VIII-Ⅱ-1.　Project Research

Project 4

PR4-1 Project for Improving the Utilization Activity on KUR and HL in KURRI under Strategic Promotion Program for Basic Nuclear Research (II)

Y. Saito and Y. Kawabata

Research Reactor Institute, Kyoto University

INTRODUCTION: Neutron radiography is a powerful tool for fluid flow visualization as well as multiphase flow research. However, the experimental conditions performed in research reactors are in most cases much different from the practical applications. Due to safety reasons it has been difficult to perform boiling heat transfer experiments at a high system pressure with large electrical current in the reactor room. In order to visualize such boiling two-phase flow, a new neutron radiography facility was installed at the B-4 beam hole, at the Kyoto University Research Reactor (KUR). DC power supply, a thermal hydraulic loop, a cooling water unit, and an imaging system were installed in the experimental room to perform boiling two-phase flow experiments. Various experiments were performed to verify the availability of this facility.

RESEARCH ACTIVITY: The B-4 beam hole is equipped with a super-mirror neutron guide tube with a characteristic wavelength of 1.2Å. In the experimental room not only the NR facility but also prompt gamma analyzing system were installed as shown in Fig.1.

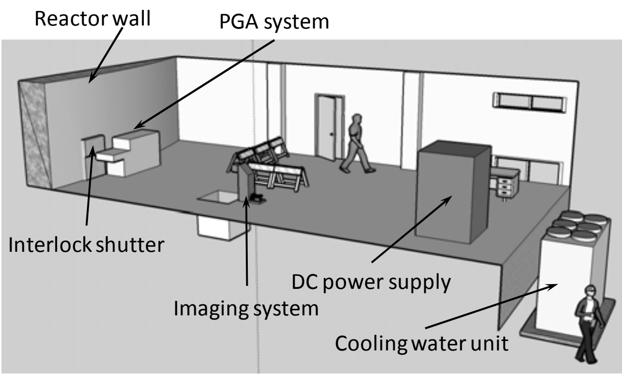


Fig.1 Schematic view of B-4 facility.

In this project, various experiments have been performed using this neutron radiography facility as follows:

1) Static NR for Two-phase flow

Figure 2 shows static NR images taken by using the CCD camera. The test tubes are made of stainless steel. One has a uniform outer diameter and the other has a non uniform diameter to obtain non-uniform heat flux distribution, which gives a maximum heat flux at the center of the tube for boiling heat transfer experiments. Both of the tests were performed without joule heating for preliminary visualization and the liquid-gas interface can be clearly observed as shown in these pictures.

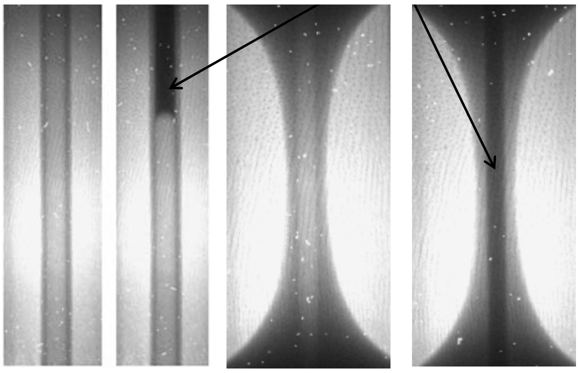


Fig. 2. Static NR for Two-phase flow.

2) Dynamic NR for Two-phase flow

A high-speed camera was used to take dynamic two-phase flow images with an image intensifier. Figures 3 show consecutive images of a water-air two-phase flow at 5MW operation. The exposure time was 2ms corresponding 200fps. The movement of liquid slug bubble can be clearly seen as shown in these consecutive images.

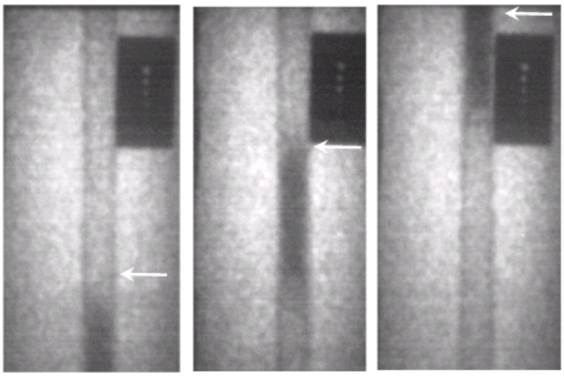


Fig.3. Dynamic NR for Two-phase flow.

CONCLUSION: To visualize boiling two-phase flow at high heat flux by using neutron radiography, a new neutron radiography facility was developed in the B-4 beam hole of the KUR. This new NR facility enables boiling heat transfer experiments under high heat flux conditions and various visualizations owing to the flexible arrangements of devices in the experimental room.

