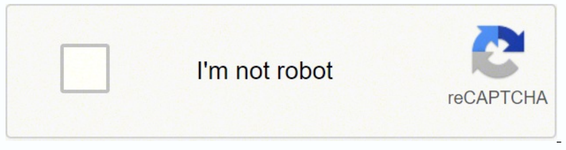

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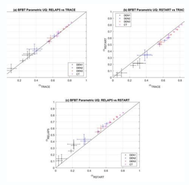

ПОВЕРХНОСТЬ. РЕНТГЕНОВСКИЕ, СИНХРОТРОННЫЕ И НЕЙТРОННЫЕ ИССЛЕДОВАНИЯ, 2019, № 1, с. 1–7

УДК 538.971

КОМПЛЕКТ МНОГОСЛОЙНЫХ РЕНТГЕНОВСКИХ ЗЕРКАЛ ДЛЯ ДВУХЗЕРКАЛЬНОГО МОНОХРОМАТОРА В ДИАПАЗОНЕ ДЛИН ВОЛН 0.41–15.5 нм

© 2019 г. А. А. Ахсахалян[1], Ю. А. Вайнер[1], С. А. Гарахин[1], К. А. Елина[2], П. С. Заверткин[2], С. Ю. Зуев[1], Д. В. Ивлюшкин[2], А. Н. Нечай[1], А. Д. Николенко[2], Д. Е. Парьев[1], Р. С. Плешков[1], В. Н. Полковников[1], Н. Н. Салащенко[1], М. В. Свечников[1], Н. И. Чхало[1, *]

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Оптимизирован состав, рассчитаны рентгенооптические характеристики, изготовлен и изучен комплект многослойных зеркал для модернизированной версии двухзеркального монохроматора, установленного на синхротроне ВЭПП-5 Института ядерной физики им. Г.И. Будкера. За счет использования семи поддиапазонов, для каждого из которых выбрана оптимальная пара материалов, комплект зеркал обеспечивает высокие, от 10 до 75%, коэффициенты отражения в широком диапазоне значений энергии фотонов 80–3000 эВ и длин волн 0.413–15.48 нм. Сообщается о принципах оптимизации пар материалов. Впервые изготовлены и изучены многослойные зеркала на основе пары материалов W/Be.

Ключевые слова: многослойное рентгеновское зеркало, синхротронное излучение, рентгеновская спектрометрия.

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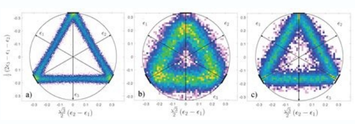
ВВЕДЕНИЕ

Для значительной части экспериментов с использованием синхротронного излучения достаточно спектрального разрешения на уровне $\lambda/\Delta\lambda \sim 100$, а на первый план выходят высокие пиковые и интегральные коэффициенты отражения. Также критически важной является минимизация влияния длинноволнового и коротковолнового излучений на результаты экспериментов на выбранной длине волны. В наибольшей степени этим условиям удовлетворяют многослойные рентгеновские зеркала (МРЗ) брэгговского типа. Большие рабочие углы, существенно превосходящие критические углы полного внешнего отражения, подавляют вклады как коротковолнового, так и длинноволнового излучений в результирующий монохроматический сигнал. Многослойные зеркала также могут эффективно подавлять высшие порядки дифракции. Четные порядки можно подавить практически до уровня нерезонансного отражения за счет выбора толщины сильно и слабо поглощающих материалов для периода d в соотношении 1 : 1. Отражение третьей и высших резонансных m-гармоник эффективно подавляется за счет межслоевых шероховатостей σ, так как коэффициент отражения $R_m \sim \exp(-4\pi^2(m\sigma/d)^2)$. Двукратное отражение в составе двухзеркального монохроматора только усиливает фильтрующие свойства МРЗ, а также повышает результирующее спектральное разрешение примерно в 1.4 раза.

Дополнительным преимуществом использования МРЗ на практике являются относительно невысокие требования к конструкции спектрометра-монохроматора. Большие рабочие углы и широкая кривая качания существенно упрощают требования к точности механических узлов.

