Supporting Information

SI 1) Extraction procedure for the Si and Al 2D elemental maps. The R-ratio method.

For this particular specimen made of silica and alumina, a tricky point concerns the extraction of the Si 2D elemental maps. The raison is that the Si and Al-L$_{23}$ edges are very close, giving thus rise to a superposition of the corresponding elemental signals. In that regard, we have employed a customised method, making the hypothesis that any ternary compound is present in the specimen; in such a case, the shape of the Al-L$_{23}$ chemical signal is similar to that in the alumina pure phase. The last one was deduced after the background subtraction from a series of typical EELS spectra recorded at various tilt angles on a pure alumina grain. In particular, we have observed that the ratio between the integrated signals from the W5 and W6 windows (see Figure) on an EELS spectrum is almost constant, and that for all the considered tilt angles (its mean value is 0.78).

Considering now the alumina-silica sample, the Al 2D elemental maps were obtained by using the usual three windows method. The next step consists in the calculation of two new images by applying the same method to W1, W2 (considered as pre-edge images) and W5 and W6 images (considered successively as post-edge image). The first new image (called W5') contains only the Al elemental signal, since it corresponds to an energy position before the Si-L$_{23}$ ionisation edge. The second one (W6) contains both Al and Si elemental signals, due to its energy position after the Si-L$_{23}$ ionisation edge. Then, the W5' image is multiplied by the R-ratio, giving rise to another image (W6'') that contains only the Al elemental signal at the same energy position as W6'. Making the difference between W6' and W6'', we have obtained finally the Si 2D elemental maps for all the tilt angles.
SNR improvement in the 3D elemental map with respect to the initial 2D elemental maps

We compare one of the projections (at 0° tilt) extracted from the elemental tilt-series of Al with the corresponding projection deduced from the Al elemental reconstruction. A striking improvement in SNR happens, thanks to the redundancy of information in the reconstruction provided by the use of several projections of the same object.