採択課題番号 22P4-1　京大炉（ＫＵＲ）及びホットラボの利用高度化に関する研究　プロジェクト
（京大・原子炉）川端祐司、田中浩基、高宮幸一、関本　俊、齊藤泰司、徐　虬、高橋千太郎、

PR4-2 Studies on Boiling Two-phase Flow by Neutron Radiography

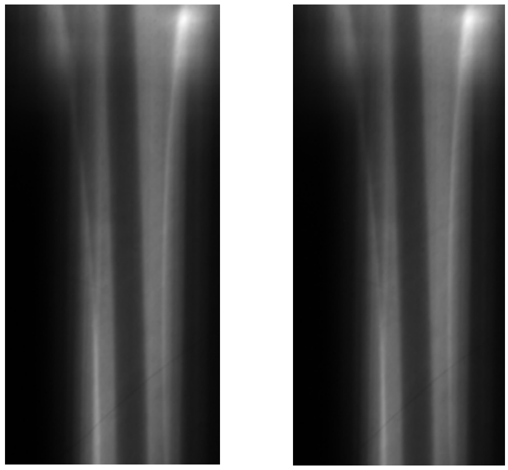
N. Takenaka, H. Asano, K. Sugimoto, H. Murakawa, Y. Kawabata[1] and Y. Saito[1]

Graduate School of Engineering, Kobe University
[1]Research Reactor Institute, Kyoto University

INTRODUCTION: It is important to measure void fraction to study two-phase phenomena. Subcool boiling two-phase flow has been studied from safety consideration of a nuclear reactor. However, it was difficult to measure the void fraction since the two-phase flow was in a metallic tube and the value was quite low. Neutron radiography is applicable to the void fraction measurement of boiling two-phase flow under high pressure and high temperature condition. The void fraction in subcool boiling two-phase flow was measured by neutron radiography.

EXPERIMENTS: Neutron radiography system at B-4 port in KUR was used for visualization. Irradiation room of the B-4 port is out of reactor room and suitable for two-phase flow experiments. The neutron radiography images were obtained by a cooled-CCD camera (16bits, 1024x1024 pixels). Subccoled water was supplied to a stainless steel tube heated by direct AC electrical current. Boiling started to occur at the exit of the tube. Image processing methods were applied to the obtained images and cross-sectional averaged axial void fraction distributions and radial void fraction distributions by Abel transformation were measured.

RESULTS: Figure1 shows examples of the obtained image without and with boiling. The black regions near the center indicate the water in the tube. It is difficult to see the boiling condition by the images since the void fraction was quite low in the subcool boiling. The void fraction was calculated with the two images by image processing methods. The cross-sectional averages axial void fraction distribution near the exit of the tube was obtained as shown in Fig.2. The measured void fraction was very small less than 1%. The void fraction increases with increasing the axial distance. The reasonable void fraction distribution less than the void fraction 1% could be obtained. The radial void fraction distribution was calculated by Abel transformation assuming that the void fraction distribution in the tube was axially symmetric. Fig.3 shows an example the radial distribution at 124 mm in the axial distance in Fig.2. The typical peak neat the wall surface in the subcool boilng can be reasonably seen. It was shown that the neutron radiography was applicable to the void fraction measurement of boiling two-phase flow less than 1%, which had been difficult by the other void fraction measurement methods.



(a) non-boiling (b) subcool boiling

Fig.1. Original image without and with boiling.

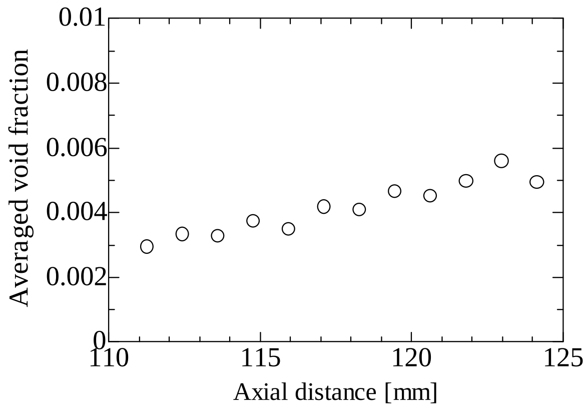


Fig.2. Cross-sectional averaged axial void fraction distribution.

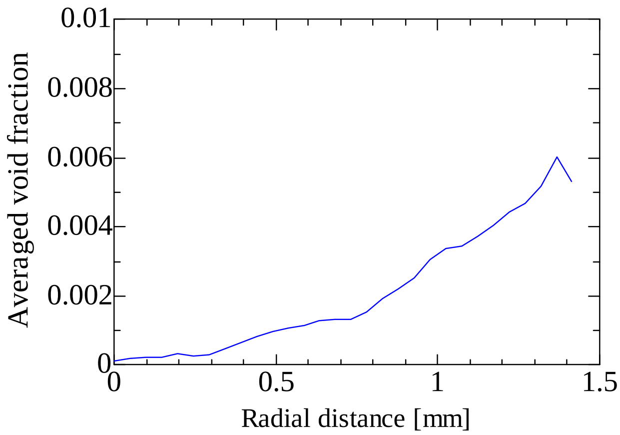


Fig.3. Radial void fraction distribution obtained by Abel transformation.

採択課題番号 22P4-2 中性子ラジオグラフィによる沸騰二相流の研究 プロジェクト
（神戸大・工）竹中信幸、浅野等、杉本勝美、村川英樹、（京大・原子炉）川端祐司、齊藤泰司

PR4-3 In-Situ Observation of Mixing Behavior in a Flow-Type Reactor for Supercritical Hydrothermal Synthesis Using Neutron Radiography

T. Tsukada, K. Sugioka, S. Takami [1], T. Adschiri[1], K. Sugimoto[2], N. Takenaka[2], Y. Saito[3] and Y. Kawabata[3]

Dept. of Chemical Engineering, Tohoku University
[1]*IMRAM, Tohoku University*
[2]*Dept. of Mechanical Engineering, Kobe University*
[3]*Research Reactor Institute, Kyoto University*

INTRODUCTION: Recently, a variety of metal-oxide nanoparticles have been synthesized by supercritical hydrothermal synthesis [1]. For the design and optimization of the process, it is important to acquire the correct knowledge about the mixing behavior of cold aqueous feed solution and supercritical water in a hydrothermal reactor. However, a common technique to visualize the flow is not available because the high-pressure reactor vessel is opaque to visible light. In this work, neutron radiography (NRG) was used to visualize the flow in a flow-type reactor for supercritical hydrothermal synthesis, and the effects of fluid flow rates and temperature of supercritical water on the mixing behavior in the reactor were investigated.