В 1998 г. в Институте ядерной физики им. Г.И. Будкера СО РАН был разработан спектрометр на основе двухзеркально монохроматора [1]. Спектрометр позволял исследовать спектры мягкого рентгеновского излучения в диапазоне значений энергии фотонов от 150 до 1800 эВ (0.7–8.2 нм) со спектральной селективностью $\lambda/\Delta\lambda \sim 60$ в середине рабочего диапазона. В работе использовались МРЗ на основе Fe/C, изготовленные методом импульсного лазерного напыления [2], и на основе W/Si, изготовленные магнетронным распылением [3]. Подобные зеркала применяют в монохроматоре станции "Космос", которая с 2007 г. по настоящее время функционирует на накопителе ВЭПП-4 в Институте ядерной



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Applied Physics A
Materials Science & Processing

Sm_2O_3 effects on mass stopping power/projected range and nuclear shielding characteristics of TeO_2–ZnO glass systems

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Abstract
This work aims to research not only neutron and gamma shielding specialties of Sm_2O_3-doped TeO_2–ZnO glasses but also mass stopping power (MSP) and projected range (PR) for alpha and proton particles. Mass attenuation coefficient (μ/ρ) of $60(TeO_2)$–$(40-x)ZnO$–xSm_2O_3 (x = 0.0, 0.1, 0.2, 0.3, 0.4, and 0.5 mol%) glasses were obtained using GEANT4 Monte Carlo codes and WinXCOM software. A good agreement was observed between the two outcomes. The insertion of Sm_2O_3 into the glasses raised the μ/ρ values. It was found that TZSm0.4 glass owns lowest MFP, HVL, and TVL values than the other glass samples due to its high specific gravity. Besides, the additive material increased effective atomic number (Z_{eff}) values of the glasses. Moreover, the addition of Sm_2O_3 into the glasses increased the Z_{eff} values in the energy region 0.015–0.2 MeV photon energies up to 40 mfp. This shows that the addition of Sm_2O_3 improves the performance of glasses to reduce gamma radiation. Moreover, fast neutron macroscopic cross-sections (ΣR) of the glasses were specified. MSP and PR values were also computed for proton (H+) and alpha (He^{2+}) particles. The outcomes display that the specific gravity of the TZSm glasses are extremely influential on neutron, alpha and proton shielding. With the largest ΣR and lowest PR values, the TZ0.4 glass showed the ability to stop both neutral and charged particles. It can be deduced that TZSM glasses with Sm_2O_3 addition may be preferred shield materials in the sense of gamma, neutron, alpha and proton attenuation.

1 Introduction

To avoid the detrimental influences of radiation on humans, studying the nature of the interaction between radiation and materials has received great attention for several physicists and investigators. It is because of that distinct kinds of radiation such as neutrons, gamma, X-rays and electrons can be produced from radioactive source, nuclear reactors, radiation therapy in hospitals, and chemical industries. Gamma-rays are classified as energetic ionizing radiation with no charge and mass, this leads to γ-radiation being able to travel fast for long distance with high energy and have ability to penetrate the materials. It is well known that when γ-rays incident on the human body for long time, many dangerous effects such as blood cells damage, genetic damage, cataracts, skin diseases, cancer and may be death might occur [1]. For the aforementioned reasons, searching for materials with good γ and γ-radiation shielding materials became an important target for several of scientists and engineers. Over the past years, the more common commercial radiation protection materials were clay, concretes, rocks, alloys, bricks, and polymers [2–6]. In spite of these materials being low cost and easy in preparation, they have many of disadvantages such as being opaque and not transparent to the visible light, water permeability, and crack formation. Currently, investigators are paying more attention and efforts to find alternatives for conventional materials to be more effective and suitable as radiation shielding materials. Based on the numerous physical and chemical features of glasses such as having high density, chemical durability, thermal stability, radiation stability, corrosion resistance, ease in formatting, and being environmentally friendly [7–9], several researchers reported that glasses become more suitable radiation protection materials [10–15]. And these glasses can be used to apply in many of nuclear establishments such as X-ray screens and CT scans, windows and doors, radiation therapy chambers, security X-ray screens at airports, and in space technology.

