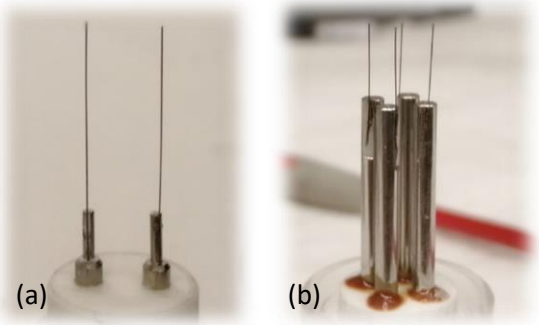

Figure1: Custom made holders prepared to hold (a) two and (b) four tungsten tips in the FIM chamber.

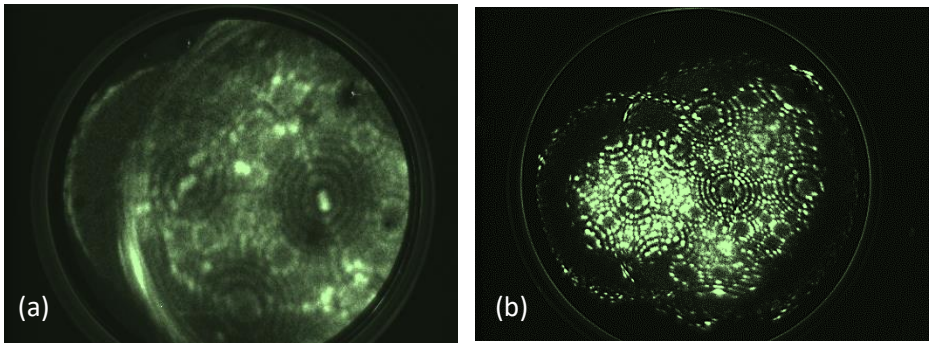

Fig.2. (a)-(b) Frames captured from the FIM patterns of two tips with different magnifications. The various magnifications occur because of different selected tip to screen distances. (a) was judged to have too high a magnification to achieved controlled etching. (b) Magnification allowed for easy identification of multiple tips for easy etching. Note in both (a) and (b) tips have varying radii of curvatures.