EXPERIMENTS: The flow-type reactor consists of stainless steel 1/4-inch tubes and a tubing connector at which water at room temperature (cold water), corresponding to the feed aqueous solution, is mixed with supercritical water. In the experiment, pressure in the reactor was set to be 25 MPa, and the temperature of supercritical water T_{scf} was varied between 657 and 671 K. The flow rate ranges of supercritical water Q_{scf} and cold water Q_{rt} were 4–8 mL/min and 1–20 mL/min, respectively. The tubing connector in the reactor, i.e., the mixing part, was irradiated by neutron beam for flow visualization, where the attenuation coefficient of neutron beam for supercritical water is lower than that for cold water depending on their density. The density of water is less than 0.2 g/cm^3 at 673 K, and approximately 1 g/cm^3 at room temperature, respectively.

RESULTS: Figure 1 shows the NRG images at the mixing part in the reactor for the two flow rates of cold water, where Q_{scf} = 4 mL/min. The figure demonstrates that the mixing behavior of supercritical water and cold water can be visualized definitely by NRG. In addition, it is found that the density-stratified layer of two fluids is generated in the feed line of cold water when Q_{rt} is relatively small as shown in Fig.1(a).
Fig.2 shows the effect of Q_{rt} on the density distributions of water in the reactor for Q_{scf} = 4 mL/min, where the distributions were obtained by applying the appropriate image-processing technique to the NRG images shown in Fig.1. The horizontal axis on the figure represents the number of pixels along the vertical tube, and the region between 502 and 577 corresponds to the mixing part. From the figure, the density of supercritical water increases rapidly after mixing with cold water, and the tendency becomes more remarkable as Q_{rt} increases. These distributions of water density correspond to the temperature distributions in the reactor.

CONCLUSIONS: In this work, it was demonstrated that the mixing behavior of aqueous feed solution and supercritical water in a flow-type reactor for supercritical hydrothermal synthesis can be visualized by NRG.

REFERENCES:
[1] T. Mousavand *et al.*, *J. Mater. Sci.*, **41** (2006) 1445.

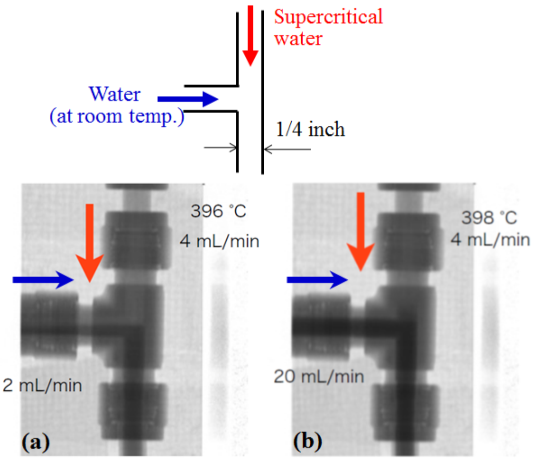


Fig.1. Neutron radiographic images of mixing part in the flow-type reactor.

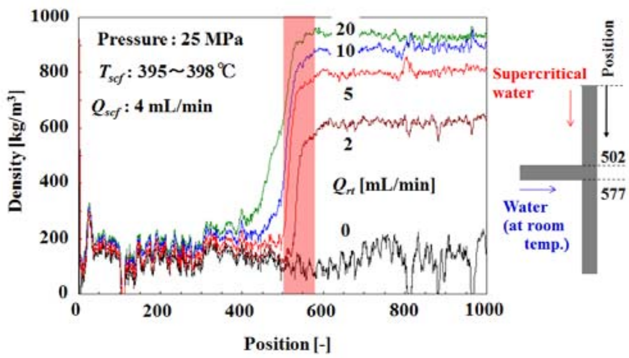


Fig.2. Effect of Q_{rt} on the axial density distributions in the reactor for Q_{scf} = 4 mL/min.

採択課題番号 22P4-3 中性子ラジオグラフィを利用した超臨界水反応場の in-situ 観察 プロジェクト
（東北大院・工）塚田隆夫、杉岡健一、（東北大・多元研）高見誠一、阿尻雅文、
（神戸大院・工）杉本勝美、竹中信幸、（京大・原子炉）齊藤泰司、川端祐司

PR4-4 Quantitative Measurement of Liquid-film Movement under Forced Convective Boiling Condition by Using Neutron Radiography

S. Nakamura, S.Taniguchi, T. Hirose, K. Sakaura, M. Ozawa, T. Ami, R. Matumoto, H. Umekawa and Y. Saito[1]

Dept. Mech. Eng., Kansai University
[1]Research Reactor Institute, Kyoto University

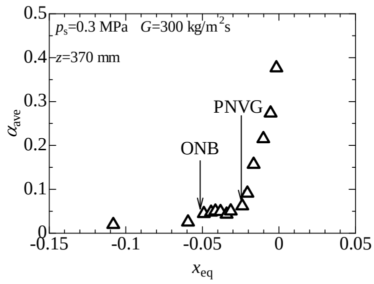
INTRODUCTION: The understanding of the liquid film characteristics in forced convective boiling is a key issue of the understanding of the liquid film dryout. Thus, the qualitatively measurement of liquid by using the neutron radiography can be considered as the powerful tool in these fields. In this paper, to estimate the performance of this procedure, the qualitatively measurement of the void fraction and the estimation of the point of vapor generation were conducted.

