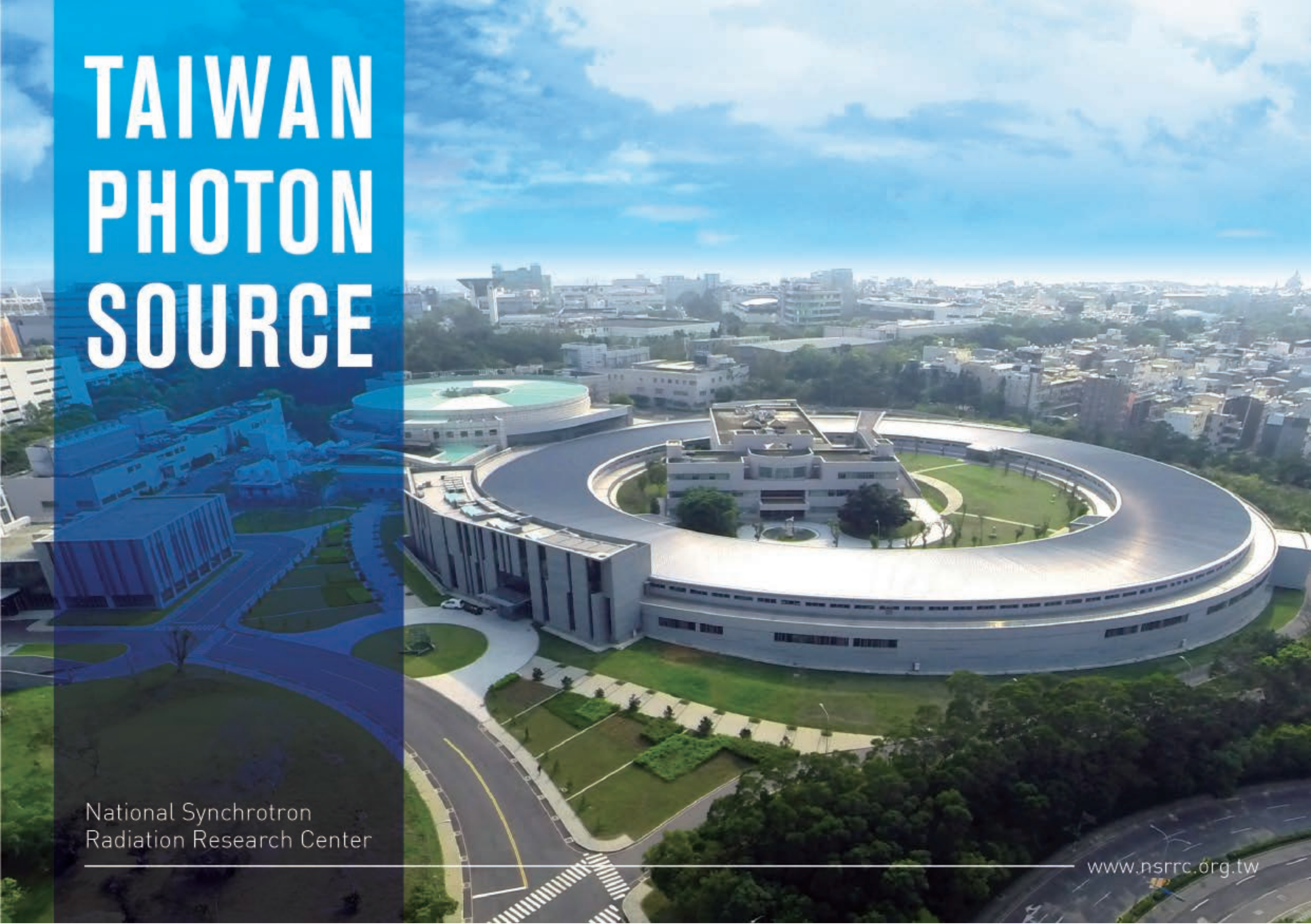
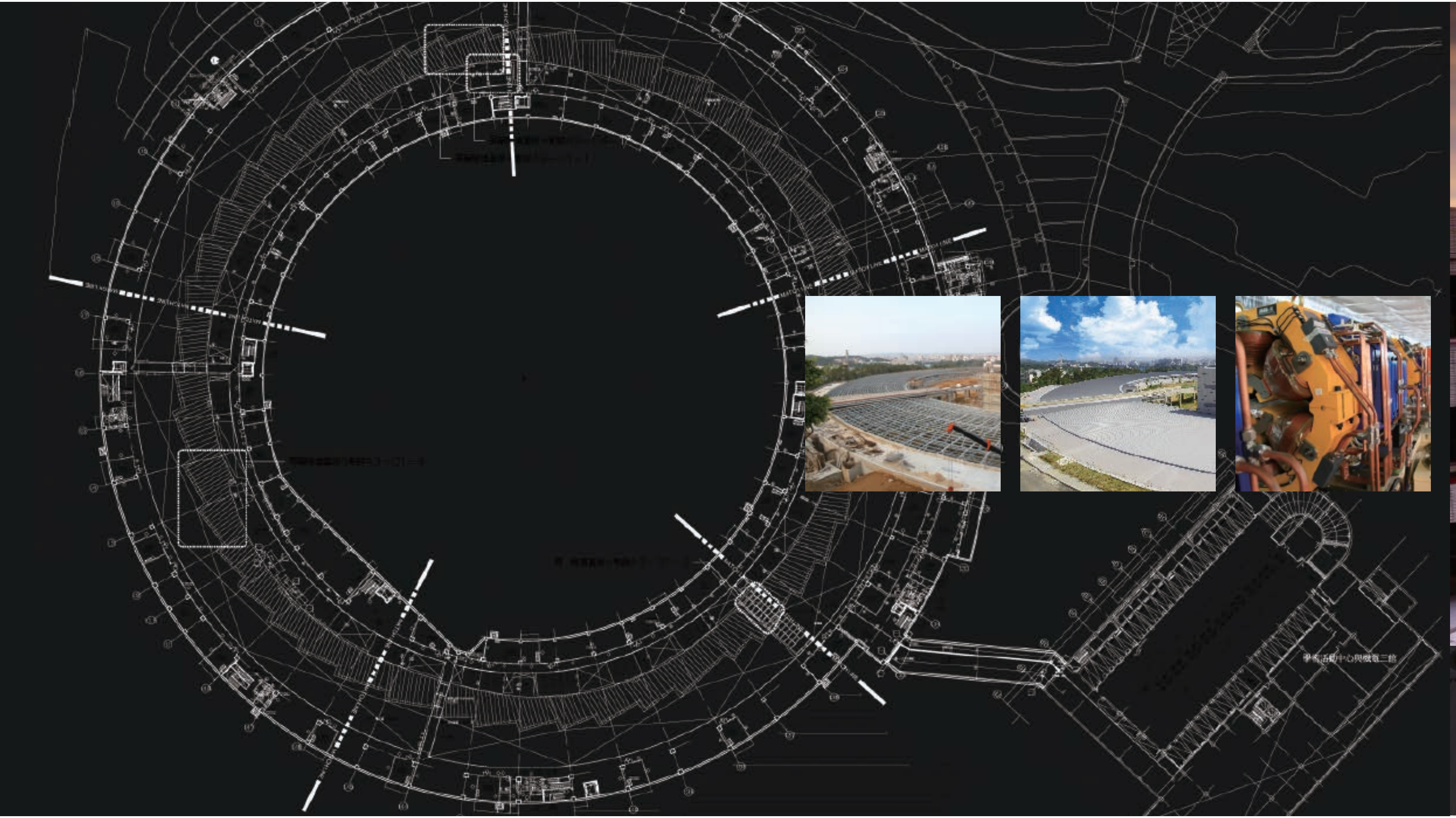


