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Time-of-Flight Secondary Ion Mass Spectrometry Analyses of Genesis samples and standards

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Why TOF-SIMS?

- Simultaneous analysis of all elements, and molecules (if they can be resolved)
- Analyses can be obtained with high spatial resolution
- Sputtering is at a much slower rate than with DC SIMS instruments (so although this usually means that it takes much longer to acquire data, it can be done in a very controlled way)

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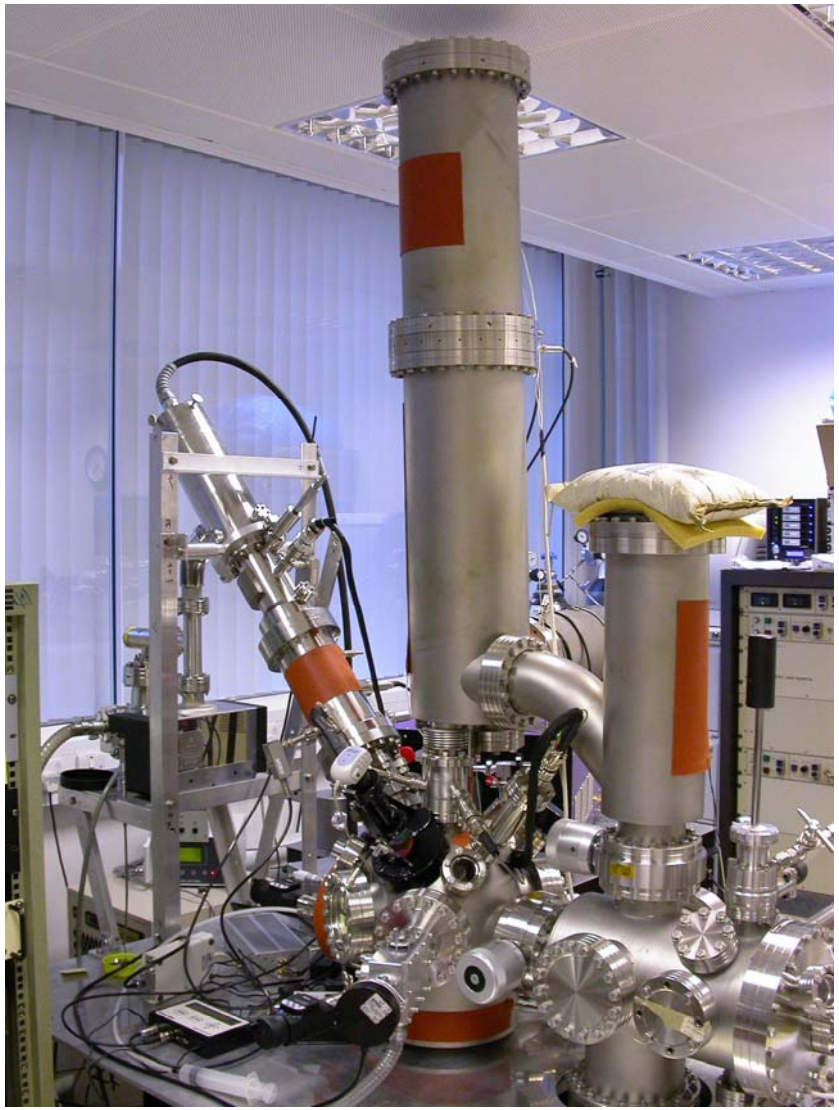
Aims

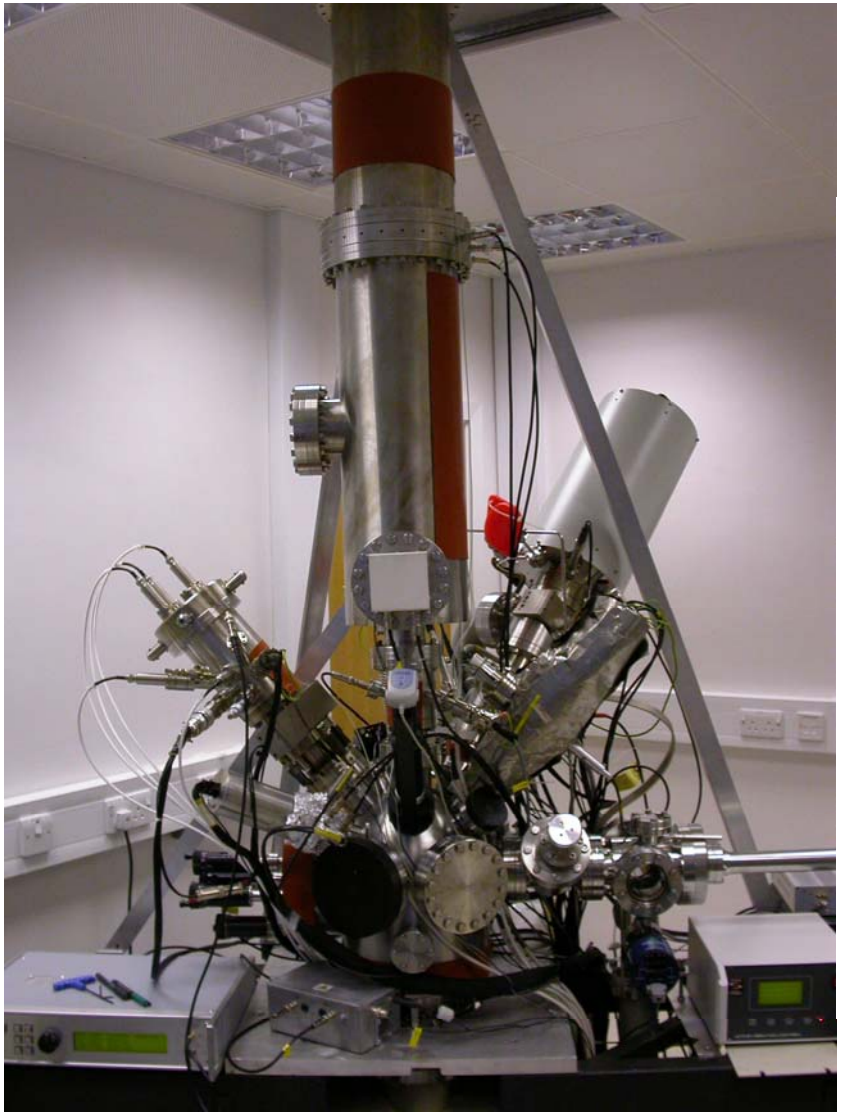
Learn sputtering properties of C_{60} for very high depth resolution depth profiling