EXPERIMENTS: An experimental apparatus was a vertical forced convective boiling system. It mainly consisted of a reserve tank, pump, a flow-meter, a vertical test section and a separator. Test section was a SUS304 tube with I.D. 5.2 mm O.D. 7mm and 400 mm in heated length. Test-section was uniformly heated by Joule heating of DC power. Experimental condition was as follows; the system pressure was up to 0.3 MPa, the mass flux was set to 300, 500 and 700 kg/m^{2}s, the inlet temperature was 60 deg.C. The working fluid was the degassed ion-exchanged water.

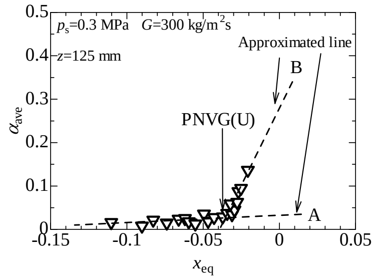
As a neutron source, Kyoto University Research Reactor (neutron flux was 1×10^7 n/(cm^{2}s) at the port exit under 1 MW operation) was used. Time average images were obtained by CCD camera with 30 seconds of exposure period. In the image processing the spatial average value among 0.06 mm(horizontal) ×0.42 mm(vertical) was used, and the measurement error of the void fraction was roughly estimated as 6%.

RESULTS: Figure 1 shows the average void fraction among the cross section at two axial positions (z=125mm, z=370mm). The Void Fraction was measured under the stepwisely increasing of the heat flux. Thus the magnitude of the heat flux of z=125mm was slightly higher than that of the z=370mm. As shown in Fig.1(a), under low heat flux condition, stepwisely increment of void fraction is observed firstly, and after the plateau, the drastically increasing is observed. In this paper, these two typical transient points are represented as the ONB (Onset of Nucleate Boiling) and PNVG (Point of Net Vapor Generation). On the other side, under slightly higher heat flux condition (Fig.1(b)) the plateau is not observed, and only the drastically increasing can be observed. This transition of void fraction is represented as PNVG(U) to distinguish with the PNVG in Fig.1-(a).
In Fig.2, These results are plotted by the quality and the Boiling number. In this figure, several correlations (PNVG: Saha-Zuber[1], ONB:Sekoguchi[2]) are also drawn. Although the experimental condition of this investigation corresponds to the Low Peclet number region, the PNVG takes the similar tendency with the high Peclet number case and PNVG(U) takes the similar tendency with the original tendency as shown in Fig.2. These results suggested the influence of the magnitude of the heat flux on PNVG not only the Peclet number.
These data express the usability of the thermal neutron radiography in the investigations of forced convective boiling.

This investigation is partially supported by the Kansai University Research Grants.: Grant-in-Aid for Joint Research 2009-2010.



(a) z = 370 mm (lower heat flux condition).



(b) z = 125 mm (higher heat flux condition)

Fig.1 Estimation of the onset of nucleate boiling.

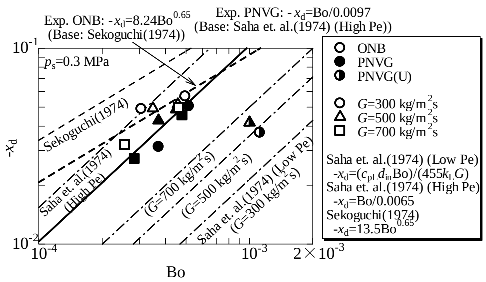


Fig.2 Comparison of the experimental results with correlation.

REFERENCES:
[1] P. Saha *et al.*, Proc. 5th Int. Heat Trans. Conf., (1974) 175.
[2] K. Sekoguchi *et al.*, Proc.5th Int.Heat Trans.Conf.,(1974)180.

採択課題番号 22P4-4 強制流動沸騰系における管内液膜挙動の定量評価に関する研究 プロジェクト
（関大院）梅川尚嗣、小澤　守、網 健行、谷口　斉、中村祥太、廣瀬拓哉、阪倉一成、中川将彦
（京大・京大炉）齊藤泰司、川端祐二、沈　秀中

PR4-5

Neutron Imaging of Industrial Components and Simulation Using VCAD System

Y. Yamagata[1,6], K. Hirota[1,3], S. Morita[1,6], J. Ju[1,6]
Y. Ohtake[1,3], H.Yokota[2,7], T. Sera[2,4], H. Sunaga[1,8], Y. Kawabata[5], M.Hino[5], M. Kitaguchi[5] and M. Sugiyama[5]

RIKEN Cluster for Innovation, RIKEN
([1]Advanced Manufacturing Metrology Team,
[2]Bio-research Infrastructure Construction Team,
[3]Nishina Accelerator Research Center, Radiation Laboratory)
[4]Osaka University
[5]Research Reactor Institute, Kyoto University
([6]previously at VCAD Applied Fabrication Team,
[7]VCAD Bio-research Infrastructure Construction Team,
[8]VCAD System Support Team)

INTRODUCTION:

Non-destructive testing of industrial components are becoming important for recent production engineering. The purpose of such testing includes control the quality of the product to lower the production cost, to maintain reliability and safety, to realize ecological performance. Neutron radiography has advantage over X-ray that heavy metals like steel, nickel or tungsten can be well penetrated, while light elements like hydrogen gives better contrast so that liquid inside metal structure or composite materials can be observed with better precision.

