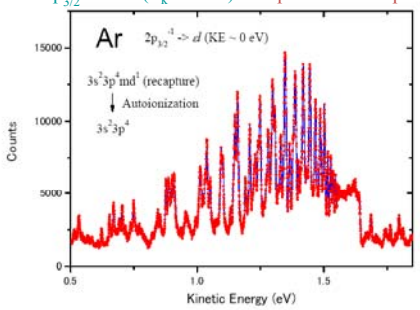


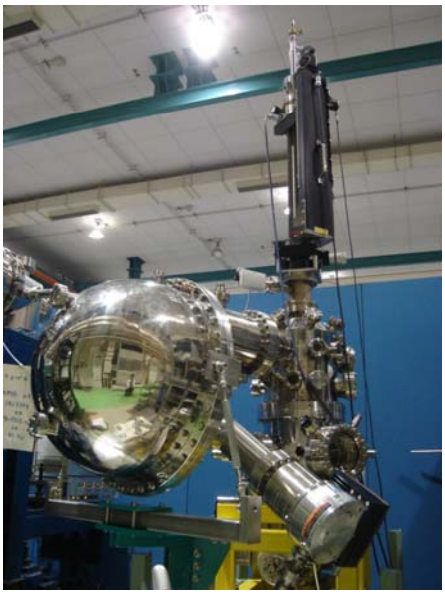
E. Shigemasa

BL6Uで予定している研究

・気体の高分解能電子分光（繁政G）　・固体・表面の角度分解光電子分光

$2p_{3/2}^{-1} \rightarrow \varepsilon l\ (E_k \sim 0\ eV)$　$3s^2 3p^4 md^1 \rightarrow 3s^2 3p^4 + \varepsilon l$





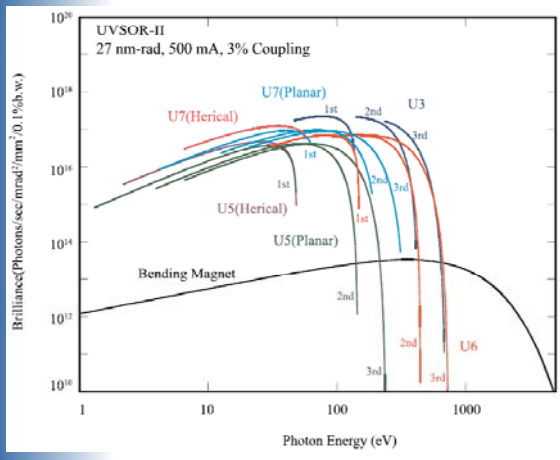
有機薄膜･界面　(分子研 小杉グループ)
➔ 弱い分子間相互作用で支配された
局所電子状態や電荷移動ダイナミクス

表面吸着系　(国際共同研究等)
➔ ナノワイヤー、小分子系など

E. Shigemasa

Conclusion: Undulators at UVSOR-II

Solid State Spectroscopy Group
UVSOR Facility
Institute for Molecular Science



Electron Energy	750 MeV
Circumstance	53.2 m
Emittance	27nm-rad
Straight Sections	4mx4+1.5mx4
Filling Beam Current	350 mA (multi-bunch)
Injection Interval	6 hours

Top-up operation is partly started.

1m In-vacuum Undulator

2.3 m Variably Polarized Undulator (SPring-8 type)