Apply to Genesis samples

Brief from Don to study surface contamination remaining after cleaning

IDLE2 and IDLE3





C_{60} sputtering

C_{60} – Buckminsterfullerene (God may not play dice but he certainly plays football (soccer))

Great deal of interest because of potential dramatic improvements in many aspects of sputtering

Contrast with single atom ion sputtering – where high energy single atomic ion crashes into surface, loses energy through collisions and ends up buried >10nm depth.

‘Gardens’ atoms on the surface down into the material

C_{60} sputtering

When high energy C_{60}^{+} ion impacts surface, disintegrates into 60 carbon atoms

None carry very much energy so none penetrate very deeply into the surface

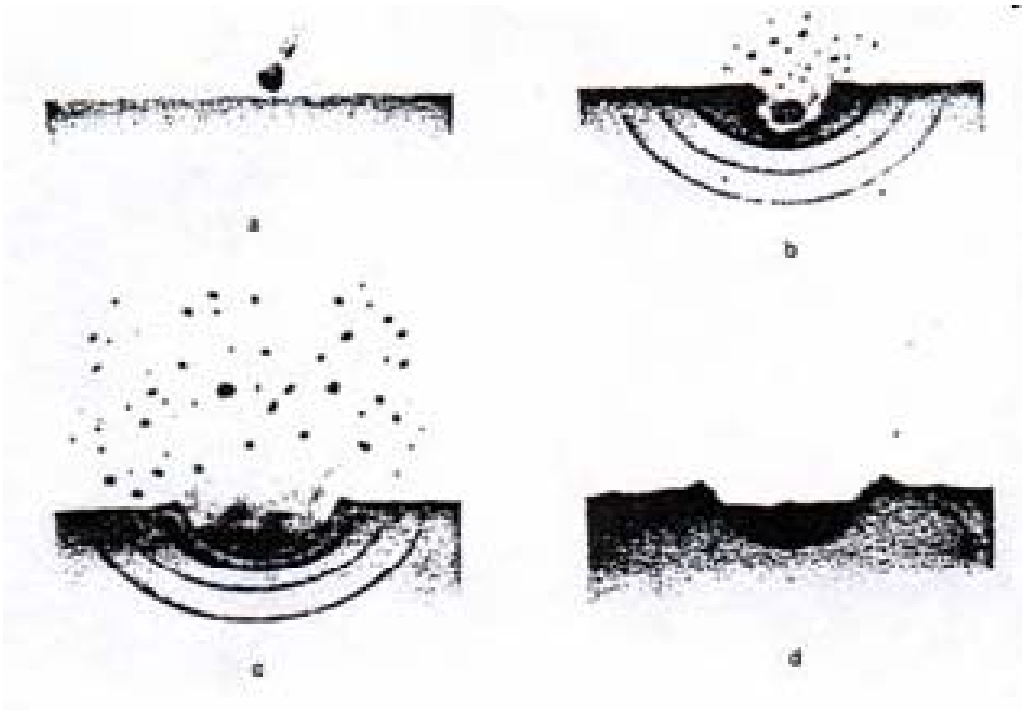
Creates almost an instantaneous plasma ~2-3nm in diameter and ~2-3nm deep

Virtually mono-layer depth resolution

Quantification

- Ionization mechanism for secondary ions is different from conventional sputtering means that secondary ionization is very reproducible
- We have achieved reproducibility of within a few % on relative sensitivity factors (ie element ratios) for many elements on silicate standards (at least order of magnitude better accuracy than conventional single atomic ion sputtering)
- Organic and large bio-molecules are lifted gently from the surface with often minimal fragmentation