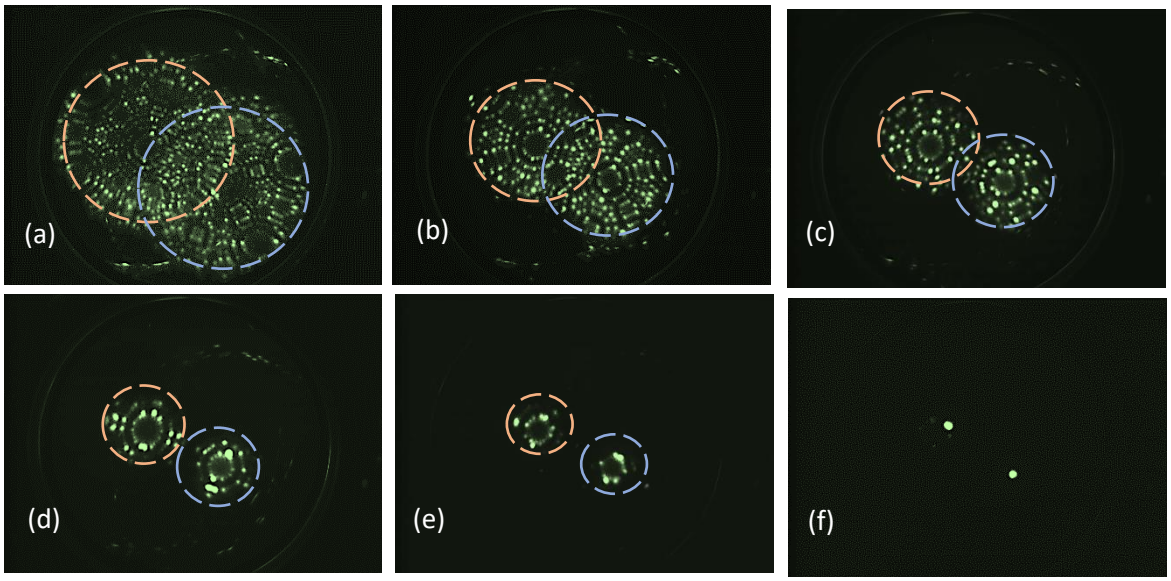

Fig.3. (a)-(f) Frames captured from the FIM patterns showing the etching of W(110) tips. Applied voltages are 5.3kV, 5kV, 4.5kV, 4.2kV, 4kV and 3.6kV for frames a-f. Coloured circles highlight the two tips.

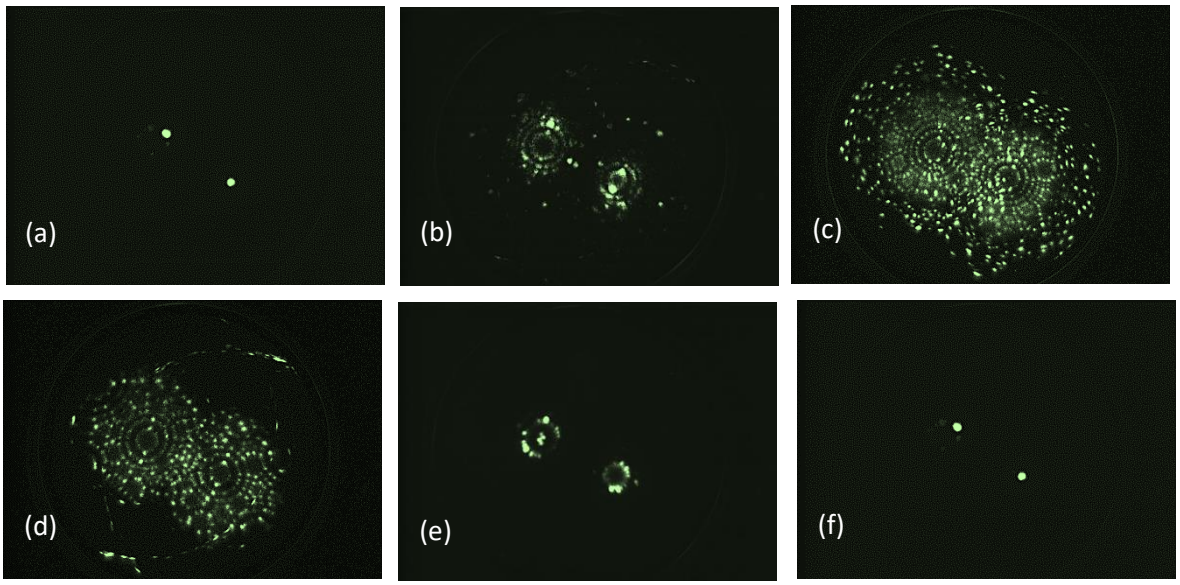

Fig.4. (a)-(c) Frames captured from the FIM patterns showing the field evaporation of two single atom tips, followed by etching again to single atom tips (d-f). This sequence shows the reproducibility the method. Applied voltages are 3.7kV, 4.7kV, 6.5kV, 5.3kV, 4.2kV and 3.7kV for frames a-f. Both SATs are formed at 3.7kV.

