Report of Taiwan Beamline Office at SPring-8

The 1.5 GeV storage ring of TLS was built to be a 3rd generation synchrotron source for VUV and soft X-ray research. For Taiwan users to perform advanced X-ray studies, access to foreign synchrotron X-ray facilities is necessary. With strong support of the National Science Council, a Memorandum of Understanding and Agreement for SPring-8 Taiwan Contract Beamlines was signed between JASRI (Japan Synchrotron Radiation Research Institute) and APCST (Asia and Pacific Council for Science and Technology) in December 1998, which marked the beginning of SRRC's Taiwan Beamline Project at SPring-8. Under this project, two beamlines namely the bending magnet line BL12B2 and the undulator line BL12XU were funded for completion in five years with a total budget of NTD 300 M (~ USD 10M). The Project has proceeded smoothly since then with helps of SPring-8. Both beamlines are now in operation with 80% of the beam time given to NSRRC users. The two Taiwan contract beamlines at SPring-8 have opened a new chapter of synchrotron X-ray research in Taiwan.

We are pleased to see strong request of uses at BL12B2 with the number of user-runs increased from 90 in 2001 to 190 in 2002. A profile of the user distribution of BL12B2 is shown in Fig. 1. In 2002, we celebrated the opening of the protein crystallography station at BL12B2 and the completion of inelastic X-ray scattering beamline BL12XU. The installation of a protein crystallography station was achieved through a joint effort of JASRI and NSRRC. Based on the use of this station, numerous new structures of protein crystals have already been solved (see Research Highlights: Biology). As for BL12XU, a 3-meter long inelastic X-ray spectrometer was installed in April 2002. Through continuous technical advances, a total energy resolution of 70 meV with 10 keV photons has been achieved at present (see Research Highlights: Experimental Methology).

The Taiwan Beamline Office at SPring-8, as established in October 1999, takes charge of the operation of the Taiwan Beamlines at SPring-8. At present, the Office stations five staff members, including three scientists, one engineer and one office assistant.

A short selection of scientific highlights on materials studies is shown in the following. For biostructural studies, the readers are referred to the article of Protein Crystallography Initiative. Major milestones of the SPring-8 project are listed in the following for reference.

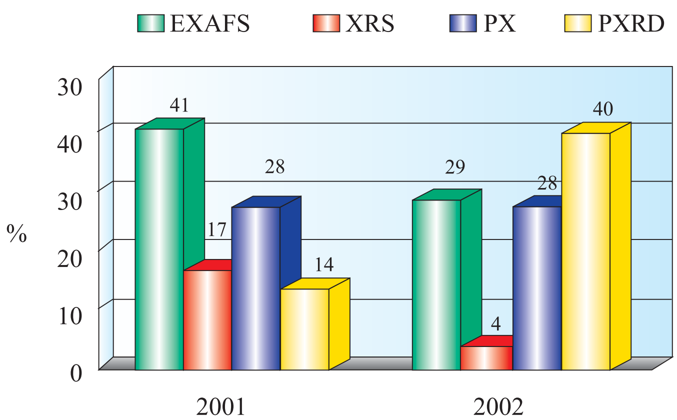

Fig. 1: Distribution of the beamtime allocation to four different end stations on BL12B2.

General Administration

+ Apr. 1998	Letter of Intent submitted to JASRI
+ Dec. 18, 1998	Memorandum of Understanding signed
+ Oct. 1999	Taiwan Beamline Office (TBO) at SPring-8 established
+ Feb. 18, 2003	First SPring-8 interaction meeting with TBO

BL12B2

+ Aug. 1999	Installation of front end
+ Jun. 2000	Hutch installation completed
+ Oct. 13, 2000	Beamline commissioning
+ Nov. 3, 2000	First EXAFS on Cd edge (26.7 keV) obtained
+ Sep. 2001	Open for XAS and X-ray diffraction/scattering
+ Dec. 2001	First protein structure solved by MAD
+ Sep. 2002	Open for protein crystallography users

BL12XU

+ Jan. 2000	Installation of undulator
+ Aug. 2000	Installation of front end
+ Dec. 17, 2001	Beamline commissioning
+ Apr. 2002	Installation of IXS spectrometer
+ Jun. 9, 2002	First IXS spectrum of plasmon loss of aluminum
+ Feb. 2003	First resonant inelastic X-ray scattering on NiO
+ Sep. 2003	Open for IXS users

Acknowledgements

We are indebted to the SPring-8 Director Prof. Akira Kira and former Director Prof. Hiromichi Kamitsubo for their strong support of the Taiwan beamline project. We give our thanks to many staff members at SPring-8 for their kind helps with special thanks due to Drs. S. Kikuta, T. Ueki, H. Suematsu, T. Ishikawa, and H. Kitamura, for their technical and scientific advices. The smooth operation of the Taiwan Beamline Office at SPring-8 is largely credited to the administrative support from SPring-8 Users Office. We also acknowledge generous technical supports given by many staff members of NSRRC in Taiwan. Special thanks are given to Profs. Y-C Liu and P-K Tsang and Dr. C-C Kao (NSLS) for their invaluable helps in the early stage of beamline construction. The running of SPring-8 project would not be possible without a strong financial commitment of National Science Council of Taiwan.