The authors have constructed a cooled CCD based neutron imaging device at E-2 radiography port and tested the performance using various industrial components. Besides, captured images are process by VCAD software, which is developed at RIKEN. VCAD system can handle three dimensional data of "real" object, which usually contains profile errors or defects inside. By using VCAD software, three dimensional images are reconstructed based on neutron radiography data.

EXPERIMENTS: A cooled CCD based neutron imaging device was constructed. Fig.1 shows the configuration of the device. It has 6LiF-ZnS based scintillator with thickness of 100micrometer and area of 150x150mm. The cooled CCD camera has 4008x2672 pixels. This resulted in the equivalent pixel size at scintillator of about 50 micrometer.

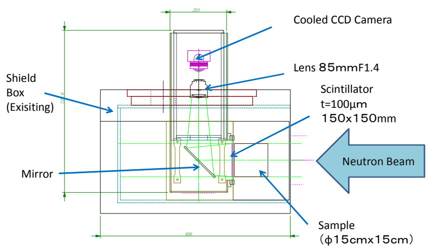
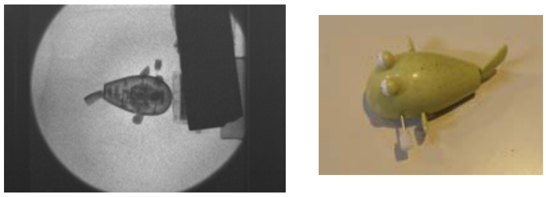
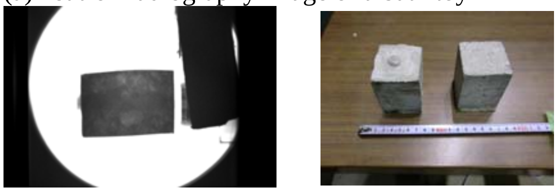


Fig.1. Developed Imaging Camera.

A number of industrial samples are captured by this camera and some images are processed to construct 3D images. Fig.2 (a) is a bath toy sample consisting of plastic shell and metallic gear components, which represent composite industrial components. The result shows that both plastic and metallic components can be well observed by neutron radiography. Fig.2 (b) represent concrete with steel reinforcement. Internal structure of concrete and steel rod can be recognized. Fig.2 (c) is a steel pyramid and penetration depth of about 5 cm can be confirmed.



(a)Neutron radiography image of a bath toy



(b) Neuron raidography of concrete with steel reinforcement

(c) Neutron radiography of steel pyramid
Fig .2. Neutron radiography of industrial components.

By using VCAD software system, a number of consecutively rotated images are converted into 3D images, which represent the possibility of neutron radiography of industrial components.

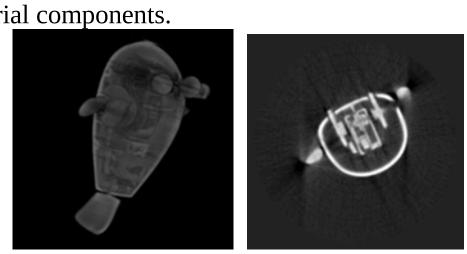


Fig.3. 3D rendered image and cross section of a bath toy.

採択課題番号 22P4-6　　中性子ラジオグラフィによる工業製品の内部情報取得と　　プロジェクト
ＶＣＡＤによるシミュレーション
（理研）山形豊、広田克也、森田晋也、朱正 明、大竹淑恵、横田秀夫、世良俊博
（京大・原子炉）川端祐司、日野正裕、北口雅暁

PR4-6 **Analysis of Neutron Spin-Phase Data of Electric Current**

S. Tasaki, Y. Iwata, T. Tanaka, Y. Abe and M. Hino[1]

Department of Nuclear Engineering, Kyoto University
[1]Research Reactor Institute, Kyoto University

INTRODUCTION: Neutron spin phase contrast (NSPC) imaging is a method to visualize the magnetic field integral along the trajectory of neutron. The principle of NSPC is to measure additional phase difference between spin eigen states of Larmor precessing neutron, by means of neutron spin interferometry. In NSPC imaging, neutron intensity changes sinusoidally, depending on the phase difference of incident neutron. Due to the magnetic field along the way of neutron, the sinusoidal curve is shifted, and the shift is proportional to the magnetic field integral. Moreover, the contrast (visibility) of the sinusoidal curve may change depending on the homogeneity and the direction of the magnetic field.
In the present study, we apply NSPC method to measure magnetic field induced by electric current, to develop NSPC imaging to visualize electric current distribution.

