quantum beam science

Editorial

Quantum Beams Applying to Innovative Industrial Materials

Yasunari Maekawa [1,*] and Masakazu Washio [2]

[1] National Institutes for Quantum and Radiological Science and Technology (QST), Takasaki Advanced Radiation Research Institute, 1233 Watanuki, Takasaki, Gunma 370-1292, Japan
[2] Waseda Research Institute for Science and Engineering, Waseda University, 3-4-1, Okubo, Shinjuku, Tokyo 169-8555, Japan; washiom@waseda.jp
* Correspondence: maekawa.yasunari@qst.go.jp; Tel.: +81-27-346-9410

Received: 10 July 2020; Accepted: 21 July 2020; Published: 27 July 2020

Welcome to this Special Issue of *Quantum Beam Science* entitled "Quantum Beams Applying to Innovative Industrial Materials". We are very proud to receive original articles, reviews, and perspectives for the research and development of novel functional materials by "preparation and processing" using radiation crosslinking, curing, and grafting techniques; "analysis and characterization" of structure and functionality; "advanced quantum beam equipment", such as electron and ion accelerators and X-ray radiation sources. These articles include the functional materials, devices, and equipment aiming to innovative industrial materials in the fields of energy/environmental, life science/medical, and electronics.

The facility, equipment, and radiation process of quantum beams have been developed to produce novel industrial functional materials. Crosslinked polymers were developed even in the early 1950s, using electron beam (EB) and γ-rays, and commercialized as power cables, polyethylene foams, radial tires, and so on in the 1960s and later. Especially, EB-curing techniques for coatings were put to market first in 1970 and had been widely utilized for a wide range of applications. By EB-induced grafting of acrylic acid to a PE film, the separator for the alkaline button battery was brought to market in 1982. Thereafter, grafting techniques have been intensively investigated to develop ultrafine filtration and metal/gas absorbent fabrics. On the other hand, quantum beam characterization of structures and properties of materials has recently been recognized as a new tool for non-destructive analytical methods for industrial application, such as visualization of engines and batteries in operating conditions.

The contributed papers, for which we are very thankful, include very attractive topics in the following research fields for innovative industrial materials: (1) As for new functional polymer materials using EB or γ-ray-induced crosslinking and grafting, the articles cover biocompatible micro/nanofabricated devices [1], hydrogen permselective gas separation membranes [2], and lithium, protein, and cesium captured grafted adsorbents [3,4]. (2) In addition to polymer-based materials, there are several reports on advanced ion beam technology, such as the single event effects of heavy ion beams to semiconductor devices [5], the radiation-induced modification of lattice structures and mechanical properties of metallic materials [6], and the novel preparation of nanostructured catalysts for energy devices [7,8]. (3) In the fields of nanotechnology and microfabrication processes, it was reported that low dimensional functional organic matters were created using single charged particle-induced chemical reactions in nanospace [9] and oriented lamellae of self-assembled block copolymers were designed with a single nanoscale using EB for future lithographic materials [10]. (4) Regarding novel application of quantum beam technology, this Special Issue provides the recent progress of phase imaging using synchrotron X-rays and pulsed neutron beams [11] and ultrafast electron diffractometers with relativistic electron pulses for the investigation of ultrafast structural dynamics [12]. Furthermore, as for new ion beam applications, highly intensified C_{60} ion beams created by negatively charged fullerene with the electron attachment technique [13] and widely applied microbeams, being utilized for the samples under atmospheric conditions via tapered glass capillary attached directly to beam lines [14], are reported.