Picture is very much like an impact crater!



http://web.ics.purdue.edu/~nowack/geos105/lect8-dir/lecture8.htm

So some really interesting properties – many potentially of great importance to the Genesis quest of high accuracy quantification

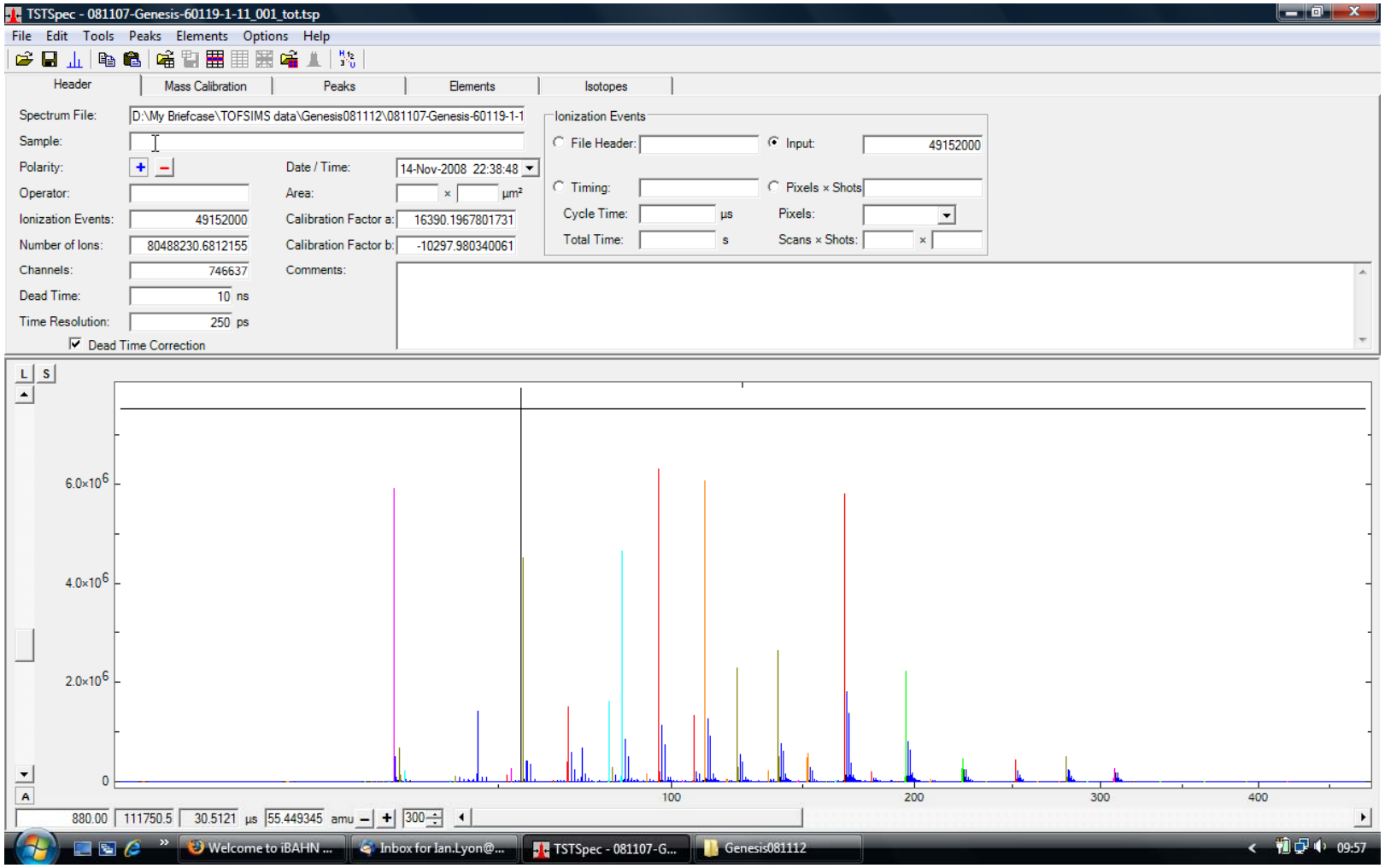
So – what are the problems?

Lots of interesting physics but not all of it helpful

Turns out that when C_{60} impacts pure Si, the C-Si bonds formed are stronger than the Si-Si bonds

Sputters vast quantities of Si clusters (right up to Si_{15}) and Si_nC_m molecules

Spectrum is extremely complex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Welcome to iBAHN ...
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09:57

C_{60} sputtering

So have spent time on this but have got sidestepped into the problems so far

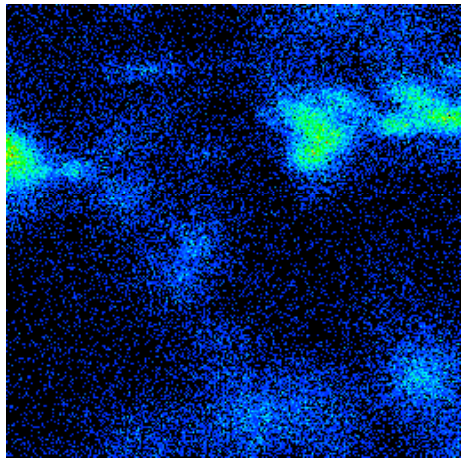
Holds potential for high depth resolution sputtering but each new solution creates its own problems