EXPERIMENTS:
Photograph of the sample is shown in Fig.1. Two copper wires with 1mm-diameter and 20mm-length is soldered between Cu plates. The electric current flows inside of the wires. Such current produces the magnetic field, and is to be measured.
Neutron experiments were performed at C3-1-2-2 beam port of JRR-3M in JAEA. Wavelength of the neutron beam is 0.88nm ($\delta\lambda/\lambda$=2.7%), available beam size is 10mm in width and 30mm in height.
Experimental set-up is shown in Fig.2. Incident neutron is polarized vertically with 5Q-supermirror polaizer fabricated with Ion Beam Sputtering system in KUR. Then the spin of the neutron is half flipped with resonance neutron flipper. In the middle of the set-up, PI-flipper is installed in order to cancel outer magnetic-field and to introduce phase difference ϕ between two spin states of neutron. The sample is located after the PI-flipper and then PI/2-flipper and spin analyser is set for analyzing the phase of neutron spin wave. Neutron spin analyser is V-shape polarizer with 5Q-polarizing supermirror and the transmitted neutron is measured with 2D-RPMT with Li-glass scintillator. Interference fringe is obtained from the change of neutron intensity via the phase between neutron spin states.

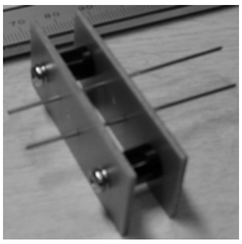


Fig.1. Photograph of the sample.

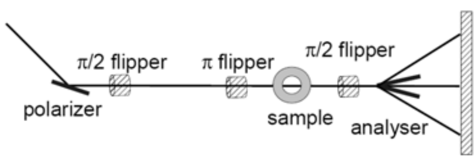


Fig.2. Experimental set-up.

RESULTS: Figure 3shows measured phase difference between neutron eigen states distribution due to the magnetic field of the 2A-electric current of the wire. In Fig.4 measured phase is compared with calculated results and shows good agreement.

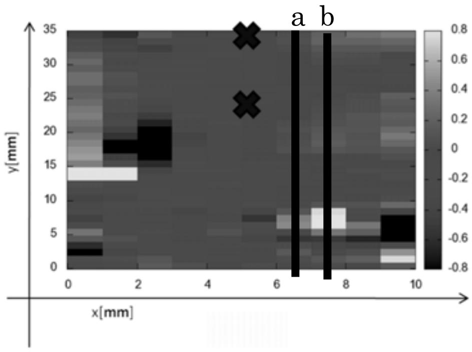


Fig.3. Phase distribution of neutron around the current(×mark).

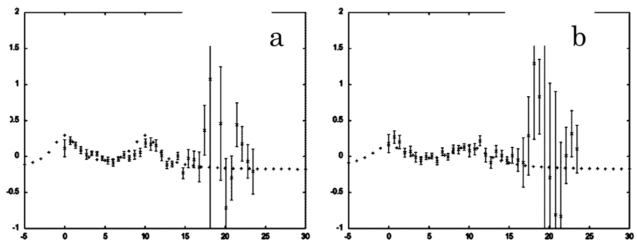


Fig.4. Comparison of measured(dots) and calculated(broken lines) phase along the lines in Fig.3.

PR4-7

Trial to Fabricate Large-scale Neutron Supermirror by using IBS Instrument at KURRI

M. Hino, T. Oda[1], M. Kitaguchi and Y. Kawabata
Research Reactor Institute, Kyoto University
[1]*Department of Nucl. Eng., Kyoto University*

INTRODUCTION:

Multilayer mirror is one of the most important devices for slow neutron experiments. The multilayer mirror consists of alternating layers of two materials with different potential energies for the neutron. It has artificial lattice spacing (d-spacing) and gives one-dimensional optical potentials for a neutron beam. Supermirror is a stack of the multilayers with gradually increasing value of the d-spacing. A multilayer with small d-spacing and supermirror with large-m are desirable to enlarge utilization efficiency for neutron scattering experiments. Here m is a maximum critical angle of the mirror in unit of critical angle of nickel. Of course, it is also very important to fabricate high reflectivity supermirror even in low-m. Ion beam sputtering (IBS) technique enables us to fabricate smooth layer structure with sharp edge. we have succeeded in fabricating m>5 supermirrors and very small d-spacing multilayer using ion beam sputtering (IBS) technique [1], and neutron optics group in JAEA has installed a large IBS machine and is producing supermirror for J-PARC project [2]. Even today, the performance of supermirror and small d-spacing multilayer are improved. In fact, we have succeeded in fabricating m=7 supermirrors and very small d-spacing multilayer mirror with wide-band and high reflectivity. The d-spacing at maximum intensity is 2.89 nm and reflectivity is higher than 0.4 [3].

Supermirror is used as most important key component of neutron guide tube. In general, the total length of neutron guide tube is longer than 10 m. When we fabricate neutron guide tube, the size of deposition area is very important. The maximum substrate area for our KUR-IBS was limited to 200 mm in diameter due to the size of load lock. On the other hand, the maximum substrate area of IBS at JAEA is 500 mm in diameter. It is enough large to fabricate real neutron guide tube. Though these purposes were different at that time, we studied feasibility to fabricate large scale supermirror with high performance.

EXPERIMENTS:

It is necessary a lot of expense and large space to enlarge load lock system at KUR-IBS. Thus we gave up use the load lock system and replaced substrate holding system in this time. The maximum area of new substrate holder was 480mm and it was limited by size of process vacuum chamber. The substrate holder is fabricated in the workshop in KURRI. The deposition parameter was optimized by estimation of test sample coating by using X-ray reflectometer.