As introduced above, we are very pleased to publish the Special Issue "Quantum Beams Applying to Innovative Industrial Materials", providing original articles and reviews in a wide range of research works from the recent development of conventional EB and γ-rays-induced radiation application for advanced functional materials to the advanced beam technologies such as nano-focused, pulsed, or polarized X-rays, neutrons, and ions, which should be very promising tools for the further development of innovative industrial materials.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Oyama, T.G.; Kimura, A.; Nagasawa, N.; Oyama, K.; Taguchi, M. Development of Advanced Biodevices Using Quantum Beam Microfabrication Technology. *Quantum Beam Sci.* **2020**, *4*, 14. [CrossRef]
2. Hasegawa, S.; Sawada, S.; Azami, S.; Hagiwara, T.; Hiroki, A.; Maekawa, Y. Development of Hydrogen-Permselective Porous Membranes Using Radiation-Induced Graft Polymerization. *Quantum Beam Sci.* **2020**, *4*, 23. [CrossRef]
3. Xu, C.; Yu, T.; Peng, J.; Zhao, L.; Li, J.; Zhai, M. Efficient Adsorption Performance of Lithium Ion onto Cellulose Microspheres with Sulfonic Acid Groups. *Quantum Beam Sci.* **2020**, *4*, 6. [CrossRef]
4. Ishihara, R.; Asai, S. Recent Progress in Charged Polymer Chains Grafted by Radiation-Induced Graft Polymerization; Adsorption of Proteins and Immobilization of Inorganic Precipitates. *Quantum Beam Sci.* **2020**, *4*, 20. [CrossRef]
5. Makino, T.; Onoda, S.; Ohshima, T.; Kobayashi, D.; Ikeda, H.; Hirose, K. A Methodology for Reconstructing DSET Pulses from Heavy-Ion Broad-Beam Measurements. *Quantum Beam Sci.* **2020**, *4*, 15. [CrossRef]
6. Iwase, A.; Hori, F. Modification of Lattice Structures and Mechanical Properties of Metallic Materials by Energetic Ion Irradiation and Subsequent Thermal Treatments. *Quantum Beam Sci.* **2020**, *4*, 17. [CrossRef]
7. Yamamoto, S.; Koshikawa, H.; Taguchi, T.; Yamaki, T. Precipitation of Pt Nanoparticles inside Ion-Track-Etched Capillaries. *Quantum Beam Sci.* **2020**, *4*, 8. [CrossRef]
8. Idesaki, A.; Yamamoto, S.; Sugimoto, M.; Yamaki, T.; Maekawa, Y. Formation of Fe Nanoparticles by Ion Implantation Technique for Catalytic Graphitization of a Phenolic Resin. *Quantum Beam Sci.* **2020**, *4*, 11. [CrossRef]
9. Sakaguchi, S.; Kamiya, K.; Sakurai, T.; Seki, S. Interactions of Single Particle with Organic Matters: A Facile Bottom-Up Approach to Low Dimensional Nanostructures. *Quantum Beam Sci.* **2020**, *4*, 7. [CrossRef]
10. Yamamoto, H.; Dawson, G.; Kozawa, T.; Robinson, A.P.G. Lamellar Orientation of a Block Copolymer via an Electron-Beam Induced Polarity Switch in a Nitrophenyl Self-Assembled Monolayer or Si Etching Treatments. *Quantum Beam Sci.* **2020**, *4*, 19. [CrossRef]
11. Momose, A.; Takano, H.; Wu, Y.; Hashimoto, K.; Samoto, T.; Hoshino, M.; Seki, Y.; Shinohara, T. Recent Progress in X-ray and Neutron Phase Imaging with Gratings. *Quantum Beam Sci.* **2020**, *4*, 9. [CrossRef]
12. Yang, J.; Gen, K.; Naruse, N.; Sakakihara, S.; Yoshida, Y. A Compact Ultrafast Electron Diffractometer with Relativistic Femtosecond Electron Pulses. *Quantum Beam Sci.* **2020**, *4*, 4. [CrossRef]
13. Chiba, A.; Usui, A.; Hirano, Y.; Yamada, K.; Narumi, K.; Saitoh, Y. Novel Approaches for Intensifying Negative C60 Ion Beams Using Conventional Ion Sources Installed on a Tandem Accelerator. *Quantum Beam Sci.* **2020**, *4*, 13. [CrossRef]
14. Ikeda, T. Applications of Microbeams Produced by Tapered Glass Capillary Optics. *Quantum Beam Sci.* **2020**, *4*, 22. [CrossRef]