Multi-beam Synchrotron Infrared Chemical Imaging with High Spatial Resolution (IRENI): Assessing Performance

M.J. Nasse\textsuperscript{a,b}, E.C. Mattson\textsuperscript{a}, and C.J. Hirschmugl\textsuperscript{a}

\textsuperscript{a} Department of Physics, University of Wisconsin-Milwaukee, Milwaukee, WI 53211
\textsuperscript{b} Synchrotron Radiation Center, University of Wisconsin-Madison, Stoughton, WI 53589

The new infrared chemical imaging beamline IRENI (Infrared Environmental Imaging) is the world’s first multi-beam synchrotron-base IR imaging beamline. We extract $320(h) \times 25(v) \text{ mrad}^2$ from a dedicated bending magnet (BM 2) and split the fan of radiation into 12 individual IR beams that we rearrange into a $3 \times 4$ matrix to illuminate the sample homogeneously\textsuperscript{1}, which is then imaged onto a Focal Plane Array multi-element detector by a $74 \times$ high numerical aperture Schwarzschild objective. This imaging system delivers, within minutes, very high spatial resolution images, while maintaining high spectral quality. It achieves diffraction-limited resolution over the entire mid-IR bandwidth with an effective pixel size of $0.54 \times 0.54 \text{ \mu m}^2$ and can cover a sample area of up to $52 \times 52 \text{ \mu m}^2$ with $96 \times 96$ pixels. This small pixel size is required to obtain this high resolution. It also allows us to measure the point spread function (PSF) of the instrument at all wavelengths using pinholes of various diameters. The PSF can be used to implement image reconstruction methods that further enhance the spatial resolution.

In this contribution we assess IRENI’s performance, such as spatial resolution by exploring general requirements\textsuperscript{2} for high resolution imaging like spatial sampling, pixel size, magnification, numerical aperture, signal-to-noise ratio, etc. and by applying them for various IR instrumental configurations available today (dual-aperture, wide-field IR microscopy, single synchrotron beam vs. multiple synchrotron beams). For example we use a common 1951 US Air force (USAF) resolution test target (see Fig. 1) and line profiles to determine the optical contrast obtained with the IRENI imaging system to show that we can obtain the highest (far-field) spatial resolution images in transmission mode available today.

References