These are intrinsically interesting but not helpful to the present cause

60130 Silicon Surface Cleanliness Studies

- Don supplied fragment of 60130 that had been cleaned
- Ozone treated and Don's 'A2' solution
- No surface elements visible with XPS
- Was removed from shipping container and into cleaned prepared holder and into vacuum lock in <2 minutes
- Used Au^+ ions for high spatial resolution in 'IDLE3'

Surface of 60130 – no presputtering



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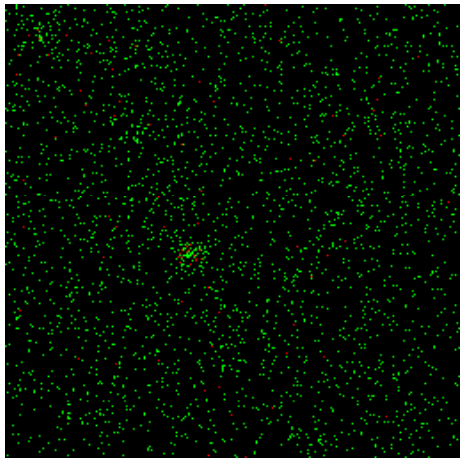

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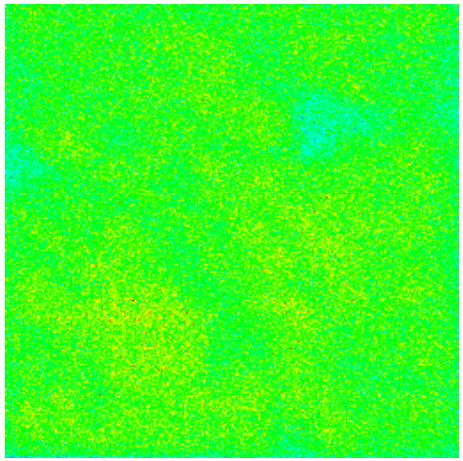

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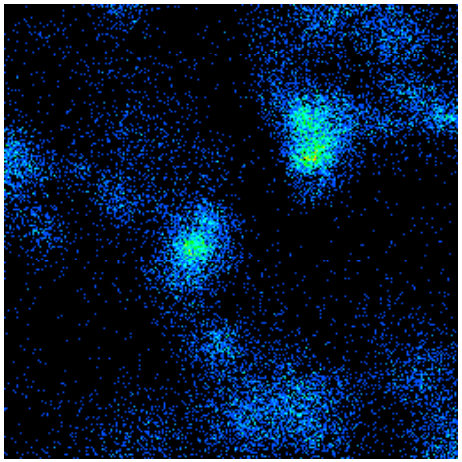
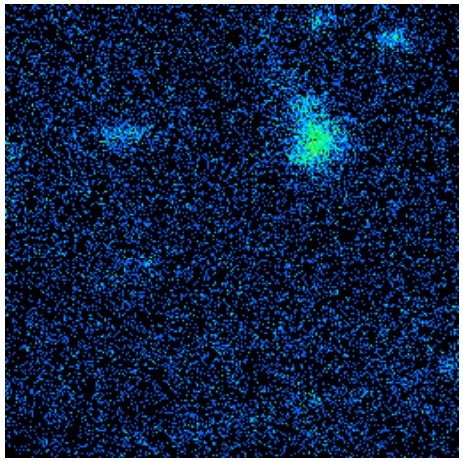


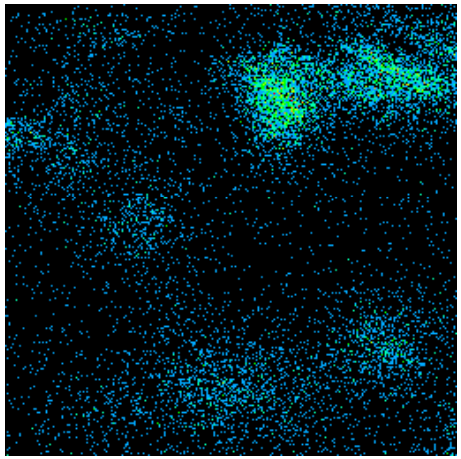
K



Ca

Field of view 100µm x 100µm

Surface of 60130 – few nm sputtered



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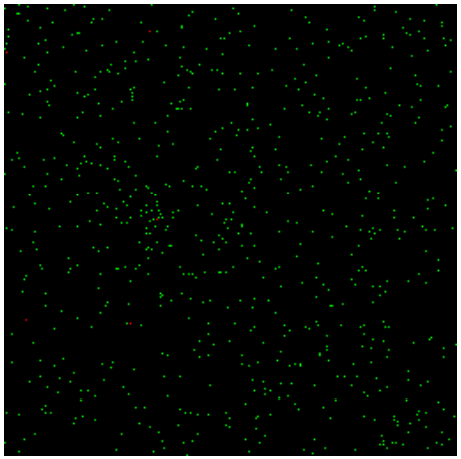