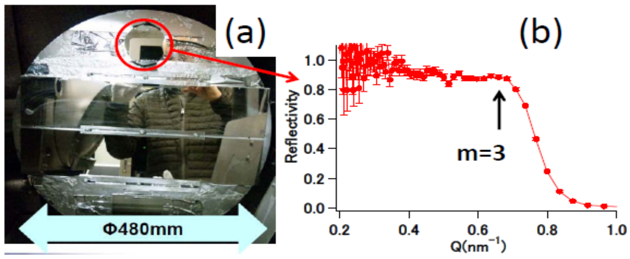


Fig.1. (a) The photograph of two pieces of float glass and silicon wafer fixed on new substrate holder. (b) Measured reflectivity of m=3 supermirror deposited on silicon.

Figure 1(a) shows photograph two rectangular pieces and a 3 inch silicon wafer after coating of m=3 NiC/Ti supermirror. They are mounted on the sample holder. The size of float-glass is 450 mm in length, 100 mm in width and 5mm in thickness. The number of layer of supermirror (m=3) was 524. The total process time was about 40 hours.

Figure 1(b) shows reflectivity by m=3 supermirror on the silicon wafer. The measurement was carried out at Time-Of Flight (TOF) instrument installed at CN-3 beam port at KURRI. The net measurement time was less than 2 hour even in 1MW reactor operation. As shown in Fig.1 (b), the reflectivity on silicon wafer was high, however, reflectivity on glass was about 10% lower than that on silicon.

Though we have to improve the performance deposited on float glass, in this study, we succeeded in production and checking for large scale neutron supermirror, and showing feasibility to product real high performance neutron supermirror guide tube in house.

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採択課題番号 22P4-9　　　超薄・多層・中性子反射ミラーの開発　　　プロジェクト
（京大・原子炉）日野正裕、川端祐司、北口雅暁（京大・工）小田達郎

PR4-8 **Development of Resonance Spin Scho for Neutron Small Angle Scattering Spectrometer**

M. Kitaguchi, M. Hino, Y. Kawabata, T. Oda[1], S. Tasaki[1], Y. Noda[2] and S. Koizumi[2]

Research Reactor Institute, Kyoto University,
[1]Department of Nuclear Engineering, Kyoto University
[2]Japan Atomic Energy Research Agency

INTRODUCTION: Neutron spin echo (NSE) is one of the techniques with the highest energy resolution for quasi-elastic scattering by measuring rotation of the neutron spin[1]. Modulated intensity by zero effort (MIEZE) spectrometer is a type of neutron resonance spin echo (NRSE)[2]. MIEZE has two resonance spin flippers (RSFs) before scattering at the sample. The phase difference between up- and down-spin components, which is added by the RSFs before scattering is compensated with the flight in the zero magnetic field after scattering. This arrangement is suitable to small angle scattering measurements. The combination of MIEZE and small angle neutron scattering (SANS) enables us to study both of static and dynamical structure of the sample at same time[3].
The compact RSFs for MIEZE-SANS were developed (Fig. 1). An RSF consists of a static magnetic field and an oscillating magnetic field. The static field is proportional to the frequency of the oscillating field. The energy resolution of MIEZE spectrometer is proportional to the frequency of the oscillating field. We designed the RSF with the static field of 17mT for the oscillating field of 500kHz. In order to install the RSFs into existing SANS spectrometer, the gap distance between two poles for the static field was only 76mm. The direction of oscillating field was along to the beam direction. The homogeneity of the field was not good enough to arrange MIEZE with high frequency.

EXPERIMENTS: Test experiments to observe MIEZE signals in SANS spectrometer using the compact RSFs have been performed using the cold neutron beam line SANS-J-II at JRR-3 reactor at JAEA (Fig. 2). We set the two RSFs into the collimator of SANS with the distance of 4.5m. There was the polarizer before the first RSF and the analyzer after the second RSF respectively. We also set the guide field coils to keep neutron polarization. The position sensitive photomultiplier tube, which had been already used for measurements of very small Q region of SANS, was utilized for MIEZE with time-of-flight data acquisition system. The wavelength of the neutron beam could be selected from 0.65nm to 2.0nm by using neutron velocity selector.

RESULTS: The clear MIEZE signals were observed with effective frequency of up to 100kHz (Fig. 3). The distance between the second RSF and the detector was 5m. The wavelength was 0.65nm. We are now trying much higher frequency. When the proper frequencies are selected for the RSFs, the distance between the sample and detector can be enlarged for both of the resolution of SANS and MIEZE. In the case of neutron spin echo, the energy resolution is proportional to the cube of the wavelength. We are also continuing on the developing MIEZE-SANS with longer wavelength neutrons. Polarizer and analyzer for neutrons with wide range of wavelength will be required.

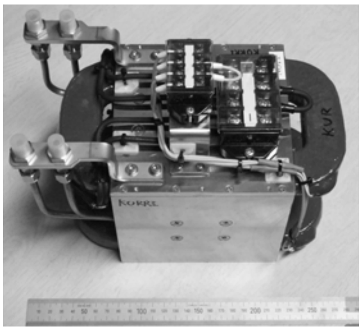

Fig. 1.
New compact RSF for SANS option.