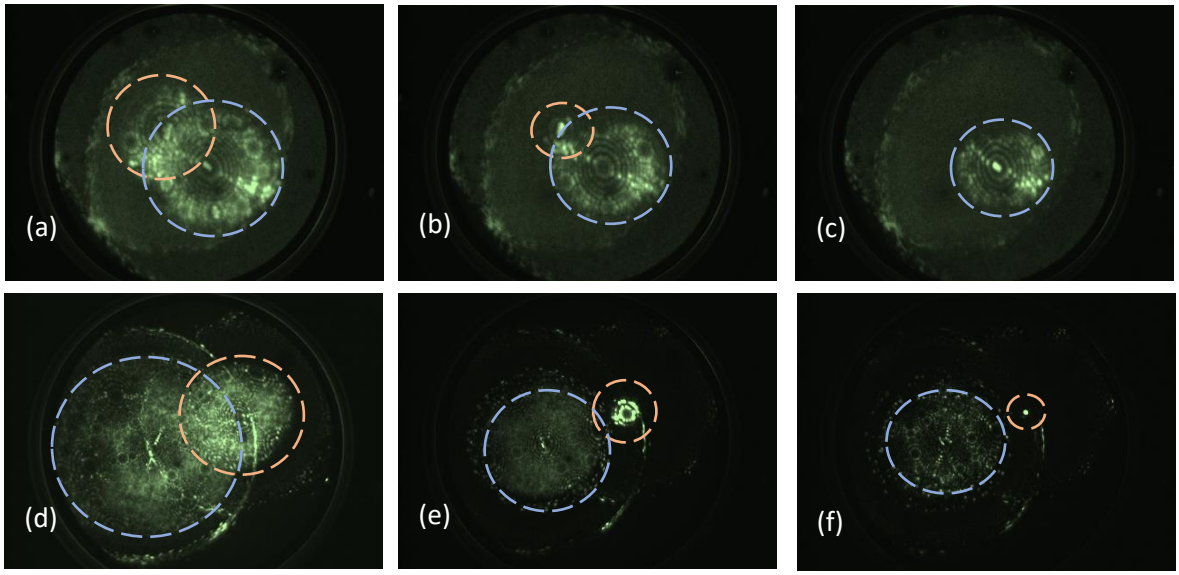

Fig. 5 Two different cases of FIM pattern of W(110) having two different apex sizes for the two tips. (a)-(c) refers to one tip and (d)-(f) refers to another. In both the cases the smaller tips, etched to a SAT before the larger one could catch up. in (a) the number of rings of the two tips between [110] and [121] are 5 and 9 (orange and blue) respectively. Starting voltages are 14kV, and 10.5kV for (a) and (d). Coloured circles highlight the two tips.

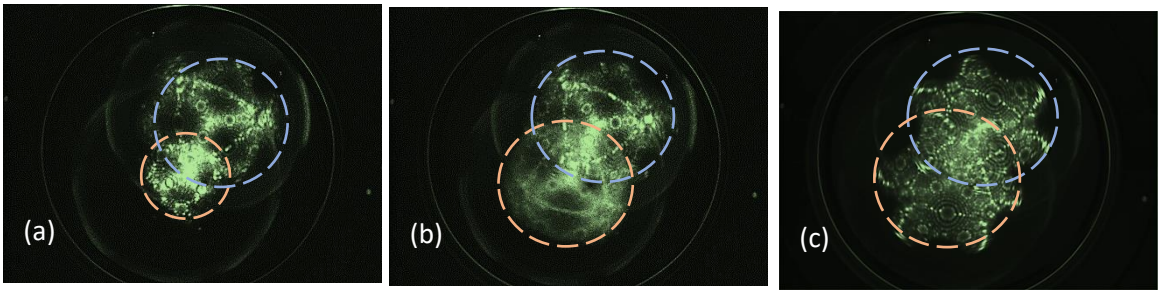

Fig.6: Frames captured from FIM patterns during the preparation of two W(111) tips. (a) Two W(111) tips with different radii. (b) The voltage in increased causing the sharper tips to field evaporate. The fuzzy character of the tip is indicative of evaporation. (c) After evaporation, both tips have similar sizes. Coloured circles highlight the two tips.