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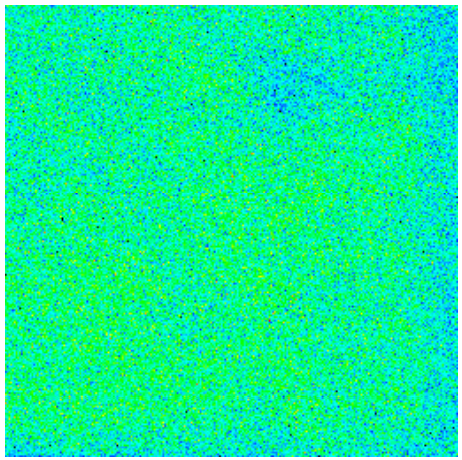

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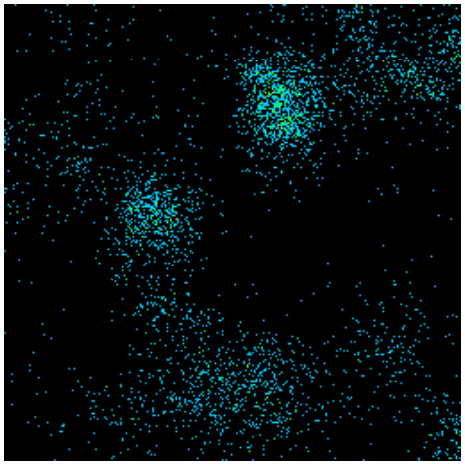

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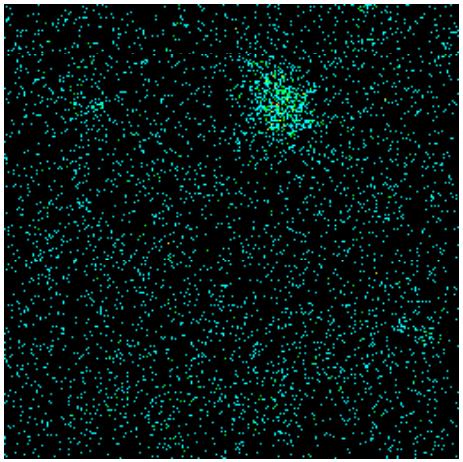
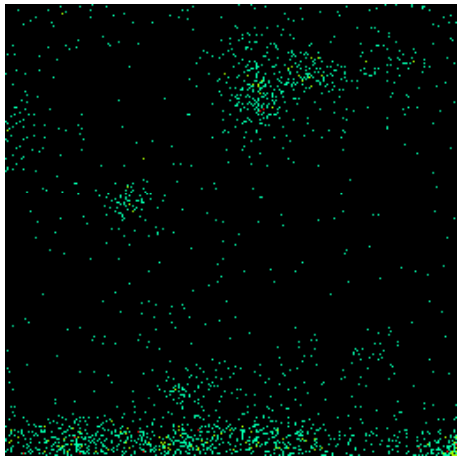


Ca

Field of view 100µm x 100µm

Surface of 60130 – few more nm sputtered



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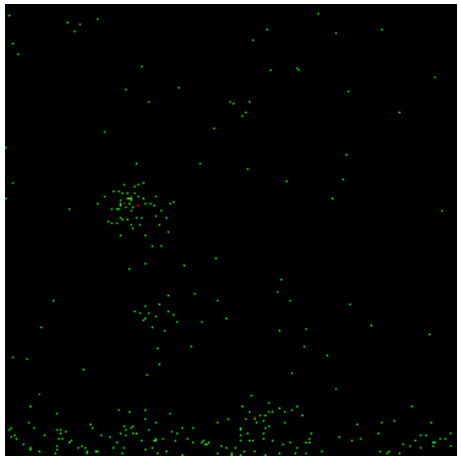

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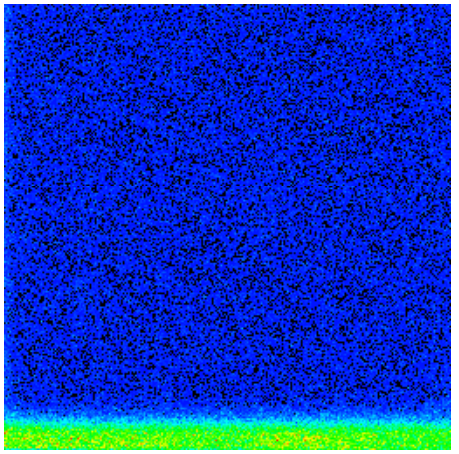

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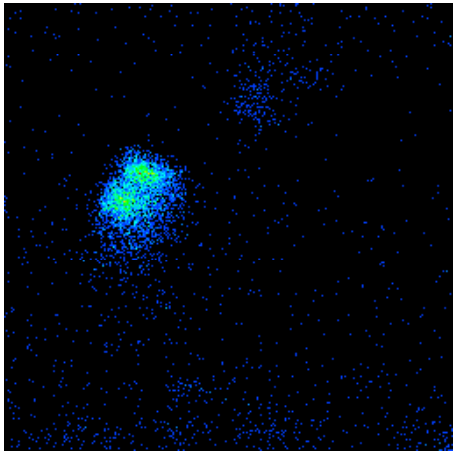