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Experimental Highlights

X-ray Absorption Spectroscopy

The XAS station has been a busy station since the commissioning period of the beamline. A new study led by Prof. C-M Lin (NHCTC) has been initiated to look for the high pressure phase transition of MnTe. The nearest-neighbour bond distance of Mn-Te as obtained from EXAFS was measured under pressure up to 12 GPa. Combined with Raman scattering spectrum and powder X-ray diffraction, the long suspected structural phase transition of MnTe at around 6.0 GPa (in average) was experimentally confirmed. (See Fig. 2)

X-ray Scattering

The self-assembled quantum dots (QDs) have recently attracted intensive research interests due to their potential applications in optoelectronic industry. The surface X-rays scattering has been

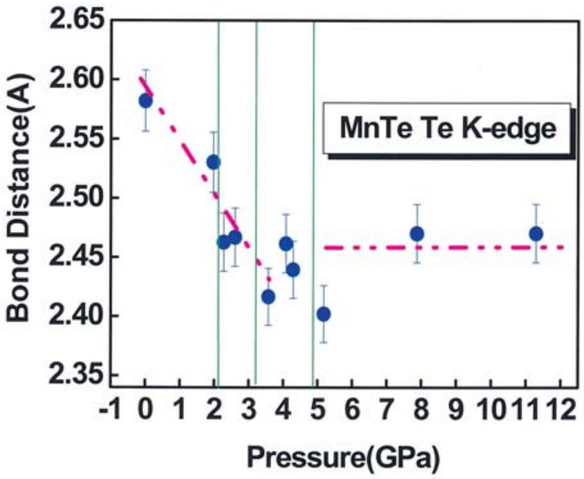

Fig. 2: The nearest-neighbour bond distance of Mn-Te as obtained from EXAFS measurement under pressure up to 12 Gpa. Combined with Raman scattering spectrum and powder X-ray diffraction, the long suspected structural phase transition of MnTe at around 6.0 GPa was experimentally confirmed.

applied to provide an atomic resolution probe in mapping the strain distribution and compositional profile within the dots. By applying the anomalous X-ray scattering at the Ga *K*-edge to the (020) weak reflection of the InGaAs/GaAs QDs, Drs. C.-H. Hsu and Y. Stetsko (NSRRC) developed an element sensitive technique to precisely map the In/Ga composition distribution in the self-assembly In0.5Ga0.5As QDs with much enhancement in sensitivity. (See Fig. 3)

Another interesting study performed on

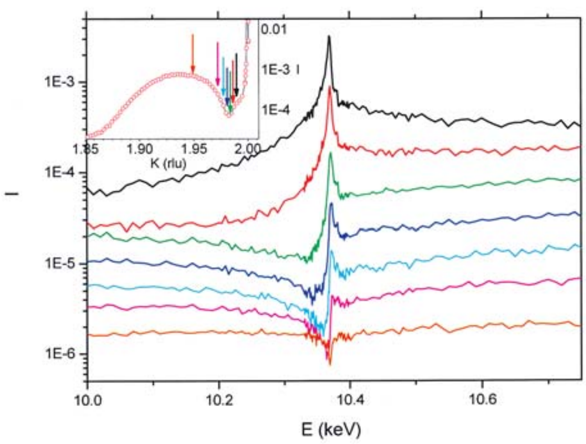

Fig. 3: The anomalous X-ray Diffraction (AXD) technique was adopted to determine the In composition in self-assembled growth InGaAs/GaAs quantum dots. A factor of 20 increase in measurement sensitivity was obtained while performing the AXD at a weak reflection (222) of QD's at Ga K-edge.

BL12B2 is the field induced dynamic phase transitions in the quasi-one-dimensional crystal $K_{0.3}MoO_3$. In this study, Profs. C. H. Du (Tamkang U.) and S. L. Chang (NTHU) and Dr. M. T. Tang (NSRRC) applied X-ray multiple diffraction technique to measure the phase shifts of the charge-density waves (CDWs). The evolution of the multiple diffraction peaks with the applied electric field was measured at T = 100 K. The shape of the peak was observed to change as the applied fields approaching to the threshold value E_{th}(7.5 V, suggesting a relative phase shift ($\triangle\varphi_{ij}$) of about 40o (See Fig. 4). This field-induced behavior is related to the dynamic phase transitions between the states of creep, plastic flow, and moving solid.