TAIWAN PHOTON SOURCE

National Synchrotron Radiation Research Center

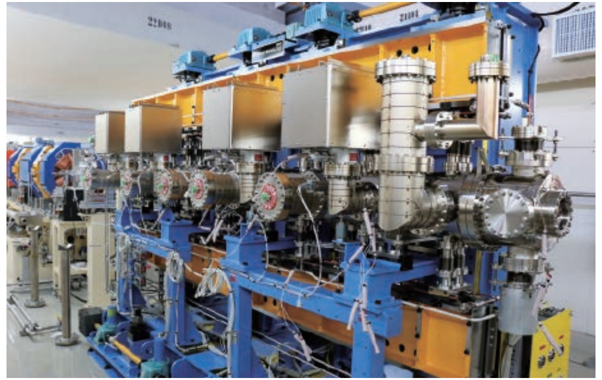
www.nsrrc.org.tw

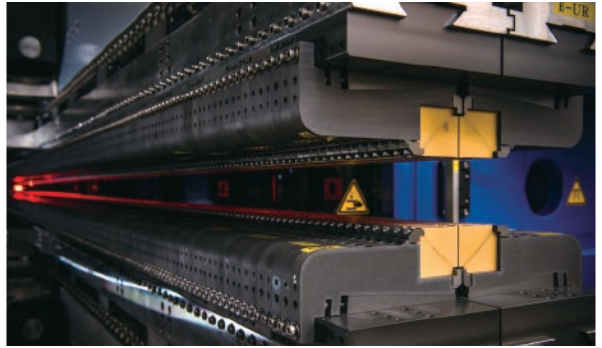


TAIWAN PHOTON SOURCE

WITH AN ACCELERATOR AND BEAMLINES PAR EXCELLENCE, THE TPS WILL BLAZE A TRAIL TO SCIENCE FRONTIERS

TPS parameters	
Energy [GeV]	3.0
Current [mA]	500
Circumference [m]	518.4
Natural horizontal emittance [nm • rad]	1.6
Critical energy of bending magnets [keV]	7.13
Cell units	24 DBA
Superperiods	6
Radiofrequency [MHz]	499.654
Straight sections	12 m x 6 7 m x 18





ABOUT THE TAIWAN PHOTON SOURCE

The Taiwan Photon Source (TPS) is one of the world's brightest synchrotron X-ray sources geared toward world-class academic research. This accelerator consists of a low-emittance synchrotron storage ring of 518.4 meters in circumference and a booster ring that are designed in a concentric fashion and housed in a donut-shaped building.

The phase-I beamlines will be available to users in 2016 and will serve scientists worldwide. The TPS is designed to emphasize electron beams of a low emittance and a great brilliance.The TPS storage ring comprises 24 double-bend achromat (DBA) cells, with six straight sections of 12 meters and eighteen straight sections of 7 meters in length.The TPS uses two sets of KEKB type superconducting RF cavities to achieve an electron current of 500 mA in a top-up injection mode and to diminish the high-order-mode instability excited by the electron beam.

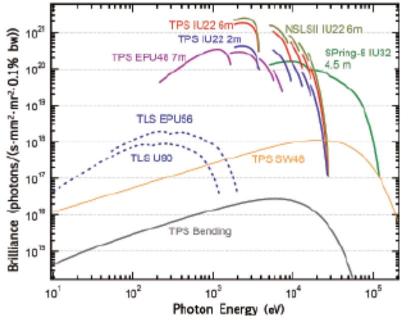
Electron Gun	1	2	Superconducting Radio Frequency Cavity
Insertion Device	3	4	Cryogenic Facility

The first synchrotron light from the TPS storage ring at the 3 GeV design energy delivered on December 31, 2014. The TPS created a world record for the fastest commissioning of an advanced accelerator light source. This very fact attests to the high caliber of the design of the accelerator system, and the high standards of the qualities of the subsystems,the alignments of all the components, the integrated diagnostics and control systems, a nd the various types of magnets.

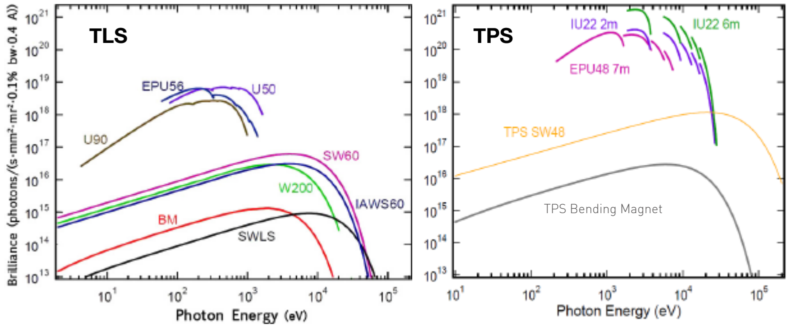
THE TPS IS ONE OF THE BRIGHTEST SYNCHROTRON X-RAY SOURCES IN THE WORLD

Improvements in brilliances of the TPS over those of the TLS are dramatic, to the tune of 3 to 4 orders of magnitude.

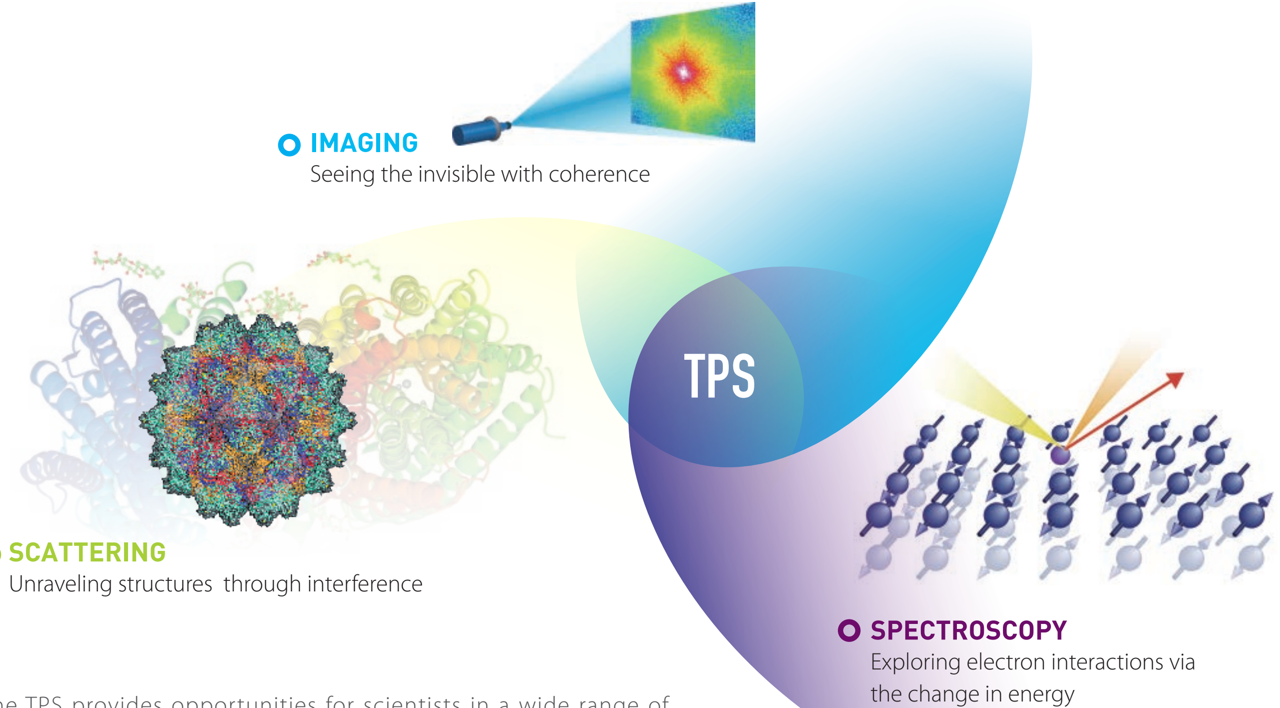
TPS bending BLs @ 10 keV: 10^2 times brighter
TPS ID BLs
@ 1 keV: ~ 10^3 times brighter
@ 10 keV: 10^4 times brighter