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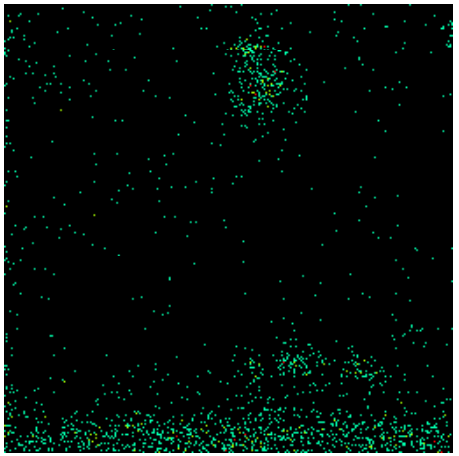
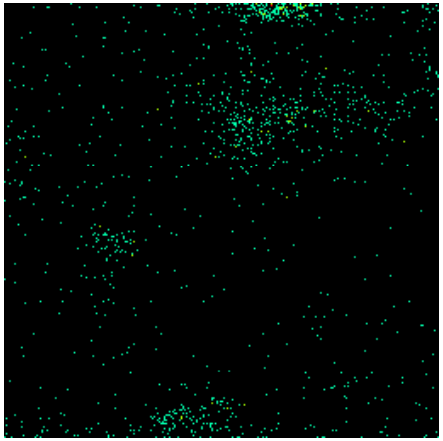


Ca

Field of view 100µm x 100µm

Surface of 60130 – few more nm sputtered



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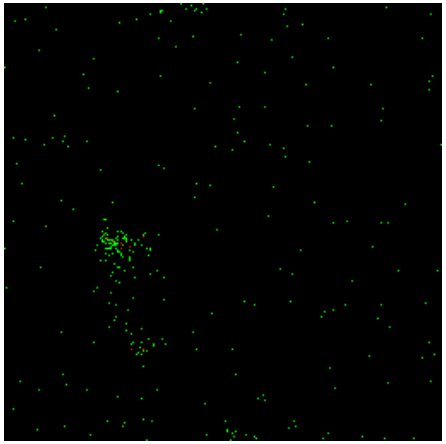

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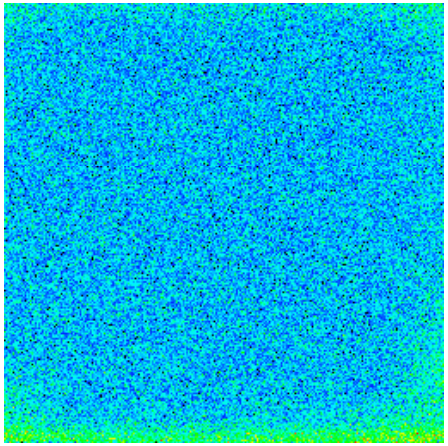

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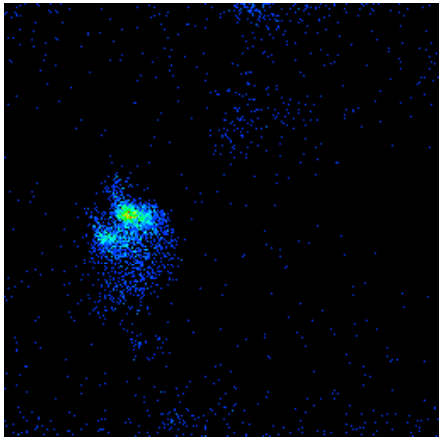

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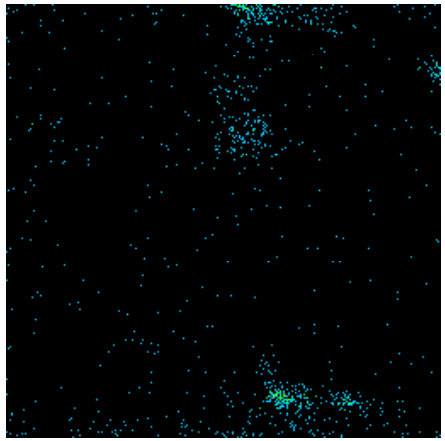
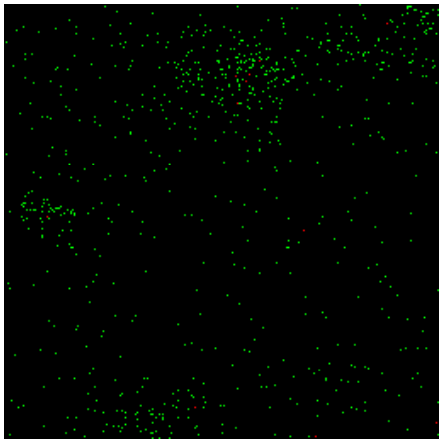