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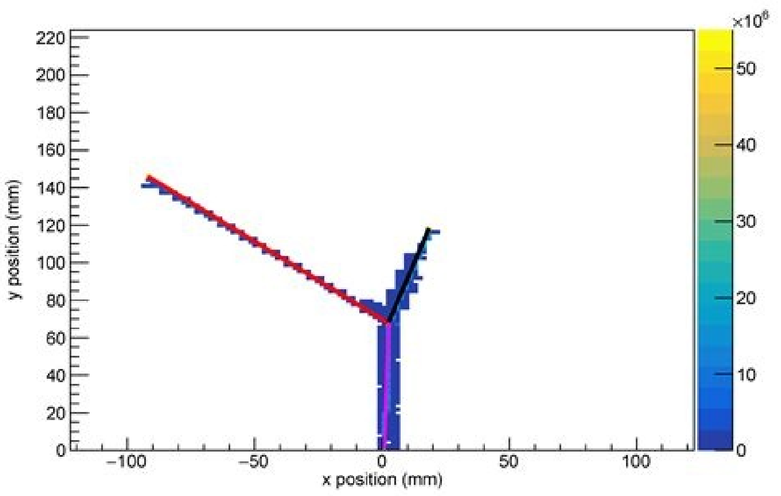

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Institute of Technology Madras Basic Calculus – 1 from Indian Institute of Technology Madras Applied Multivariate Statistical Modeling from Indian Institute of Technology, Kharagpur Integral and Vector Calculus from Indian Institute of Technology, Kharagpur Transform Calculus and its applications in Differential Equations from Indian Institute of Technology, Kharagpur Statistical Inference – IIT KGP from Indian Institute of Technology, Kharagpur Modern Algebra from Madurai Kamaraj University, Madurai, Tamil Nadu Fuzzy Sets, Logic and Systems & Applications from Indian Institute of Technology Kanpur An introduction to Point-Set-Topology Part-I from NPTEL Basic Linear Algebra from Indian Institute of Technology Bombay Introductory Mathematical Methods for Biologists from Indian Institute of Technology Bombay Introduction to Stochastic Processes from Indian Institute of Technology Bombay Basic Real Analysis from Indian Institute of Technology Bombay Numerical Linear Algebra from Indian Institute of Technology Roorkee MCDM Techniques using R from Indian Institute of Technology Roorkee Ordinary and Partial Differential Equations and Applications from Indian Institute of Technology Roorkee Multivariable calculus from Indian Institute of Technology Roorkee Mathematical Modelling: Analysis and Applications from Indian Institute of Technology Roorkee Discrete-time Markov Chains and Poisson Processes from Indian Institute of Technology Guwahati Introduction to Queueing Theory from Indian Institute of Technology Guwahati Computational Geometry from Indian Institute of Technology Delhi Advanced Probability Theory from Indian Institute of Technology Delhi Introduction to Algebraic Geometry and Commutative Algebra from Indian Institute of Technology Bangalore Discrete Mathematics – IIITB from Indian Institute of Technology Bangalore Discrete Mathematics from Chennai Mathematical Institute First Course on Partial Differential Equations – I from Indian Institute of Science Bangalore Linear Algebra from Kerala School of Mathematics Introduction to Galois Theory from Chennai Mathematical Institute Introduction to Rings and Fields from Chennai Mathematical Institute Variational Calculus and its applications in Control Theory and Nanomechanics from Indraprastha Institute of Information Technology Delhi Graph Theory from Indian Institute of Science Education and Research, Pune Probabilistic Methods in PDE from Indian Institute of Science Education and Research, Pune Probability –I with Examples Using R from Indian Statistical Institute Algebraic Combinatorics from NPTEL Algebra – II from IMSC An invitation to Topology from IMSC Functional Analysis from IMSC MCO-03: Research Methodology and Statistical Analysis from IGNOU Descriptive Statistics from Yuvaraja's College Probability and Probability Distributions from Sri Jayachamarajendra College of Engineering Sr.Secondary : Mathematics (311) from NIOS Secondary : Maths(211) from NIOS Science (167) Industrial Pharmacy-I from H.N.B Garhwal University (A Central University) Srinagar Garhwal ★★★★★(57) Organic Chemistry 1 from Jawaharlal Nehru University, New Delhi ★★★★★(25) Vocational : Mushroom Production from NIOS ★★★★☆(4) Applied Entomology from University of Mysore ★★★★★(3) Solid and hazardous Waste Management from Central University of Punjab ★★★★★(2) Food Microbiology and Food Safety from Central University of Haryana ★★★★★(2) Biochemistry from Indian Institute of Technology, Kharagpur ★★★☆☆(1) Mineral Resources: Geology, Exploration, Economics and Environment from Indian Institute of Technology, Kharagpur ★★★★★(1) Soil Science and Technology from Indian Institute of Technology, Kharagpur ★★★★☆(1) Bioinorganic Chemistry from Indian Institute of Technology Kanpur ★★★★★(1) Nanotechnology in Agriculture from Indian Institute of Technology Kanpur ★★★☆☆(1) Quantum Mechanics I from Indian Institute of Technology Bombay ★★★★☆(1) Quantitative Methods in Chemistry from Indian Institute