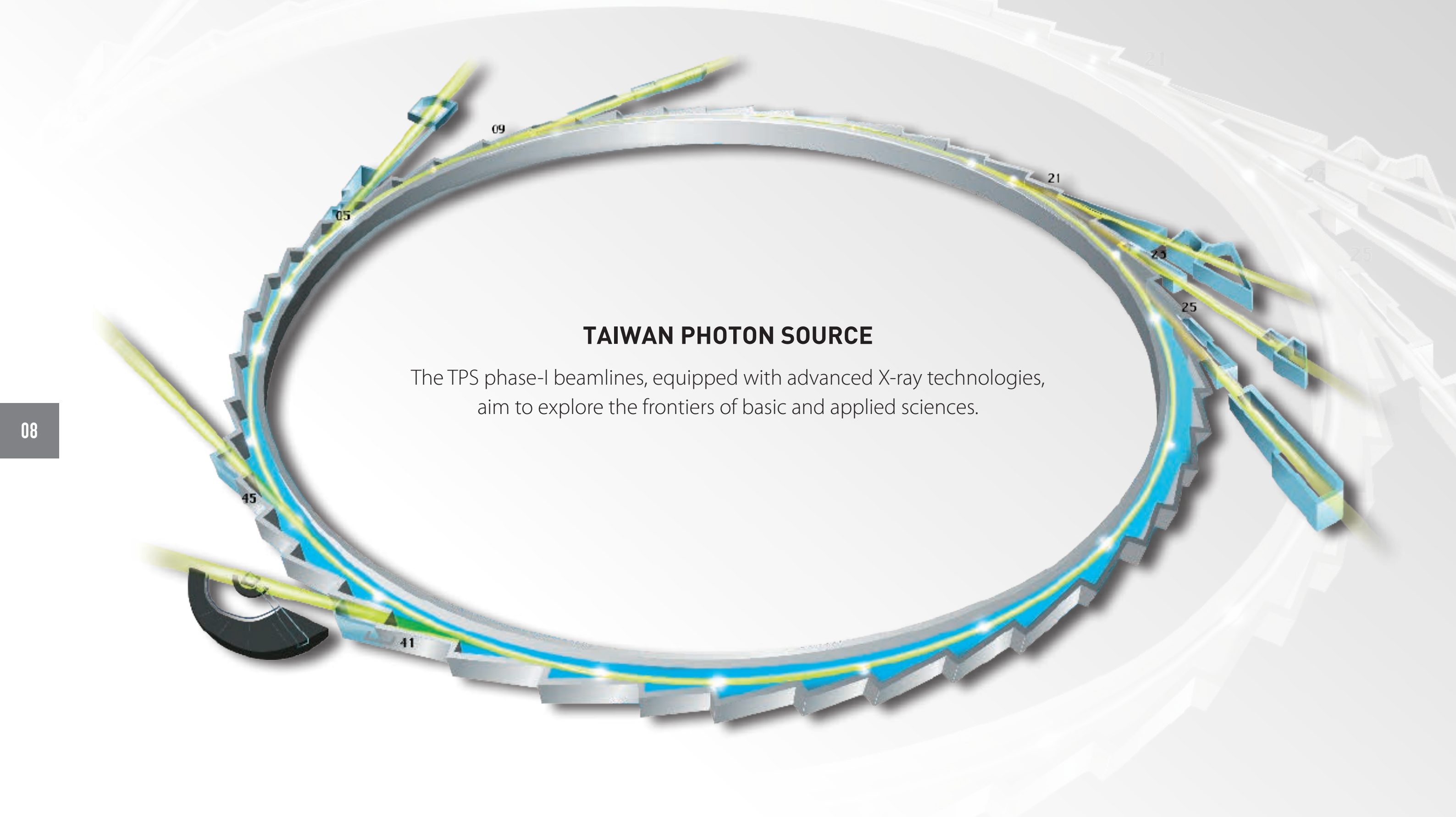
BRILLIANCES OF
THE TPS, NSLS-II, AND SPRING-8



COMPARISON OF BRILLIANCES
BETWEEN TLS AND TPS



The TPS provides opportunities for scientists in a wide range of researches to reveal structures, eletron interactions, functions of matters, and their dynamics, using various spectroscopies, imaging methods, and scattering techniques.



TAIWAN PHOTON SOURCE

The TPS phase-I beamlines, equipped with advanced X-ray technologies, aim to explore the frontiers of basic and applied sciences.

PHASE-I BEAMLINE SUMMARY

		05A Protein µ-crystallography	09A Temporally Coherent XRD	21A X-ray Nanodiffraction	23A X-ray Nanoprobe	25A X-ray Coherent Scattering	41A Soft X-ray Scattering	45A Sub-µm SoftX-ray Spectroscopy
Insertion devices		IU22 × 1	IU22 × 2	tapered IU22 × 1	IU22 × 1	IU22 × 2	EPU48 × 2	EPU46 × 1
Energy range		5.7–20 keV	5.6–25 keV	7–25 keV	4–15 keV	5.5–20 keV	400–1200 eV	280–1500 eV
Experimental techniques								
Imaging (CDI)					●	●	●	
Scattering	Structural diffraction	●	●	●	●	●	●	
	Scattering					●	●	
Spectroscopy	XAS		●	●	●	●	●	●
	XEOL			●	●			●
	RIXS						●	●
	PES							●

CDI: coherent diffraction imaging XEOL: X-ray excited optical luminescence PES: photoemission spectroscopy
XAS: X-ray absorption spectroscopy RIXS: resonant inelastic X-ray scattering

05A

Protein Microcrystallography

With a high brilliance of the light source and microfocusing optics, 05A is tailored to protein microcrystallography to reveal 3D molecular structures of complex biological macromolecules previously beyond reach.

UNIQUE FEATURES

- Energy range: 5.7 – 20 keV
- Photon flux: > 6 $\times 10^{12}$ s^{-1} at 12.4 keV
- Small beam sizes
- Low beam divergences
- Wide and accurate energy tunability
- High position stability
- Beamline automation

HIGH THROUGHPUT AND REMOTE TECHNIQUES

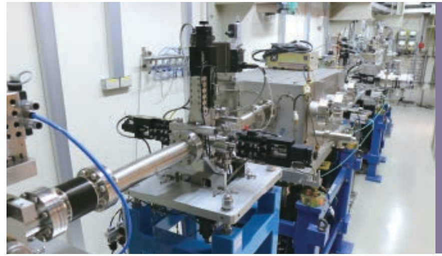
- Automated crystal mounting, centering and screening
- Automated energy selection and data collection
- Enable collaborations among worldwide researchers

