Synchrotron Radiation Techniques for Catalysts and Functional Materials

October 31 – November 3, 2022

Novosibirsk, Russia

ABSTRACTS

Federal Research Center Boreskov Institute of Catalysis
Synchrotron Radiation Facility SKIF
Budker Institute of Nuclear Physics of SB RAS
Novosibirsk State University

International Conference «Synchrotron Radiation Techniques for Catalysts and Functional Materials»

October 31 – November 3, 2022
Novosibirsk, Russia

ABSTRACTS

Novosibirsk – 2022

УДК 544.47 + 621.384.6
ББК 24.54 + 22.383
S 98

S 98 **Synchrotron Radiation Techniques for Catalysts and Functional Materials**
International Conference, Abstracts (October 31 – November 3, 2022, Novosibirsk, Russia) [Electronic resource] / eds.: Prof. V.I. Bukhtiyarov, Prof. O.N. Martyanov, Prof. Y.V. Zubavichus
– Novosibirsk : Boreskov Institute of Catalysis SB RAS, 2022.
– ISBN 978-5-906376-45-9
– URL: http://conf.nsc.ru/SRTCFM-2022/en

В надзаг.:
Federal Research Center Boreskov Institute of Catalysis
Synchrotron Radiation Facility SKIF
Budker Institute of Nuclear Physics of SB RAS
Novosibirsk State University

Сборник включает тезисы пленарных, устных и стендовых докладов.
Основные темы научной программы конференции:
The collection includes abstracts of plenary lectures, oral and poster presentations.
The main topics of the Conference scientific program are:

- Theoretical and applied aspects of experimental techniques utilizing synchrotron radiation
- Structure-driven design of catalysts and functional materials based on synchrotron diagnostics
- Synchrotron radiation for structural biology
- Development of instrumentation for synchrotron beamlines
- New data processing algorithms, artificial intelligence and machine learning in bulk data analysis
- Update on the status and scientific program of the Synchrotron Radiation Facility SKIF

УДК 544.47 + 621.384.6
ББК 24.54 + 22.383

ISBN 978-5-906376-45-9

CONFERENCE ORGANIZERS

- Federal Research Center Boreskov Institute of Catalysis, Novosibirsk, Russia
- Synchrotron Radiation Facility SKIF, Novosibirsk, Russia
- Budker Institute of Nuclear Physics of SB RAS, Novosibirsk, Russia
- Novosibirsk State University, Novosibirsk, Russia

Budker Institute

of Nuclear Physics of SB RAS

UNDER THE AUSPICES OF

Ministry of Science and Higher Education of the Russian Federation

The conference is held as part of the celebration of the 300th anniversary of the Russian Academy of Sciences

Conference Chair

Prof. Valerii BUKHTIYAROV Boreskov Institute of Catalysis, Novosibirsk, Russia

SCIENTIFIC COMMITTEE

Chair of the Scientific Committee

Prof. Oleg MARTYANOV Boreskov Institute of Catalysis, Novosibirsk, Russia

Deputy Chair of the Scientific Committee

Prof. Yan ZUBAVICHUS SRF SKIF, Boreskov Institute of Catalysis, Novosibirsk, Russia

Prof. Danil DYBTSEV Nikolaev Institute of Inorganic Chemistry, Novosibirsk, Russia
Prof. Dmitry ZHARKOV Institute of Chemical Biology and Fundamental Medicine, Novosibirsk, Russia
Dr. Vasily KAICHEV Boreskov Institute of Catalysis, Novosibirsk, Russia
Prof. Sergey TSYBULYA Boreskov Institute of Catalysis, Novosibirsk, Russia

ORGANIZING COMMITTEE

Dr. Andrey BUKHTIYAROV SRF SKIF, Boreskov Institute of Catalysis, Novosibirsk, Russia
Dr. Andrey SARAEV SRF SKIF, Boreskov Institute of Catalysis, Novosibirsk, Russia
Dr. Mikhail PLATUNOV SRF SKIF, Boreskov Institute of Catalysis, Novosibirsk, Russia
Dr. Kristina SHEFER SRF SKIF, Boreskov Institute of Catalysis, Novosibirsk, Russia
Marina SHABANOVA Boreskov Institute of Catalysis, Novosibirsk, Russia
Marina SUVOROVA Boreskov Institute of Catalysis, Novosibirsk, Russia
Svetlana LOGUNOVA Boreskov Institute of Catalysis, Novosibirsk, Russia

PP-2

Near-Field Phase-Contrast Imaging Using a Secondary SR Source

Kohn V.G.[1], Argunova T.S.[2]

1 – National Research Centre "Kurchatov Institute", Moscow, Russia

2 – Ioffe Institute RAS, St. Petersburg, Russia

argunova@mail.ioffe.ru

The third generation synchrotron radiation (SR) sources provide a powerful tool for studying microstructures by means of in-line phase contrast imaging [1]. This technique allows immediate and fast visualization of any electron density variation inside the material. A thickness variation of a few microns, for instance associated with a pore within the material, involves a very small variation of absorption, but can be associated with a phase shift sufficient for detection. The real size of a micro-pore correlates with the image size only on a very short distance behind the sample. For that, the near-field condition has to be fulfilled; namely, $2r_1 << D$, where $r_1 = (\lambda z)^{1/2}$ is the radius of the first Fresnel zone for the wavelength λ and D is the transverse pore size. Towards the far-field region, where $2r_1 >> D$, the fringe pattern arises, and the object size is visible only in the modulation of the fringes.

