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Advanced X-ray Characterization of Hierarchical Systems: from Biotissues to Electronic Devices

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Label-free Multiscale X-ray Imaging can be performed by Table-Top equipment, exploiting both Absorption (usually referred to as X-ray Transmission Microscopy “XTM”) and Scattering contrast. X-ray scattering techniques can provide a large amount of structural and morphological information, both at the atomic and nano-scale, and are thus particularly suited to study composite/nanostructured materials. The crystalline components are mainly studied by Wide Angle X-ray Scattering (WAXS), providing information on the crystallinity and crystalline phases, as well as on possible texture. The nanoscale structure/morphology can be assessed based on the Small Angle X-ray Scattering (SAXS) signal, and related to the possible crystallinity through combined SAXS/WAXS mapping. SAXS/WAXS/XT Microscopy is particularly suited to study biological tissues (or any structured material) with nano and/or atomic scale periodicity, such as calcified healthy or pathological tissues.¹ In the biomedical field, this approach allows for example to study mineralized bio-scaffolds, or reveal osteogenic differentiation of stem cells through the analysis of nanocrystalline differentiation products.² The availability of high brilliance X-ray micro-sources for laboratory equipment allows nowadays to perform the aforesaid advanced X-ray characterization, in both transmission and reflection geometries, in the home laboratory, being such X-ray sources considered as “synchrotron-class”. Moreover, suitable data treatment can further enhance the performances of the experimental equipment, returning in several cases results comparable to those obtained at a synchrotron beamline. A in-house developed package (SUNBIM) for the collection and analysis of X-ray microscopies with absorption and/or diffraction contrast, as well as data reduction for transmission and reflection geometries is freely available at http://www.ba.ic.cnr.it/softwareic/sunbimweb/, and constantly updated. The synchrotron-class micro-source combined with the SAXS/WAXS system installed at IC-Bari (XMI-L@b) has been successfully applied to the study of free-standing bio- and composite materials,³ as well as to polymer nanofibers for optoelectronic devices. Moreover, it has been successfully applied in grazing incidence reflection geometry (GISAXS/GIWAXS) for the study of several nanosttructured films for advanced electronic applications, in particular based on 2D nanocrystals.

References

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