PROTEIN MICROCRYSTALLOGRAPHY ENDSTATION

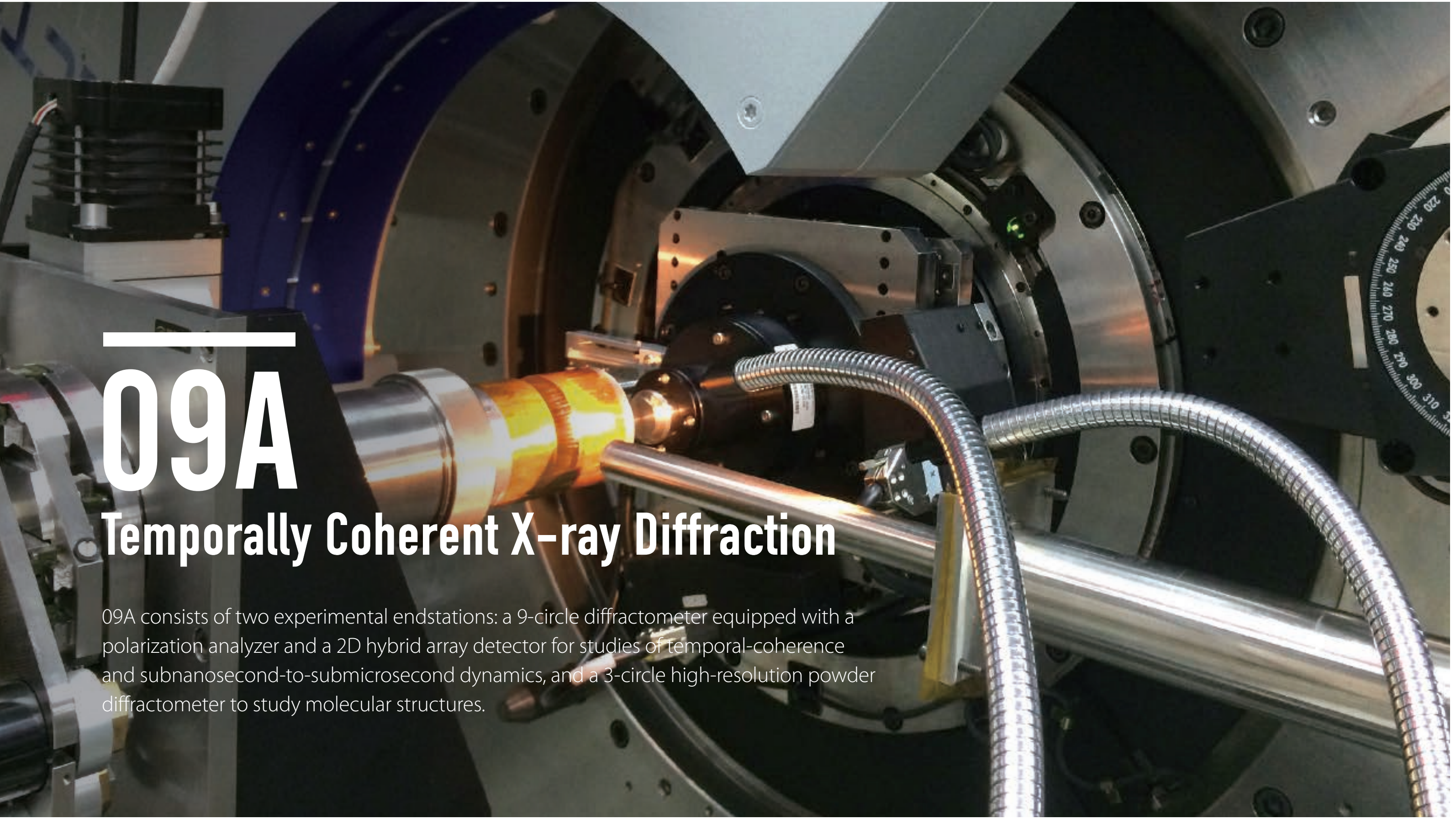
- Integrated beam shaping
  5 to 50 μm beam, user selectable
- Changeable beam divergence
  0.1 to 0.5 mrad divergence, user selectable
- On-axis sample video
  parallax error-free and real time imaging
- High precision PHI axis
  < 1 μm SOC, suitable for microdiffraction
- Maximum PHI rotation speed
  up to 130 deg/s
  suitable for inverse-beam experiments
- Grid scan to find the best diffracting area
- High-speed and large-size area detector
  suitable for shutterless and fine-slicing exp.
- Helical data collection
  to reduce the radiation damage
- Automatic sample changer
  to enable high throughput crystal screening
- Remote access capability

SCIENTIFIC OPPORTUNITIES

- Membrane proteins
- Viruses and large macromolecular assemblies
- Multi-protein and tertiary complexes
- Pathogenicity-related proteins
- Extreme-environment metalloproteins
- Structure-based drug designs



3D BIOSTRUCTURES
Solutions to your problems of Life Sciences



09A

Temporally Coherent X-ray Diffraction

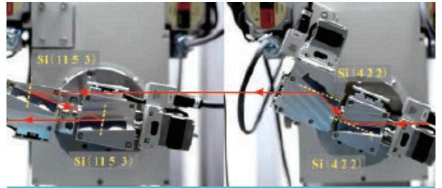
09A consists of two experimental endstations: a 9-circle diffractometer equipped with a polarization analyzer and a 2D hybrid array detector for studies of temporal-coherence and subnanosecond-to-submicrosecond dynamics, and a 3-circle high-resolution powder diffractometer to study molecular structures.

UNIQUE FEATURES

- Beam sizes:
  ≦ 600 × 700 μm^2
  ≦ 70 × 3 μm^2 with
  a compound refractive lens
- Low beam divergences:
  < 70 (H) × 20 (V) μrad^2
- Photon flux: > 10^{13} s^{-1} at 14.4 keV
- Wide and accurate energy tunability:
  5.6 – 25 keV
- Ultrahigh energy resolution achievable:
  $\Delta E/E = 2.8 \times 10^{-8}$ at E = 14.4 keV
- Polarization state of light selectable and analyzable
- Time-resolved (TR) experiments

EXPERIMENTAL TECHNIQUES

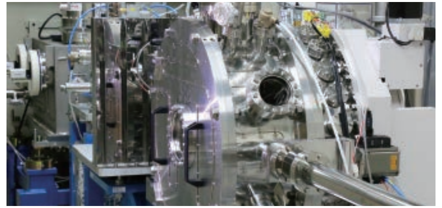
- Pump & probe TR-XRD: timescale from subnanosecond to submicrosecond
- High resolution XRD: $\Delta\theta = 0.003^\circ$ with a crystal analyzer
- High resolution powder XRD:
  $\Delta\theta = 0.04 – 0.06^\circ$ with a 1D microstrip detector
  $\Delta\theta = 0.005^\circ$ with a multi-crystal analyzer

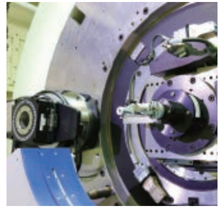


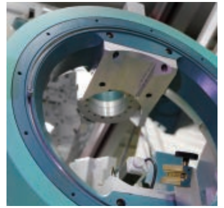
Mapping 4D structures of matter with X-ray scattering

TR & GENERAL XRD ENDSTATION

- Ultrahigh energy resolution achievable by an asymmetrically cut four-bounce monochromator
- Polarization state of light selectable and analyzable
- Ultrafast Ti-sapphire laser system with a 35 fs pulse width, can be used to perform laser pump & X-ray probe TR-XRD experiments (timescale from subnanosecond to submicrosecond)
- Non-ambient environments (4 K – 300 K)