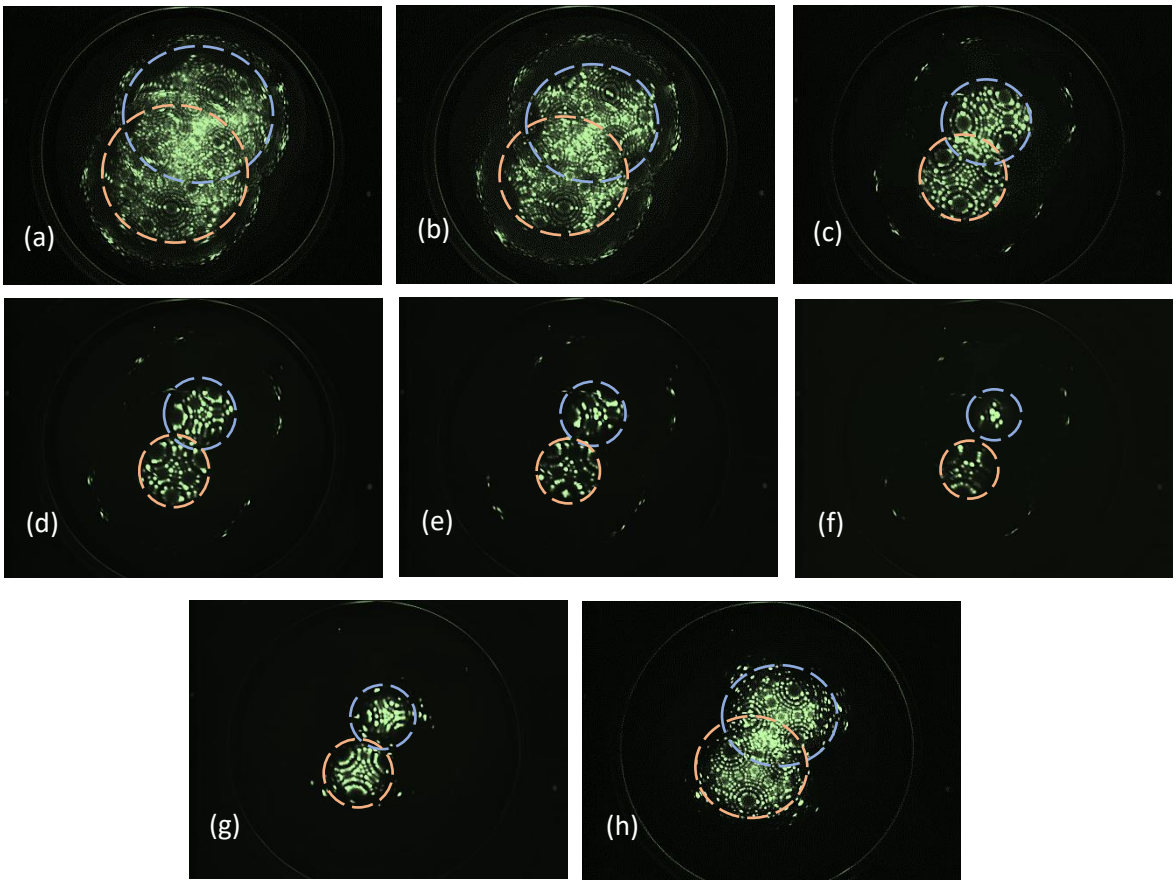

Fig.7 Frames captured from FIM patterns during the etching period of two W(111) tips with helium as the imaging gas and nitrogen as the etching gas. The etching occurs evenly between the two tips from (a) to (d). Starting at image (e), one tips becomes smaller and eventually forms a trimer in (f). At this point it was determined the two equal SATs could not be produced. An increase in voltage was applied in order to "reset" the tips through field evaporation, shown in (g) and (h) in the absence of nitrogen. FIM image (h) shows two tips with common features. Applied voltages for (a) to (h) are 8.6kV, 7.8kV, 6.3kV, 5.5kV, 4.9kV, 4.1kV, 5.4kV and 8kV respectively. Coloured circles highlight the two tips.