of Science Education and Research Bhopal ★★★★★(1) Material Science from IGNOU ★★★★★(1) Material and Energy Balances from Indian Institute of Technology Madras Mechanical Characterization of Bituminous Materials from Indian Institute of Technology Madras Biostatistics and Design of experiments from Indian Institute of Technology Madras Computational Systems Biology from Indian Institute of Technology Madras Demystifying The Brain from Indian Institute of Technology Madras Chemistry: Atomic Structure and Chemical Bonding from Indian Institute of Technology Madras Introduction to Research from Indian Institute of Technology Madras Environmental Quality Monitoring & Analysis from Indian Institute of Technology Madras Biochemistry – IITM from Indian Institute of Technology Madras Bioreactor Design and Analysis from Indian Institute of Technology Madras Pericyclic Reactions and Organic Photochemistry from Indian Institute of Technology Madras Fundamentals of combustion for propulsion from Indian Institute of Technology Madras Thermodynamics for Biological Systems: Classical and Statistical Aspect from Indian Institute of Technology Madras Electronic Waste Management – Issues and Challenges from Indian Institute of Technology, Kharagpur Co-Ordination Chemistry (Chemistry Of Transition Elements) from Indian Institute of Technology, Kharagpur Structure, Stereochemistry and Reactivity of Organic Compounds and Intermediates: A Problem-solving Approach from Indian Institute of Technology, Kharagpur A Study Guide in Organic Retrosynthesis: Problem Solving Approach from Indian Institute of Technology, Kharagpur Chemical Engineering Thermodynamics – IITKGP from Indian Institute of Technology, Kharagpur Conduction and Convection Heat Transfer from Indian Institute of Technology, Kharagpur Scanning Electron / Ion / Probe Microscopy in Materials Characterization from Indian Institute of Technology, Kharagpur Environmental Chemistry and Microbiology from Indian Institute of Technology, 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Since then, paper certificates have been discontinued, but students can still obtain virtual certificates that afford the same privileges. I paid a small extra fee (less than $2) to receive the certificate (embedded below) by mail. Click on the subject in the index below to directly jump to that section. There are 900+ free online courses starting January 2022 onwards. Certificates may, in turn, be used by students enrolled in India's higher education to earn academic credit for completing SWAYAM courses earmarked as credit-eligible by their universities. Below is a list of all SWAYAM courses categorized by subject. At the rate it's growing, in a few years, SWAYAM could become the world's largest MOOC provider, offering courses in a wide variety of disciplines from prestigious Indian institutions such as IITs and Central Universities. I joined the Class Central engineering team in April 2019, and part of my job is to make sure that Class Central's catalog is up-to-date. Class Central has compiled a list: 250+ UGC Approved Online Degrees from India's Top Universities I personally completed several courses on SWAYAM, including a SWAYAM-NPTEL course that was part of the last semester of my master's degree in computer science (specialization in AI) at the Central University of Rajasthan, India. All these courses can be taken for free. Students can also choose to pay a small fee (about $15) to sit a proctored exam in an examination center in India to earn a certificate of completion. If you'd like to know more about how India is leveraging SWAYAM at the university level, head to our previous article: In India, MOOCs Are Now Part of the Education System.

2019 Int MCA -A Batch, 2019 Int MCA-B Batch 18CSA383 Computer Graphics Lab: Tuesday: Athira B, Lab 3 2018 5 Year Integrated M.C.A, 2021 M.C.A. 18CA312/20CSA 513 Data Mining and Applications-Lab: 2019 Int MCA -A Batch, 2019 Int MCA-B Batch 18CSA399Project (Exit Option/ Non- Exit Option)---Wednesday: 2019 Int MCA -A Batch, 2019 Int MCA-B Batch

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