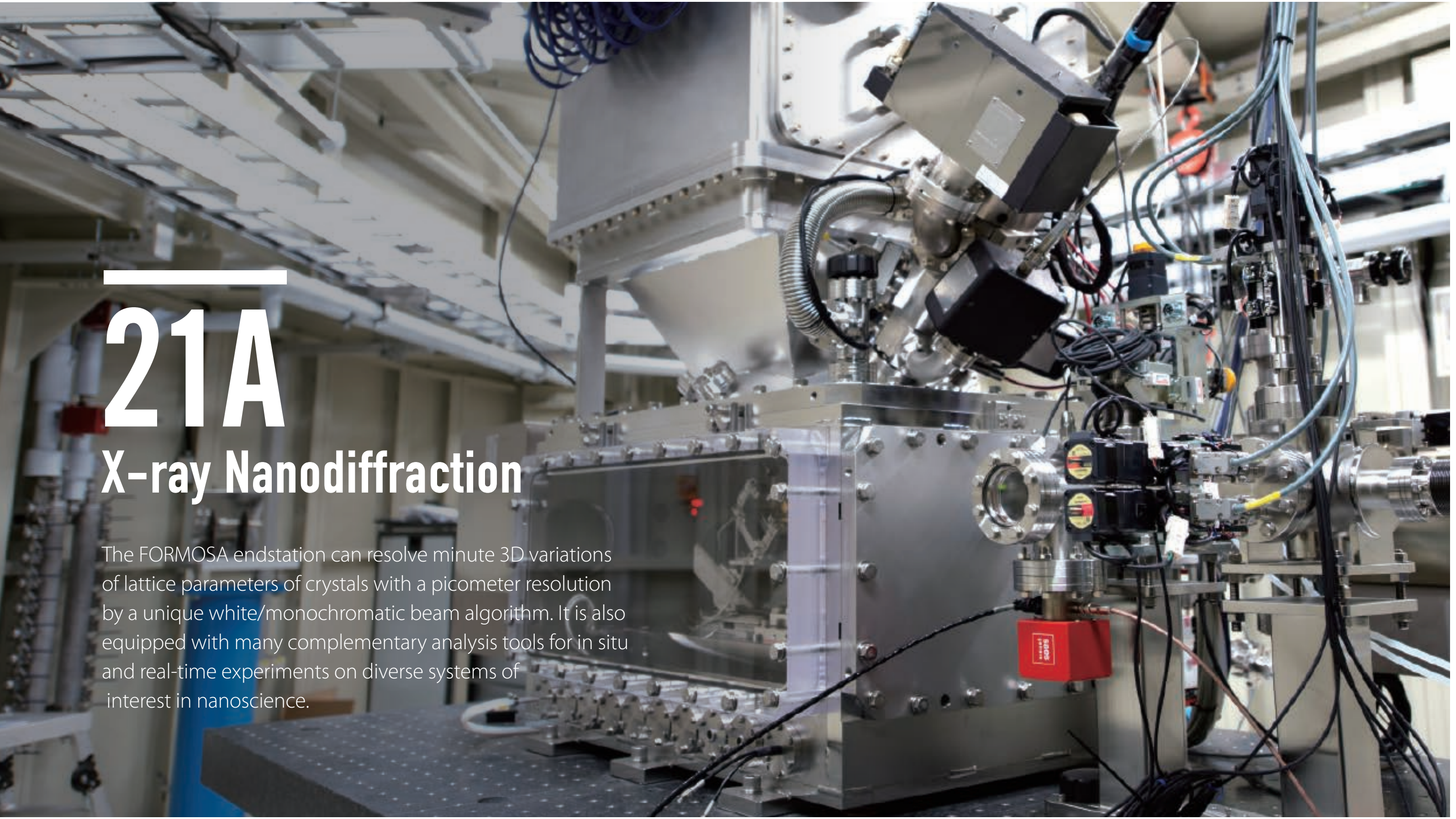






POWDER XRD ENDSTATION

- Ultrahigh angular resolution selectable by swapping to the multianalyzer detector stage
- High acquisition speed
- Non-ambient environments
- Automatic sample changer to enable high throughput data acquisition
- Remote access capability



21A

X-ray Nanodiffraction

The FORMOSA endstation can resolve minute 3D variations of lattice parameters of crystals with a picometer resolution by a unique white/monochromatic beam algorithm. It is also equipped with many complementary analysis tools for in situ and real-time experiments on diverse systems of interest in nanoscience.

UNIQUE FEATURES

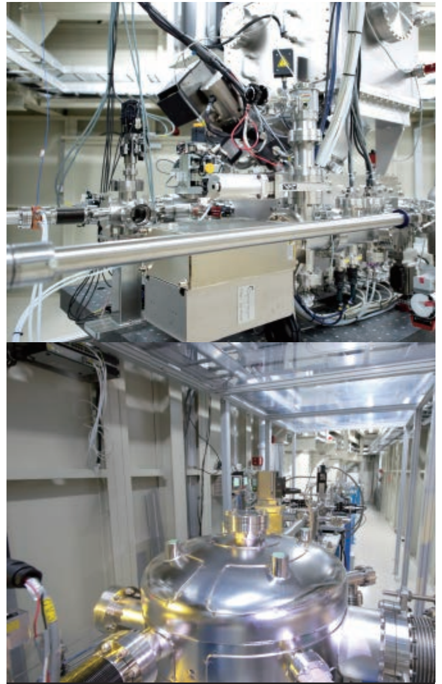
- Tapered undulator
- 4-bounce channel-cut monochromator
- White/monochromatic beam
- Energy range: 5 – 30 keV
- Energy resolution: 1×10^{-4} at 25 keV
- KB focus at 25 keV: 80×80 nm^2 (lateral)
- Photon flux: 3×10^{11} s^{-1} at 10 keV

SCIENTIFIC OPPORTUNITIES

- X-ray Laue nanodiffraction to probe orientations, stresses/strains, phases, dislocations, grain boundaries, and deformations of matters in 3D
- Nanoscience
- Materials science and condensed matters
- Extreme-environment physics

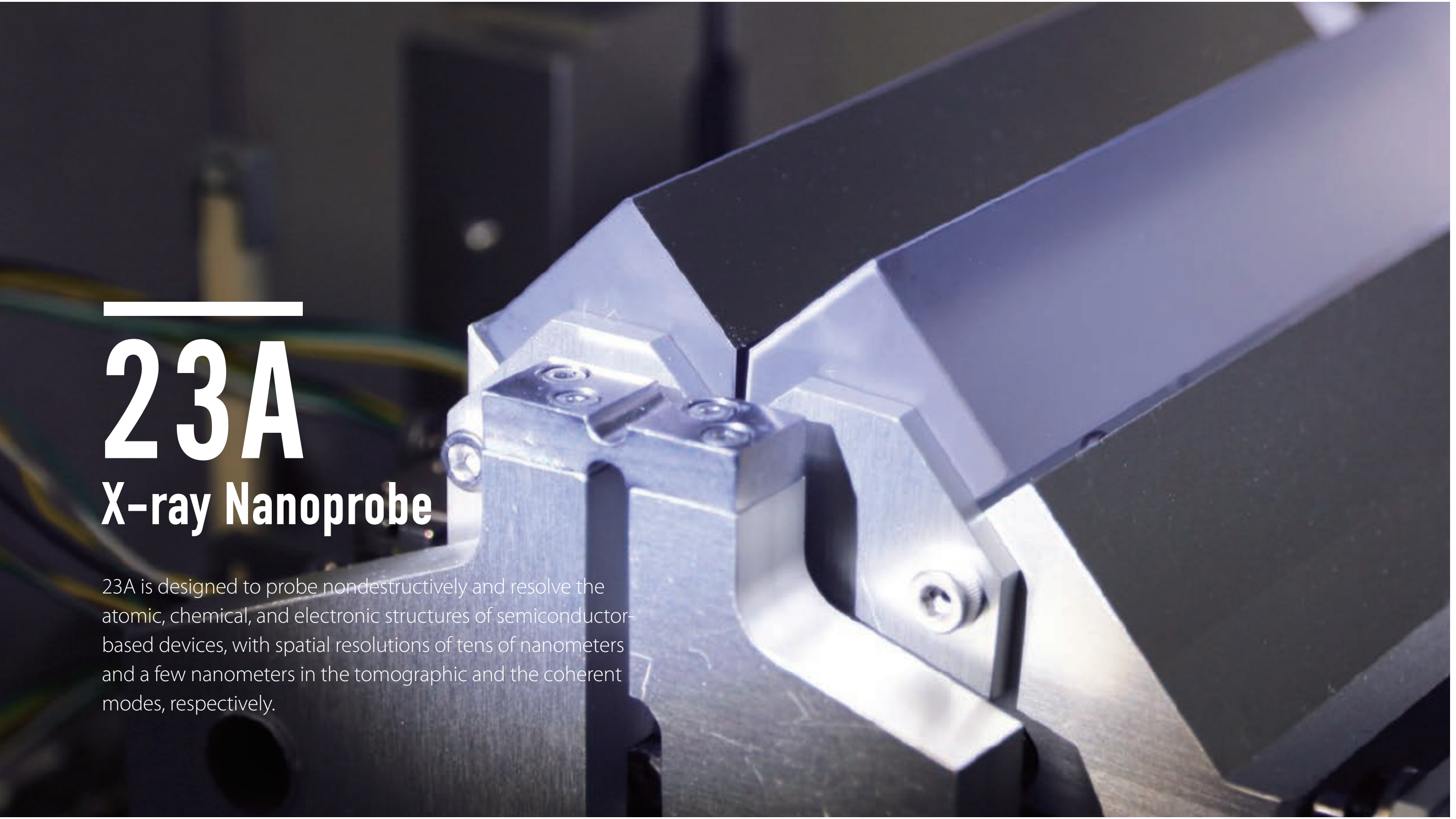
FORMOSA ENDSTATION (FOcus x-Ray for MicrO-Structure Analysis)

