In recent years, non-destructive imaging in transmission or diffraction mode and using different types of penetrating radiation has undergone tremendous developments.

X-ray and neutron tomography in materials research, especially microtomography, were pioneered in the 1990s. Today they are no longer considered exotic or academic tools whose use is limited to special case studies. Radiography and tomography in a wide range of spatial and temporal resolution, and with a number of contrast modes, have become well-established methods which routinely complement other imaging modalities, such as electron or visible-light microscopy and X-ray or neutron diffraction and scattering.

High-resolution X-ray imaging systems are nowadays widely available commercially and can be considered standard equipment for sample characterisation, as such similar to scanning electron microscopy. The large number of synchrotron light sources operational today, with more facilities and beamlines becoming available soon, has drastically increased the capabilities to perform flagship experiments requiring high spatial resolution, sensitive contrast modalities, short data acquisition times or a combination of these features. X-ray imaging is of course perfectly complementary by the available neutron imaging stations at reactors or spallation sources [1, 2].

These developments inspired the second symposium “Tomographic and radiographic imaging with X-rays and neutrons” carried out as part of the European Congress and Exhibition on Advanced Materials and Processes (EUROMAT) in Sevilla, Spain, from the 8th to the 13th September 2013. Similar to the first symposium held in Montpellier, France, in 2011 (also within EUROMAT), a wide range of topics were covered, reflecting the dynamic developments of non-destructive imaging using penetrating radiation. Dedicated sessions highlighted recent instrumental developments such as detectors and experimental stations; new techniques were introduced to the materials science community – for example, ptychography or hard X-ray dark field microscopy – and many presenters reported applications from a wide range of fields. Many of these applications relied on sophisticated combinations of imaging, sample environments and subsequent volume image analysis. Among the 40 talks and 19 posters, outstanding contributions were selected to form this special issue of the International Journal of Materials Research. Its content reflects the fact that X-ray and neutron imaging has progressed from a niche application towards a well-established tool.

The many excellent examples of applied research in materials science using laboratory and synchrotron light sources, sometimes combined, begin with a paper by Renversade et al. [3] on damage related to long-term creep under in-service conditions of martensitic steal used in steam pipes at fossil-fuel fired power plants. Specific contrast modes by combining classical powder diffraction-based data with tomographic approaches are used by Artioli et al. [4] to shed light on nano-seeded nucleation in cement pastes, while Eggert et al. [5] exploit time as the fourth dimension to understand the dynamics in protein-based liquid foams. Griesche et al. [6] demonstrate the need of further contrast modes by employing neutron imaging to understand the relation between cold cracking and hydrogen release in steels. On a more general level, the papers in this issue show that new contrast modes and enhanced time resolution can be expected to introduce imaging with neutrons or X-rays to new scientific communities in the near future, as outlined by Lehmann et al. [7], Abbey et al. [8] and Rack et al. [9]. Even approaches which, at first glance, might be considered as very specific such as ptychography, coherent diffraction imaging or grain tracking by diffraction tomography are finding their way towards materials science applications, as depicted by Phillips et al. [10] and Bormann et al [11].

Transmission imaging in two or three dimensions not only requires excellent instrumentation, it also relies heavily on a mathematical foundation. In particular, the process of fast data reconstruction and the use of dedicated algorithms allow for the extraction of quantitative, e.g., statistical, information from images and hence, to push the utility of imaging results further towards model validation and virtual materials design [12]. Here, Ohser et al. [13] introduce a new concept to analyze images of open foams in a quantitative manner, Wirjadi et al. combine microtomography with the high sensitivity of X-ray phase contrast to analyse orientations and cracks in such low-contrast samples as fibre-reinforced SiC ceramics and fibre-reinforced polymers [14], [15]. Stalder et al. combine microtomography with
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image analysis to overcome limitations of classical histological sectioning to understand bone regeneration [16].

It goes without saying that this issue and the articles in it represent only a small sample of the current developments. Other meetings with related, if different, scopes exist, and their proceedings [17 – 19] can be used to obtain a broader view of the subject. They underline the rapid progress and constant gain of importance of the exciting field of materials radiography and tomography.

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References