Ca

Field of view 100µm x 100µm

Surface of 60130 – few more nm sputtered



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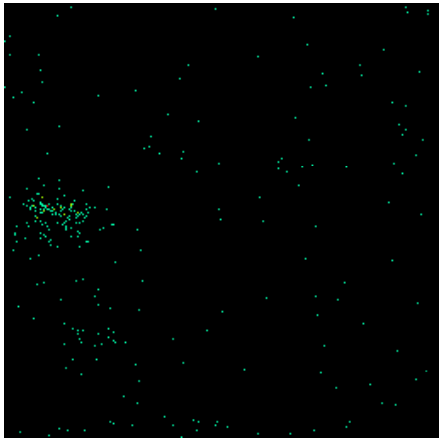

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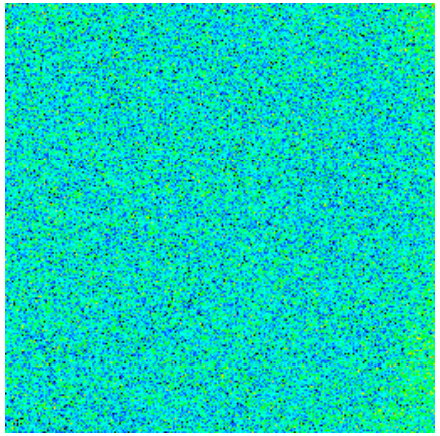

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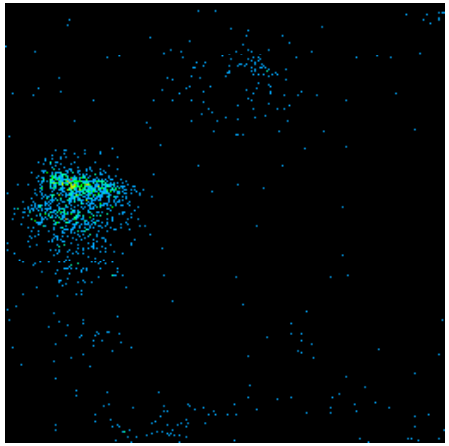

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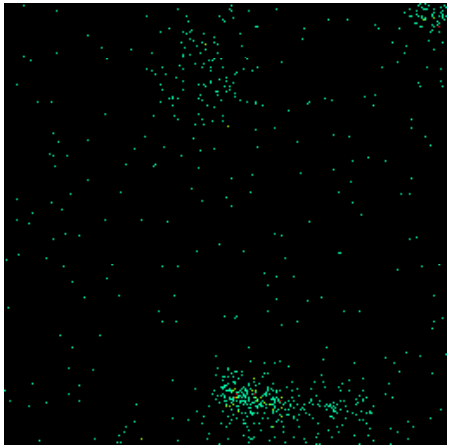
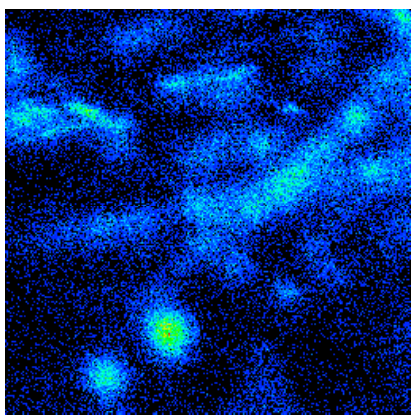


Ca

Field of view 100µm x 100µm

Surface of 60130 – Area 2 no presputtering



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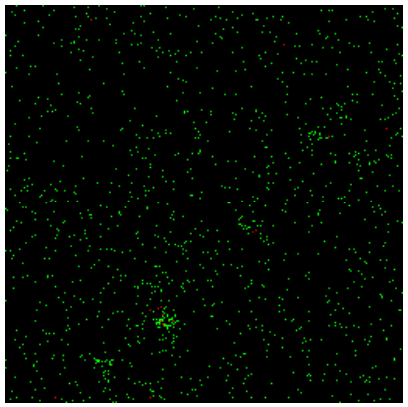
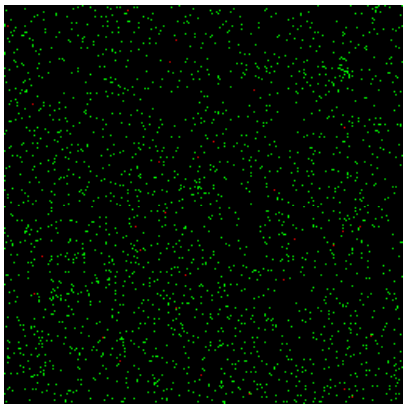


Mg



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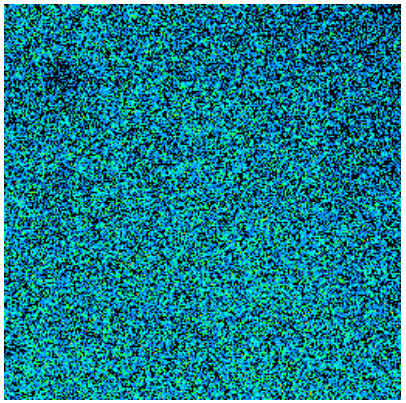
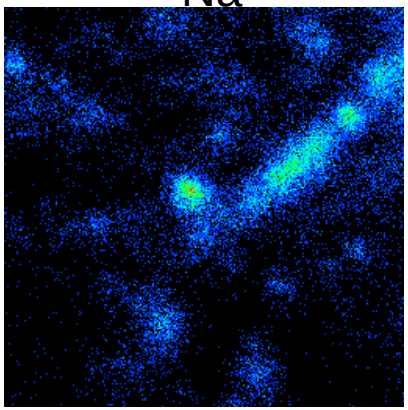