- 3D X-ray Laue diffraction by a profiler with a 40 nm depth resolution
- Multifunctional endstation providing nano- Laue XRD, nano-XAS, nano-XRF, nano-XEOL and nano-PXM simultaneously for diverse research fields
- On-line SEM & chamberscope for real-time imaging to seek out and position the probe to the areas of interest quickly
- Ambient/vacuum (7.6×10^2 – 1×10^{-7} torr) operation environments
- Quadra-probe with a variable-temperature sample stage (100 – 1,300 K) to provide complementary information (electrical, mechanical, optical and surface)
- A high-speed X-ray detector/scanner, a high-speed computer cluster, and high photon fluxes to facilitate routine 3D structural analyses



3D X-RAY NANODIFFRACTION

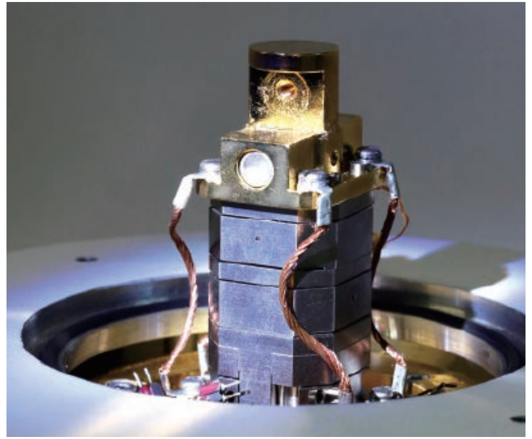
The future of materials science and engineering

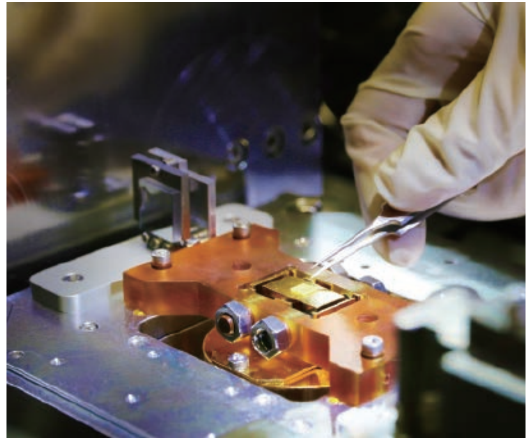


23A

X-ray Nanoprobe

23A is designed to probe nondestructively and resolve the atomic, chemical, and electronic structures of semiconductor-based devices, with spatial resolutions of tens of nanometers and a few nanometers in the tomographic and the coherent modes, respectively.





UNIQUE FEATURES

- Nano- X-ray fluorescence
- Nano- X-ray absorption
- Nano- X-ray excited optical luminescence (XEOL)
- Nano- time-resolved XEOL
- Nano- projection X-ray microscopy
- Nano- coherent X-ray diffraction imaging
- Bragg ptychography

THE EXPERIMENTAL STATION

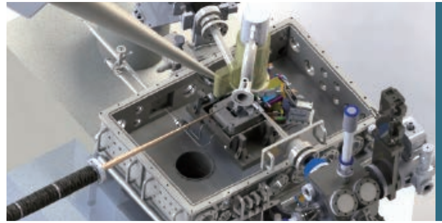
- Montel KB optics for nanofocusing (40 nm)
- Fly-scan for XRF and XEOL mappings
- Sample environment
  - He-cryogenic cooling (10 K – 300 K)
  - In-vacuum (~10^{-6} torr)
- Lateral resolution better than 10 nm (using Bragg ptychography)
- SEM integration
- Streak camera for time-resolved XEOL

SCIENTIFIC OPPORTUNITIES

- Nanoclusters and nanoparticles
- XEOL and quantum confinement
- Complex oxide heterostructures
- Strains inside nano-devices
- Emergent 2D materials, topological insulators
- In situ failure analysis
- Dynamics of luminescence

X-RAY BEAM PROPERTIES

- Energy range: 4 – 15 keV
- Beam size at 10 keV : 40 nm in both H & V directions
- Beam resolution: < 2×10^{-4} with the Si(111) crystals
- Photon flux: 5×10^{10} s^{-1} at 10 keV
- High-order harmonic contamination: $\leqq 1 \times 10^{-4}$

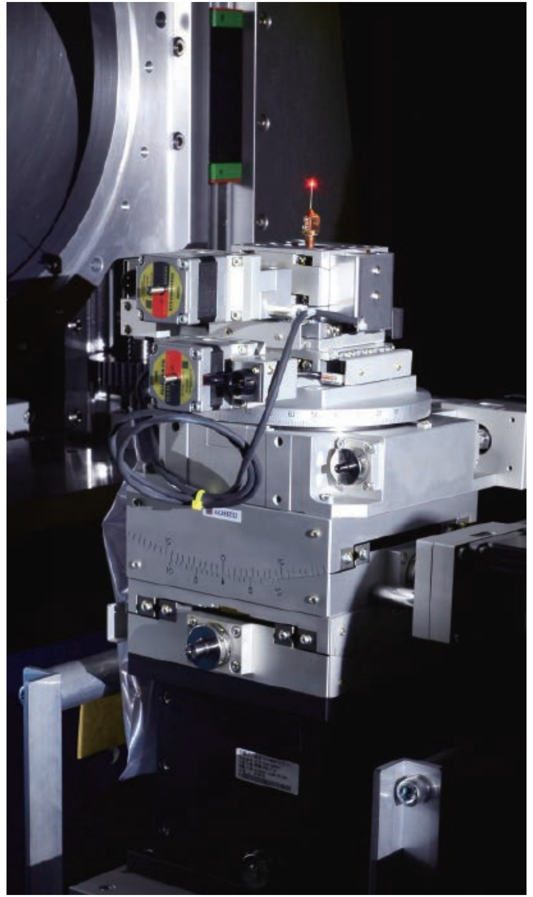


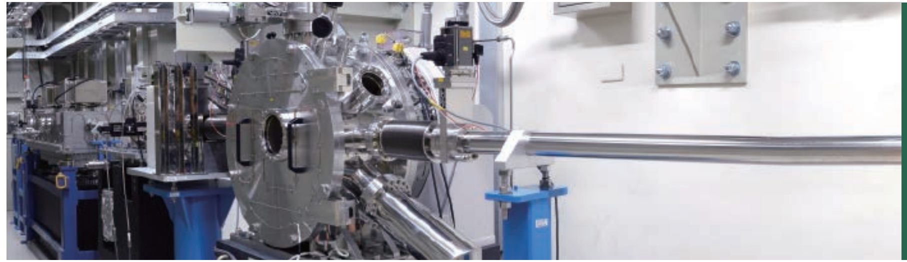
Probing beyond Moore's and more

25A

Coherent X-ray Scattering

With intense, coherent X-rays from two collinear in-vacuum undulators, 25A aims to reveal static structures and dynamics of advanced functional materials with the powerful techniques of X-ray photon correlation spectroscopy, ptychography, and small-angle X-ray scattering.