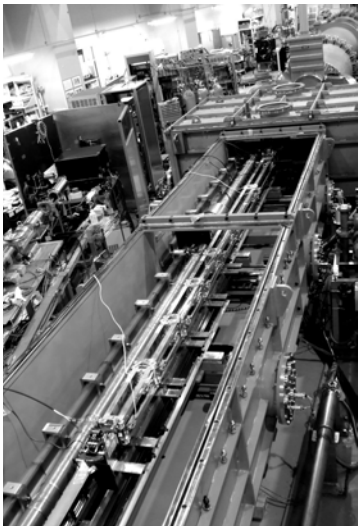

Fig. 2.
Test arrangement of MIEZE-SANS at SANS-J-II beamline in JRR-3.

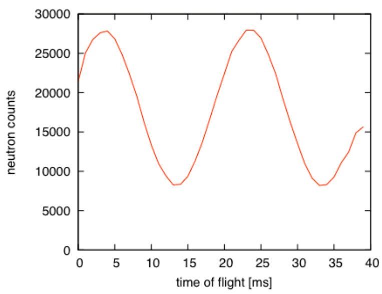

Fig. 3.
Observed MIEZE signals with the effective frequency of 50kHz.

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採択課題番号 P4-10　　中性子共鳴スピンエコー装置のためのデバイス開発　Ⅲ　　プロジェクト
（京大・原子炉）北口雅暁、日野正裕、川端祐司（京大院工）小田達郎、田崎誠司
（原子力機構）能田洋平、小泉 智

PR4 **Development of Neutron Optical Devices and its Application to New Neutron Spectrometer and Imaging**

Y. Kawabata

Research Reactor Institute, Kyoto University

OBJECTIVES AND ALLOTED RESEARCH SUBJECTS :

The aim of this project research is the development of neutron optical devices and its application.

ARS-1 Improving the utilization activity on KUR and HL in KURRI under strategic promotion program for basic nuclear research (II)

ARS-2 Studies on Boiling Two-phase flow by neutron radiography

ARS-3 In-situ observation of mixing behavior in a flow-type reactor for supercritical hydrothermal synthesis using neutron radiography

ARS-4 Quantitative measurement of liquid-film movement under forced convective boiling condition by using neutron radiography

ARS-5 Application of neutron imaging for botanical research

ARS-6 Neutron imaging of industrial components and simulation using VCAD system

ARS-7 Observation of water movement in granitic rocks using neutron radiography

ARS-8 Analysis of neutron spin-phase data of electric current

ARS-9 Trial to fabricate large-scale neutron supermirror by using IBS instrument at KURRI

ARS-10 Development of resonance spin echo for neutron small angle scattering spectrometer

ARS-11 Fabrication and characterization of high quality polarized neutron mirrors for neutron spin phase imaging

MAIN RESULTS AND THE CONTENTS OF THIS REPORT :

Y. Saito et. al (ARS-1) proceeded a project for improving the utilization activity on KUR and HL in KURRI under the Nuclear energy initiative, Research reactor and hot laboratory utilization program. In order to visualize such boiling two-phase flow, a new neutron radiography facility was installed at the B-4 beam hole. DC power supply, a thermal hydraulic loop, a cooling water unit, and an imaging system were installed in the experimental room to perform boiling two-phase flow experiments. Various experiments were performed to verify the availability of this facility.

N.Takenaka et al. (ARS-2) measured the void fraction in subcool boiling two-phase flow using neutron radiography to study safety consideration of a nuclear reactor.

T.Tsukada et al. (ARS-3) visualized the flow in a flow-type reactor for supercritical hydrothermal synthesis using neutron radiography, and investigated the effects of fluid flow rates and temperature of supercritical water on the mixing behavior in the reactor.

N.Umekawa et al. (ARS-4) studied the liquid film characteristics in forced convective boiling to understand the liquid film dryout using neutron radiography. They estimated the performance of this procedure, the qualitatively measurement of the void fraction and conducted the estimation of the point of vapor generation .

U.Matsushima et al. (ARS-5) did not perform their experiments in KUR.

Y.Yamagata et al. (ARS-6) have constructed a cooled CCD based neutron imaging device at E-2 radiography port and tested the performance using various industrial components. Besides, captured images are process by VCAD software, which is developed at RIKEN. VCAD system can handle three dimensional data of "real" object, which usually contains profile errors or defects inside. By using VCAD software, three dimensional images are reconstructed based on neutron radiography data.

A.Cho et.al (ARS-7) did not perform their experiments in KUR.

S.Tasaki et al. (ARS-8) applied neutron spin phase contrast (NSPC) imaging method to measure magnetic field induced by electric current, to develop NSPC imaging to visualize electric current distribution.

M.Hino et al. (ARS-9) had developed high Q supermirrors with very small d-spacing multilayer using ion beam sputtering (IBS) technique, and studied feasibility to fabricate large scale supermirror with high performance.

M.Kitaguchi et al. (ARS-10) have developed compact resonance spin flippers (RSFs) for MIEZE-SANS. Modulated intensity by zero effort (MIEZE) spectrometer is a type of neutron resonance spin echo (NRSE). The combination of MIEZE and small angle neutron scattering (SANS) enables us to study both of static and dynamical structure of the sample at same time.

H.Hayashida et al. (ARS-11) did not perform their experiments in KUR.

採択課題番号 22P4 中性子光学機器の開発と新型中性子散乱装置及びイメージングへの展開 プロジェクト

（京大・原子炉）川端祐司