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This special issue is designed to honour the contributions of our colleague Neville Greaves who was among the first to apply newly-available synchrotron x-ray techniques to study the synthesis, structures and properties of advanced materials [1, 2]. His wide ranging work on ceramics, glasses and nanomaterials was celebrated in a recent issue of the J. Non-Cryst. Solids [3]. Neville's contributions to synchrotron research, highlighted here, focussed on design and construction of new beamline capabilities and sample environments to probe materials under different physical and chemical conditions, integrating various techniques to obtain complementary data on structure and bonding. The innovative nature of his work is illustrated by his studies of liquids and glasses, where he incorporated aerodynamic levitation into these experimental techniques, using both synchrotron x-ray and neutron beams to probe the structural transformations and dynamics combined with molecular dynamics simulations to study atomic scale organisation. His work has had a major impact on fundamental condensed matter physics and chemistry as well as applied materials science; and in this issue, we present contributions from colleagues using and developing new experimental techniques at current and next-generation synchrotron, neutron and free-electron laser sources and in their own laboratories, that probe the fundamental physics, chemistry and functional properties of novel materials and processes.

The first paper by Alan Chadwick and Richard Catlow sets the stage by linking Neville's achievements to current and future developments, accompanied by personal recollections while they participated in these exciting times for synchrotron science. This is followed by the next section, which addresses combined x-ray absorption, scattering and diffraction measurements that Neville envisaged from his earliest studies, and how these are evolving with modern instrumentation. The perspective by Nick Terrill and colleagues describes the evolution of sample environments for materials research by x-ray scattering and spectroscopy at UK facilities, while contributions from Gopinathan Sankar, Emma Gibson, Florian Meneau and their colleagues address problems of relevance to catalysis, nanomaterials synthesis and industrial applications. Rhod Jervis, Andy Leach and colleagues follow with cell designs and operando protocols for *in situ* studies of electrochemical cells using the recently commissioned I20-EDE beamline at Diamond Light Source (DLS). Simon Macleod from AWE/Edinburgh University describes structures and phase transformations of a technologically important Ti-Al-V alloy under high pressure-high temperature conditions, and Hayley Simon and Eleanor Schofield from the Mary Rose Trust present the use of Fe XAS to study corrosion of iron-based artefacts of archaeological significance.

The following section introduces new beamline capabilities and experimental techniques developed at both the most advanced national and international facilities for x-ray science as well as in the laboratory. The section begins with contributions from Sakura Pascarelli *et al* and their colleagues, presenting capabilities at the European x-ray free-electron laser (XFEL), the upgraded ESRF (European Synchrotron Research Facility), Spring-8 (Japan), DLS and the Advanced Photon Source (APS, USA). Elliot Gann follows by describing a new beamline for resonant soft x-ray scattering developed by NIST (National Institute of

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Standards and Technology) at the upgraded National Synchrotron Light Source (NSLS, Brookhaven National Laboratory, USA). Sandro Olivo (UCL) describes experiments using phase contrast x-ray methods to image mainly soft matter and biological materials in his laboratory 'hutches' that mimic operational conditions at synchrotron facilities, while Anna Regoutz introduces the capabilities and possibilities for hard x-ray photoelectron spectroscopy studies of materials, both at large facilities and in the laboratory.

The next sections describe the power and range of applications of advanced neutron scattering for studies of materials relevant to materials and devices, including *in situ* measurements under *operando* conditions. Fabrizia Foglia and colleagues, including instrument scientists from facilities across the world, describe the power and range of applications of quasi-elastic scattering, reflectivity and imaging, while Phillipe Gutfreund develops the use of reflectometry techniques for studying polymer interface structures. James Drewitt *et al* then describe the use of levitation methods combined with high energy synchrotron x-ray scattering to study structure and recrystallisation vs glass formation in refractory ceramic liquids, combined with Monte Carlo simulations to study the processes. This section also presents work reporting new capabilities for materials studies into the very fast timescale domain, using intense x-ray beams and XFEL facilities. Malcolm McMahon and his colleagues present new possibilities and recent results from his group investigating structure and dynamics in crystals, liquids and other condensed matter states under extreme pressure-temperature conditions relevant to deep planetary interiors and high energy physics technologies. Lemke describes work at the low temperature limit of the energy scale, combining far-infrared spectroscopy and structural intense x-ray beam probes of correlated materials under cryogenic conditions.

Wim Bras and colleagues conclude by describing an issue that has long concerned synchrotron scientists: how do intense x-ray beams affect the nature of the samples you are studying and the course of their reactions? It is appropriate that the issue ends with a question that leads to further investigation and discussion. That was always Neville's point while developing new experimental techniques and reports of remarkable new results, that the answers always lay in posing new questions.

Data availability statement

No new data were created or analysed in this study.

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