Reconstructing real space images beyond conventional scattering techniques

CORE TECHNIQUES

- X-ray photon correlation spectroscopy dynamics of materials, polymers, and systems in life science
- Coherent X-ray diffraction imaging for non-periodic materials
- SAXS/liquid GI-SAXS static structures of materials

KEY PARAMETERS

- Energy range: 5.56 – 20 keV
- Beam sizes: 1 × 1 or 10 × 10 μm^2
- Coherent flux: 4 × 10^{10} s^{-1} at 6 keV
- Q-range: 0.0005 – 3 $Å^{-1}$
- Time resolution: ~ 1 ms

X-RAY PHOTON CORRELATION SPECTROSCOPY (XPCS)

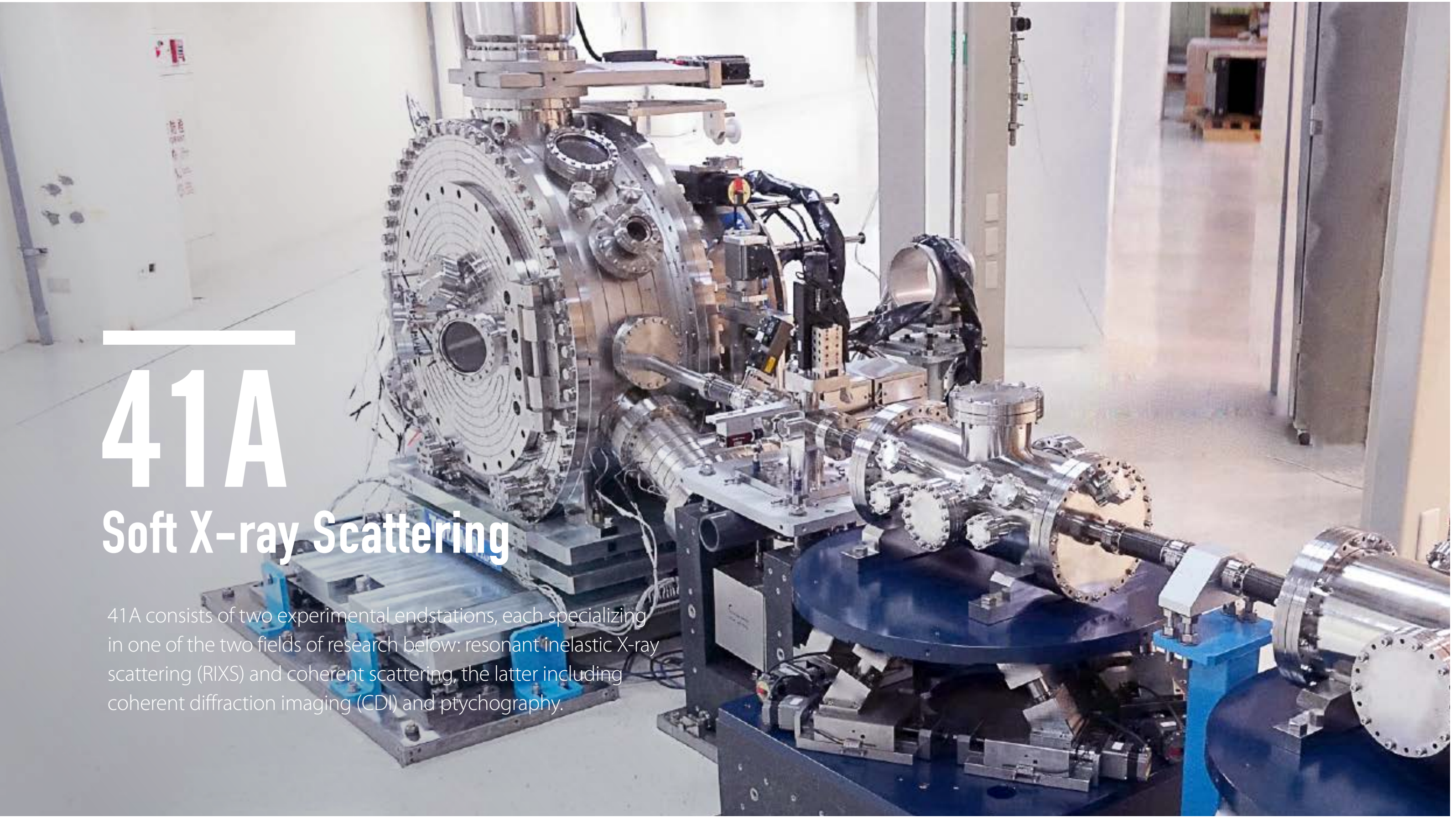
- XPCS measures the temporal changes in speckle patterns produced when coherent light is scattered by a disordered system.

COHERENT X-RAY DIFFRACTION IMAGING (CDI)

- CDI is a lensless microscopy. The real-space image of the object can be reconstructed using a phase-retrieval algorithm.

SAMPLE ENVIRONMENTS

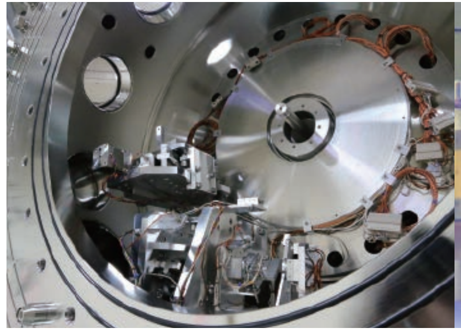
- Gas membrane cell (~ 50 GPa)
- Temperature-control system (100 K – 550 K)
- Rheometer (torque: 0.5 nN•m – 230 mN•m)
- Tensile stage (tensile force 0.1 – 200 N)
- LB troughs (compression ratio: 10.8)

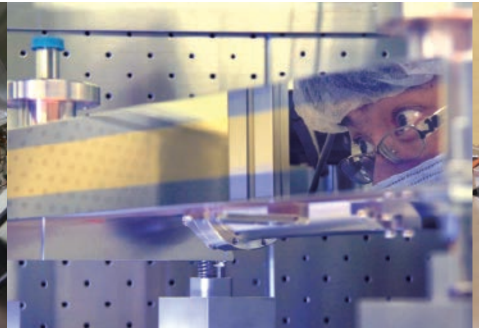


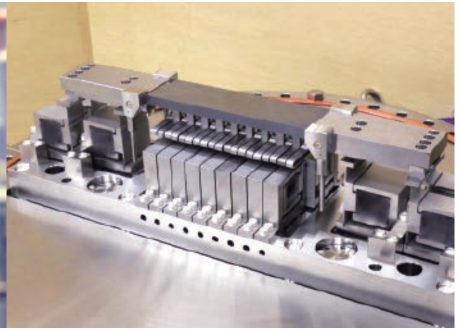
41A

Soft X-ray Scattering

41A consists of two experimental endstations, each specializing in one of the two fields of research below: resonant inelastic X-ray scattering (RIXS) and coherent scattering, the latter including coherent diffraction imaging (CDI) and ptychography.







X-RAYS OF ENERGIES FROM 400 eV TO 1200 eV

RIXS

- Photon flux at 900 eV : 7×10^{12} s^{-1} • $(0.01\%\ BW)^{-1}$
- Beam size: 5 μm (H) × 5 μm (V)
- Total resolving power at 900 eV : 60,000 (initial target), 100,000 (final goal)

COHERENT SCATTERING

- Coherent photon flux at 900 eV: ~ 1×10^{11} s^{-1} • $(0.02\%\ BW)^{-1}$
- Bragg CDI
- Ptychography with a resolution of 10 nm

HIGH-RESOLUTION RIXS

- Through the energy compensation scheme, the RIXS design using active gratings greatly improves efficiency.
- The grating profile is adaptively changed.
- Total RIXS resolutions:
  ~10 meV at O K-edge
  ~15 meV at Cu L-edge