Quantitative information from image data can be obtained by solving the inverse problem. The goal is the phase of the transmission function of the object, which is proportional to the total electron density along the beam path. It can be determined, for example, using computer simulations. In the pioneer work by Snigirev *et al*. [1], the first variant of the theory of phase-contrast imaging was also presented. Later, many papers and review articles described the theory, for example [2, 3].

It follows from the theory that the properties of the image depend on the effective distance $Z = z_0z_1/z_t$, where z_0 is the distance from the sample to the SR source, z_1 is the distance from the sample to the detector, and $z_t = z_0 + z_1$. In a standard SR phase-contrast imaging setup (Fig.1,*a*) the following relation is fulfilled: $z_0 >> z_1$. Therefore, Z is very close to z_1. In such a scheme, the projection of the source size is much smaller than the source size itself, which allows the use of the source with relatively large size. A small value of Z is achieved using a small value of z_1.

However, there is another possibility to obtain a small value of Z and implement the near-field regime. We can realize the inverse relationship $z_0 << z_1$. This case is shown in Fig. 1,*b*. In such a case, the experimental image corresponds to the near-field condition, but the image size will be much larger than the object size. At the same time, the projection of the source size also increases, as shown in the figure. The high resolution can be attained only when the transverse source size is smaller than the object size.

A secondary source is required to implement such a scheme with SR source, which, for example, can be created utilizing a compound refractive lens (CRL), first proposed by Snigirev *et al*. [4]. Figure 1,*c* presents an outline of the setup based on such a scheme. Analytical theory of imaging and focusing by CRL was first developed by Kohn [5–7].

We performed the computer simulations choosing a cylindrical micropipe (MP) with a diameter of 2 μm as a model object. MP was located in a SiC crystal. We show the images of the MP calculated at different distances. The intensity ratio at the detector to the intensity in front of the CRL is discussed. The properties of the image recorded using such a scheme are analysed and compared to those of the image recorded using the standard set up. Finally, we show that one can achieve stronger coherence by focusing the beam by the CRL. Consequently, one can implement the secondary-source setup in light sources with a relatively large angular size.

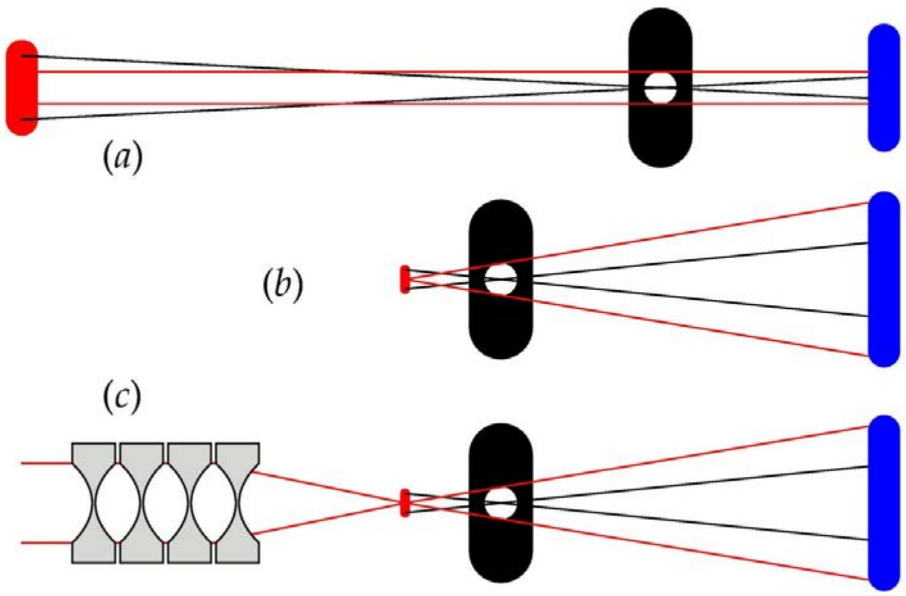

Fig. 1. Experimental schemes considered in this communication. See text for details.

Acknowledgement: V.G. Kohn (conceptualization, software, computer simulations) acknowledges Russian Foundation for Basic Research (RFBR), grant 19-29-12043mk. T.S. Argunova (experimental investigation) acknowledges RFBR, grant 19-29-12041mk, and Ministry of Science and Higher Education of the Russian Federation (Project 075-15-2021-1349).

References:

[1] A. Snigirev, I. Snigireva, V. Kohn, S. Kuznetsov, I. Schelokov, Rev. Sci. Instrum.. 66 (1995) 5486.
[2] Ya.I. Nesterets, S.W. Wilkins, T.E. Gureyev, A. Pogany, A.W. Stevenson, Rev. Sci. Instrum. 76 (2005) 093706.
[3] T. S. Argunova, V. G. Kohn, Phys.-Usp. 62 (2019) 602.
[4] A. Snigirev, V. Kohn, I. Snigireva, B. Lengeler, Nature 384 (1996) 49.
[5] V.G. Kohn, JETP Lett. 76 (2002) 600.
[6] V.G. Kohn, JETP 97 (2003) 204.
[7] V.G. Kohn, M.S. Folomeshkin, J. Synchrotron Radiat. 28 (2021) 419.