A bright future for synchrotron imaging

To the Editor — Among the analytical techniques able to yield molecular information about biological samples, a growing interest in Fourier transform infrared (FTIR) microscopy[1] has emerged during the past decade. However, there are technical challenges and limitations when applying FTIR microscopy to biological issues, owing to the limited brightness of commercial infrared sources, and the poor sensitivity and resolution of detectors. These problems have prevented high-quality analysis of thick soft-tissue sections (>20–30 μm) (ref. 2), single cells (~10 μm in size) and hard tissues such as bone or teeth[3]. We wish to draw attention to the fact that, thanks to the emergence of high-brightness synchrotron sources equipped with focal plane array (FPA) detectors, this situation now looks set to change.

A synchrotron source has the capability of providing infrared light through a 10-μm pinhole that is 2–3 orders of magnitude brighter than a conventional Globar such as those available in commercial FTIR instrumentation[4]. This superior signal-to-noise ratio (SNR) is expected to allow imaging with a spatial resolution down to the diffraction limit, or to allow analysis of thicker samples while maintaining good spatial resolution[5].

Although FTIR microscopes are now available on most of the infrared synchrotron facilities around the world (see www.lightsources.org/cms/), only a few research studies have quantitatively validated the expected advantages of a synchrotron for biomedical applications. So far, the main success obtained by combining a FTIR microscope with a synchrotron source is hard-tissue analysis[6], which has provided results that are not possible with standard sources. However, FTIR microscopy on soft tissues and cells has still not taken advantage of the performance of synchrotron sources, largely owing to detector limitations.

The availability of the infrared FPA detector[7] and its recent installation at ultra-bright synchrotron radiation facilities around the world (Table 1) promises to extend the performance and overcome the existing limitations[8]. In particular, FPA detectors promise to reduce data acquisition time from hours to minutes, improving the spectral quality and overcoming possible contributions from synchrotron radiation instability. But because no commercially available optical microscopes have been designed for use with an infrared synchrotron source, the optimal match between such sources and FPA detectors is still at the early stage of development. Linear arrays of small size coupled to an infrared microscope promise to achieve fast imaging and increase performances in terms of both spatial and time resolutions. However, the use of FPA infrared detectors optimized in the mid-infrared range seems the best solution to collect fast infrared images over large tissue areas, because of their sensitivity and speed of read-out. Alignment and optimization of these devices remains a challenge when noise or instabilities are present and because of optical layout limitations. A huge effort has already been made, with many ideas implemented and others under investigation at third-generation storage ring facilities, to improve stability and, as a consequence, spatial resolution, contrast and acquisition time of an image. There is thus a brilliant future for infrared synchrotron microscopy and imaging, and important results in biological and biomedical applications are expected in the coming years. ❐

Table 1 | Infrared synchrotron beamlines with current and planned FPA detectors.

Country	Synchrotron facility	Beamline
Germany (Karlsruhe)	ANKA (planned)	Beamline IR2 http://ankaweb.fzk.de
Italy (Frascati)	DAΦNE (installed)	Beamline SINBAD www.lnf.infn.it/dafnel
Italy (Trieste)	ELETTRA (installed)	Beamline SISSI www.elettra.trieste.it/info/index.html
Sweden (Lund)	MAX-Lab (installed)	Beamline 73 www.maxlab.lu.se
UK (Oxfordshire)	Diamond (under commission)	Beamline 22 www.diamond.ac.uk/Beamlines/Beamlineplan/B22/index.html
China (Hefei)	NSRL (under commission)	Beamline U4 www.nsrl.ustc.edu.cn/EN
Australia (Melbourne)	Australian Synchrotron (under commission)	IR Beamline www.synchrotron.vic.gov.au/content.asp?Document_ID=490
USA (Berkeley)	ALS (installed)	Beamline 1.4.4 www-als.lbl.gov
USA (Brookhaven)	NSLS (installed)	Beamline U10B www.nsls.bnl.gov
USA (Madison)	SRC (under commission)	Beamline 031-IR www.src.wisc.edu

Bruker Hyperion 3000 FTIR imaging systems are available in all facilities, except at ALS and NSLS where Thermo-Nicolet Continuum XL systems are available.

References

1. Petibois, C. & Déléris, G. *Trends Biotechnol.* **24,** 455–462 (2006).
2. Petibois, C. *et al. Analyst* **131,** 640–647 (2006).
3. Mendelsohn, R. *et al. Appl. Spectrosc.* **54,** 1183–1191 (2000).
4. Cestelli-Guidi, M. *et al. J. Opt. Soc. Am.* **22,** 2810–2817 (2005).
5. Smith, T. D. *Nucl. Instrum. Methods Phys. A* **483,** 565–570 (2002).
6. Burghardt, A. J. *et al. Bone* **40,** 160–168 (2007).
7. Colarusso, P. *et al. Appl. Spectrosc.* **52,** 106A-120A (1998).
8. Moss, D. *et al. Infrared Phys. Technol.* **49,** 53–56 (2006).

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