SCIENTIFIC OPPORTUNITIES

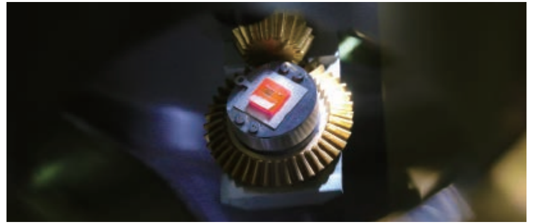
- Probing the interplays between charge, spin, orbital and lattice degrees of freedom
- Excitations of phonons, magnons, orbitons, electron–hole pairs, band gaps, etc.
- Mapping of electronic states by CDI
- Magnetic ptychography at nanoscales

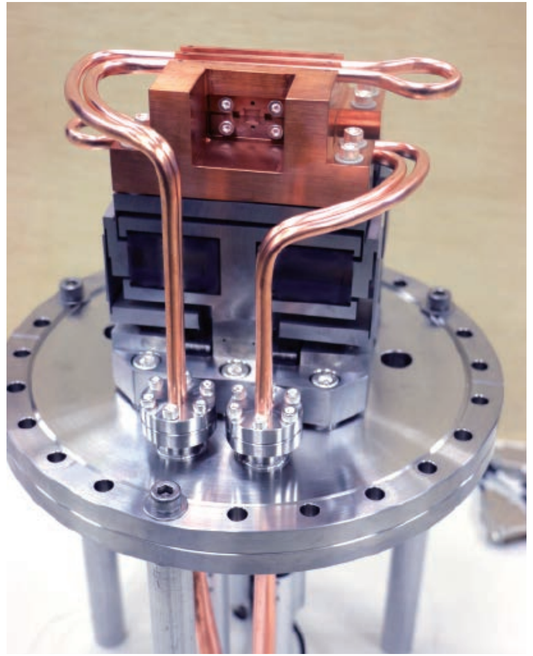
Unraveling electronic excitations with soft X-rays

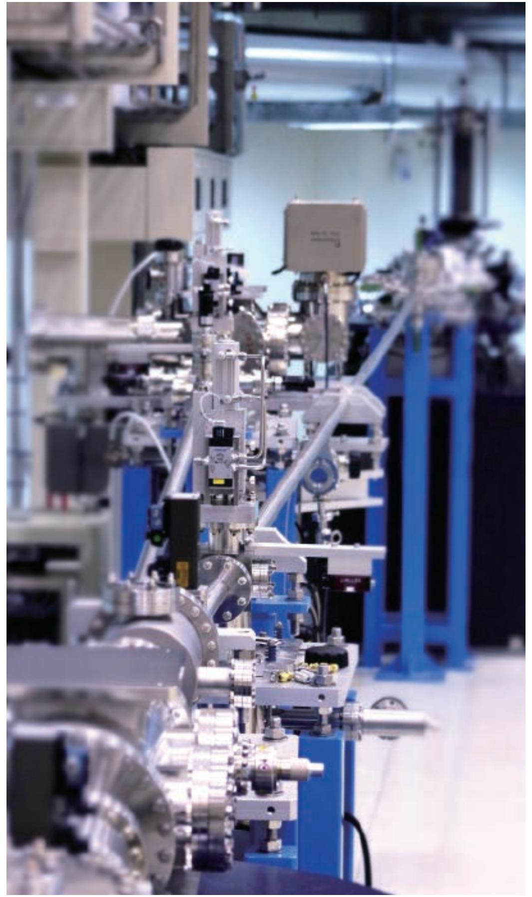
45A

Submicron Soft X-ray Spectroscopy

45A consists of two endstations, one from MPI for X-ray angle-/spin-resolved photoemission spectroscopies and the other from TKU for X-ray emission/absorption and X-ray excited optical luminescence spectroscopies.







CORE TECHNIQUES

Soft-X-ray Spectroscopies: angular/spin-resolved photoemission, X-ray emission, X-ray absorption, and magnetic circular dichroism to study the electronic (occupied and unoccupied) and magnetic structures of the following, among others:

- Topological insulators/metals/superconductors
- Carbon-related systems and nanomaterials
- Photovoltaic materials
- Electron-correlated materials
- Magnetic materials

UNIQUE FEATURES

- Energy range: 280 eV – 1,500 eV
- Small beam size 1.2 (H) × 0.4 (V) μm^2
- Energy resolving power at 750 eV: 84,000 (initial target), 140,000 (final goal)
- Photon flux: 1 × 10^{11} s^{-1} at 750 eV

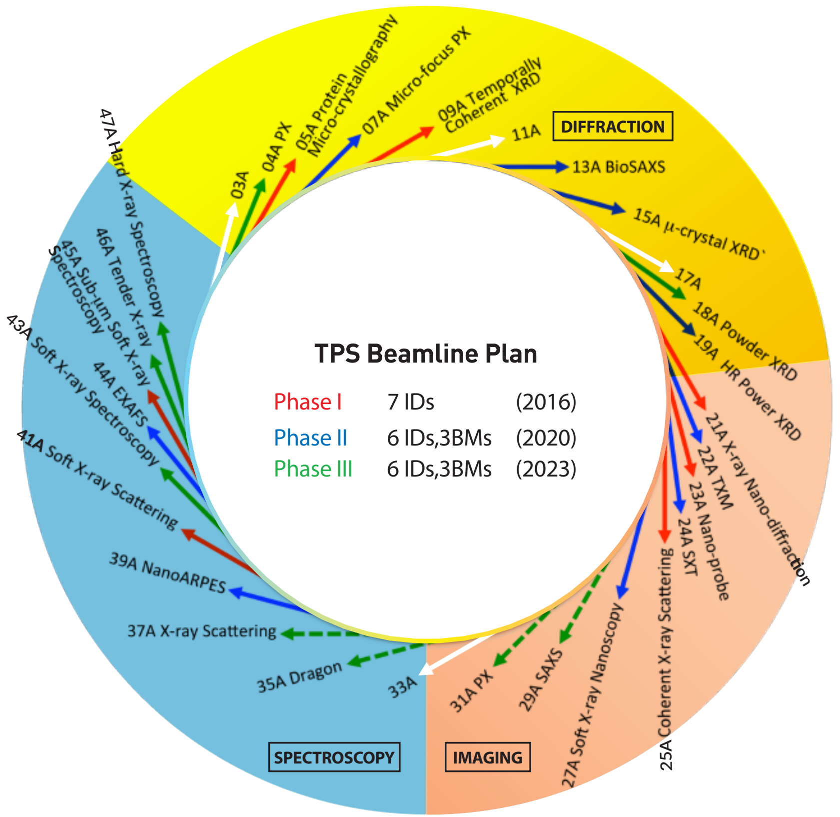
Revealing hidden subtleties of material with submicron soft-X-ray spectroscopies

TKU ENDSTATION

- Varied line-spacing X-ray emission spectrometer
- X-ray excited optical luminescence system
- In situ liquid/gas cell sample system
- Magnetic circular dichroism chamber with a 2 tesla magnetic flux density
- High precision 5-axis (x, y, z, azimuth, and polar) sample manipulator with an LHe cryostat

MPI ENDSTATION

- SPEC PHOIBOS 225 hemispherical electron energy analyzer
- Four-channel micro-Mott detector
- A molecular-beam-epitaxy (MBE) thin-film growth system with a sample transfer mechanism
- LEED, an ion sputtering gun, and e-beam heaters for sample preparations and surface characterizations



National Synchrotron Radiation Research Center

The National Synchrotron Radiation Research Center (NSRRC) is a non-profit and research institute, funded by the Ministry of Science and Technology (MOST) in Taiwan, to provide two synchrotron light sources (1st: 1.5 GeV-Taiwan Light Source (TLS) and 2nd: 3 GeV-Taiwan Photon Source (TPS)) for researchers in Taiwan and overseas to conduct frontier scientific experiments. The TLS consists of 25 beamlines and over 50 experimental stations. The TPS will accommodate ~40 beamlines (partly available for sponsor, co-sponsor, or customization per request). Currently, the NSRRC has over 2,000 users annually, the largest number of users among all large scaled scientific research facilities administrated under the MOST in Taiwan.

Apply for beam time at
http://portal.nsrrc.org.tw

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