Improved liftout quality for perovskite oxides using a Xenon Plasma FIB

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Xenon plasma FIB instruments have been recently introduced as dual (electron and ion) beam instruments and have been installed widely in the past couple of years. A major area of application has been for serial sectioning tomography, on account of the high ion current available in suitably small beam sizes [1]. But, it is also possible to use such instruments for liftout preparation of thin specimens for (scanning) transmission electron microscopy instead of Ga ion instruments, although there have been few published studies on this to date [2]. In fact, Xenon may well have a number of advantages over Gallium:

- There are no chemical interactions between Xe ions and solids, so doping, defect decoration, and gallium droplet formation will not happen. The worst that is likely is either amorphisation.
- As the Xe ions stop faster in matter than Ga ions of the same kinetic energy, this results in a thinner amorphised layer on the surface than with Ga.

In this work, we show that high quality specimens of a thin epitaxial film of La_2CoMnO_6 (LCMO) on (111) $SrTiO_3$ (STO) can be prepared using a liftout procedure in a PFIB very similar to that used in our gallium FIB instrument, and are of exceptionally high quality. In comparison to preparing the same material using a conventional gallium FIB, the initial stage of milling the trenches is much faster, due to the high current available, but the final finishing is slower due to the beam being broader than a Ga beam at low currents. Nevertheless, the total time taken was very similar to that required for a Ga beam liftout, and the sample was completed inside 4 hours. The faster time for the rough cutting suggests that time savings could possible be made on harder materials that mill slowly, such as steel.

The resulting sample was characterized by both conventional TEM, and high resolution scanning TEM. Figure 1 shows a conventional TEM image of the thin area. An EFTEM thickness map of this region showed that the area of the thin LCMO film closest to the edge had a thickness below 10 nm. Atomic resolution images, such as the iDPC image shown in Figure 2 show exceptional quality of preparation, with clear atomic columns (including O) and just ~ 3 nm of amorphous material at the outer edge.

References

[1] T. L. Burnett *et al.*, Ultramicroscopy **161**, 119-129 (2016).
[2] C. M. Hu, M. Aindow and M. Wei, Surf. Coat. Technol. **313**, 255-262 (2017).

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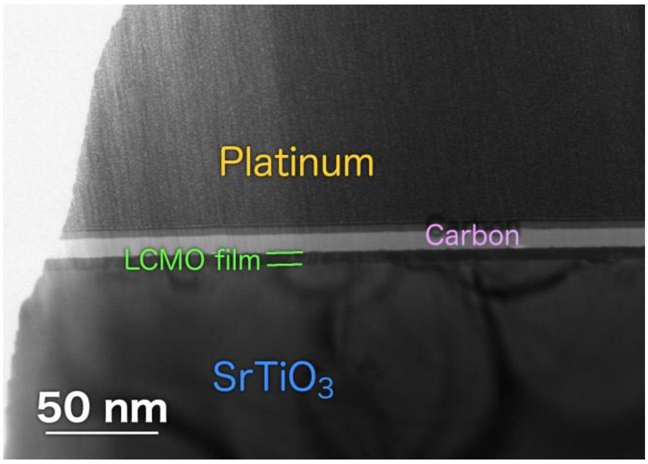

Figure 1: TEM image of the resulting sample showing a good quality specimen with minimal damage.

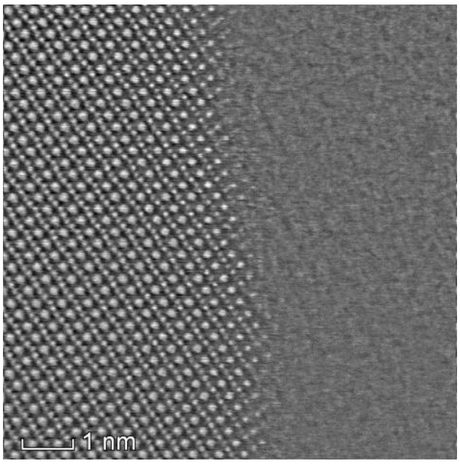

Figure 2: iDPC image of the thin edge of the LCMO film showing high quality atomic resolution and about 3 nm of amorphous material at the edge.