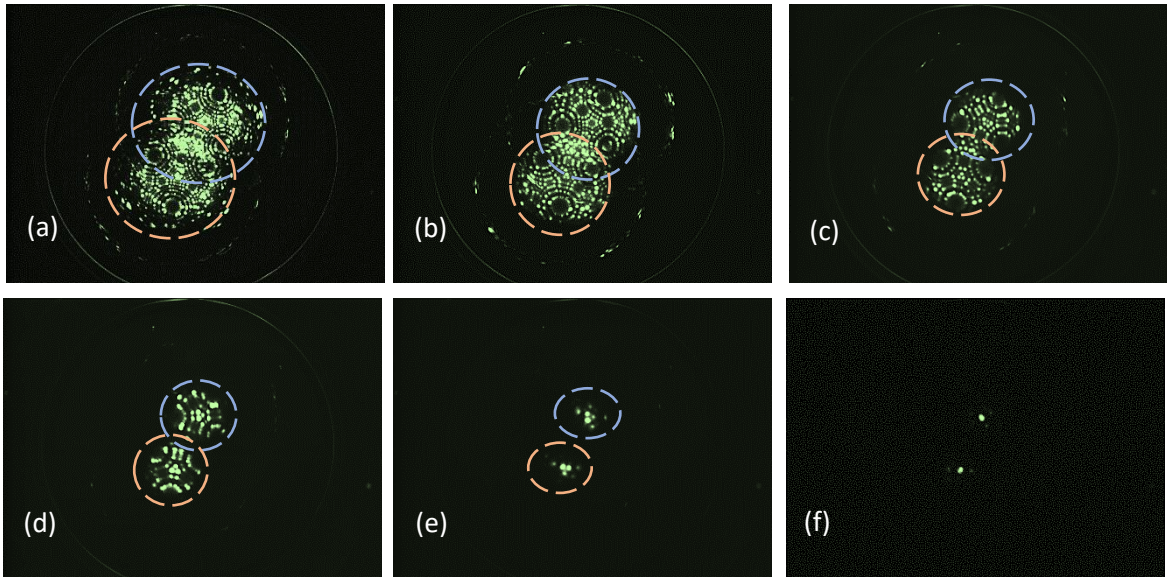

Fig.8. Frames captured from the FIM patterns showing the etching of W(111) tips for the second etch following figure 7. (a)-(d) Etching is continued with nitrogen pressure 5 X 10^{-6} Torr and applied voltage subsequently decreased to avoid the etching of the tip apex. (e)-(f) The nitrogen pressure is dropped to 7 X 10^{-7} Torr and the voltage is carefully ramped down to attain trimers in (e) and precision SATs in (f). Coloured circles highlight the two tips.

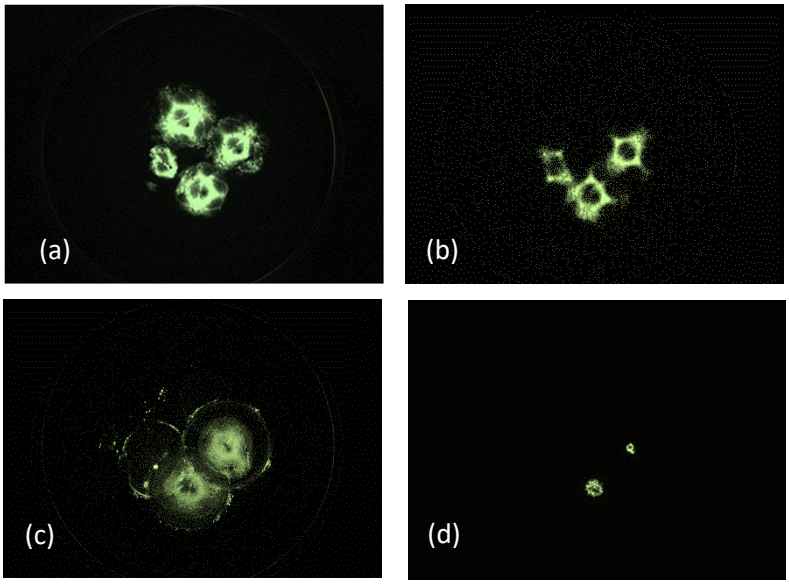

Fig. 9 FIM pattern of multiple tips. (a) 4 tips during field evaporation. (b) failure of one of the 4 tips, leaving only three remaining. (c) etching of the three tips using nitrogen. One tip is almost completed. (d) The first etched apex disappears long before the final two reach a few atoms.