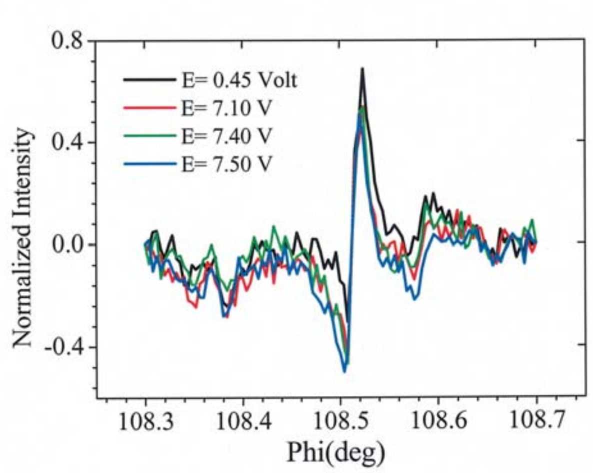

Fig. 4: The evolution of the multiple diffraction peaks with the applied electric fields. The scans were taken on a CDW reflection of $K_{0.3}MoO_3$ at T= 100 K. The shape of the peak was observed to change as the applied fields approaching to the threshold value E_{th}~7.4 V, suggesting a relative phase shift ($\triangle\varphi_{ij}$) of about 40° .

Inelastic X-ray Scattering

The inelastic X-ray scattering spectrometer is now operational with a 65 meV resolution (see article 20 of Research Highlights), and affords studies on finer features that were not possible before, as demonstrated by the successful measurement of the dynamical structure of electrons in single crystal MgB_2 led by Dr. Y. Q. Cai (NSRRC). MgB_2 is a superconductor with an unusually high critical temperature (T_c ~ 40 K). A large number of studies have been reported since its discovery and a consistent picture has emerged of a phonon-mediated, multi-gap superconductor with strong electron-phonon coupling that conforms to conventional theory. A recent first-principle calculation of the dynamical density response function of MgB_2 in particular predicted a sharp collective charge excitation in MgB_2 at ~2.5eV for **q** along the *c**-axis. This excitation is caused by coherent charge fluctuations between the Mg and B layers, and is believed to reflect the unique electronic structure of MgB_2 that is also responsible for the strong electron-phonon coupling. IXS experimental data were obtained from a free-standing single crystal of MgB_2 along the [001] direction perpendicular to the Mg and B planes at room temperature. The crystal measures $300\times500\times(\sim20)\ \mu m^3$ in size. Å collection of energy loss spectra showing the dispersion of the sharp collective mode over a range of q values is presented. The boundary of the 1st BZ corresponds to q = 0.89 $Å^{-1}$. The momentum resolution is 0.06 $Å^{-1}$. (See Fig. 5)

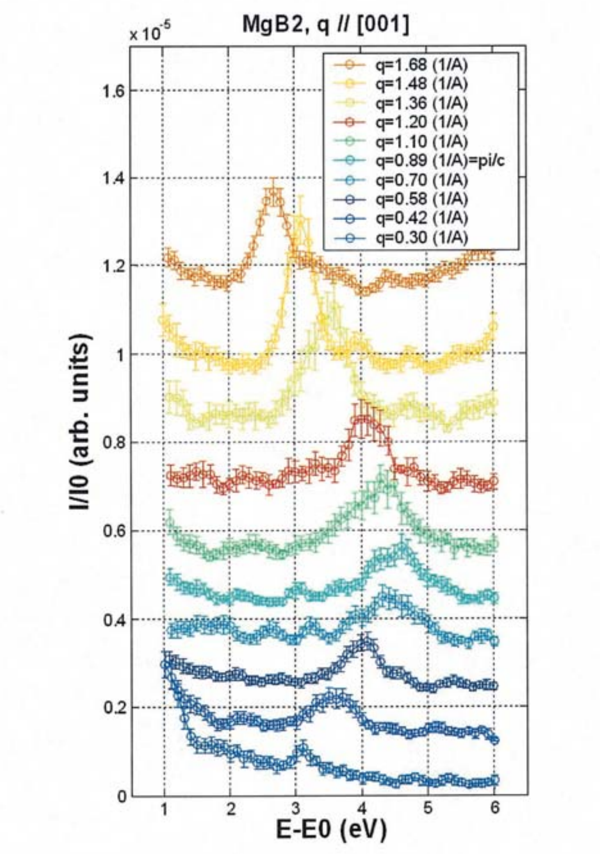

Fig. 5: A collection of energy loss spectra showing the dispersion of the sharp collective mode over a range of q values is presented. The boundary of the 1st BZ corresponds to q = 0.89 $Å^{-1}$. The momentum resolution is 0.06 Å.