Si

Na



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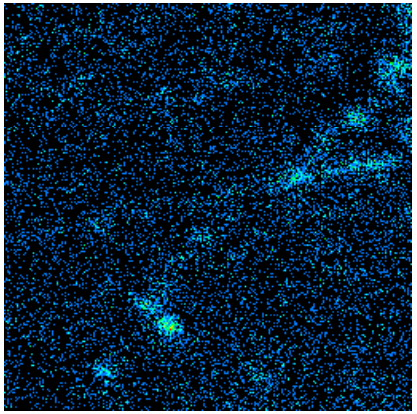

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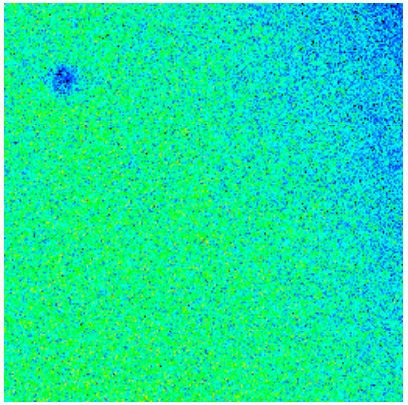
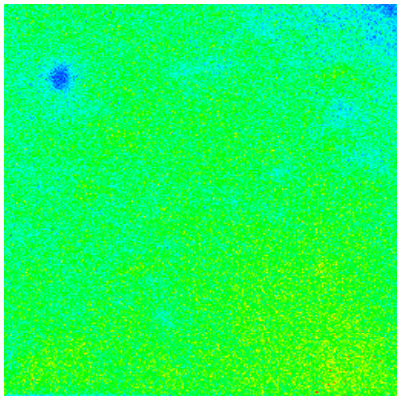


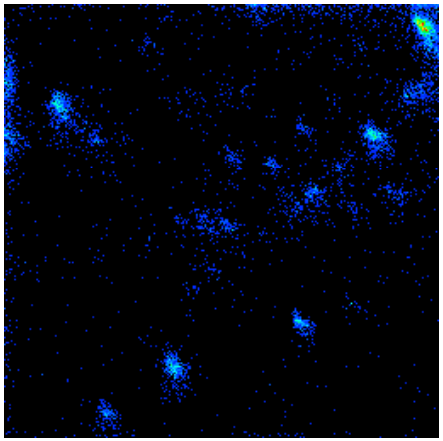
C_2H_2



C_3H_2

Field of view 100µm x 100µm

Surface of 60130 – Area 2, a few nm sputtered



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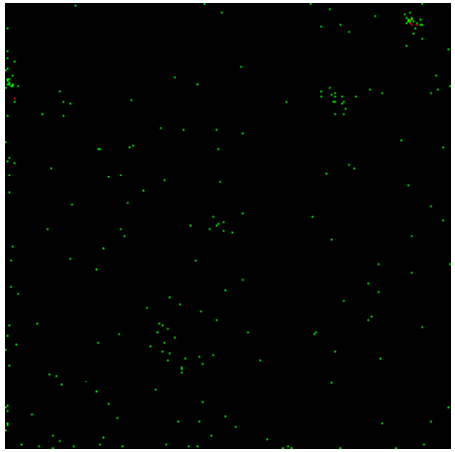

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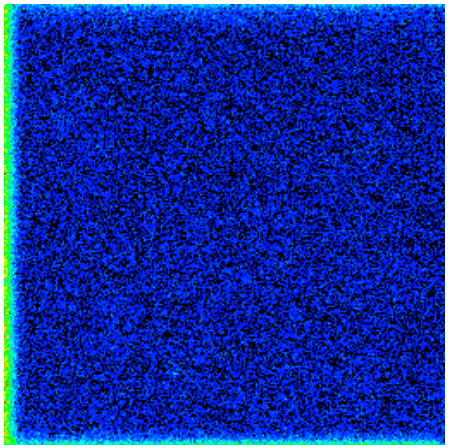
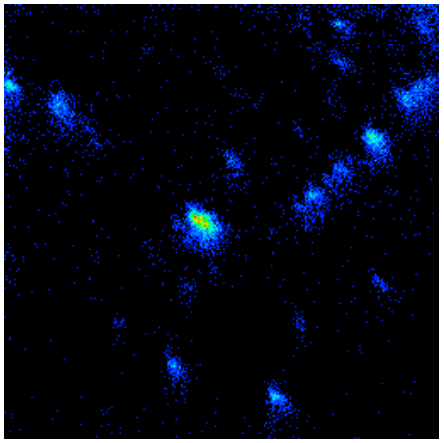


Si



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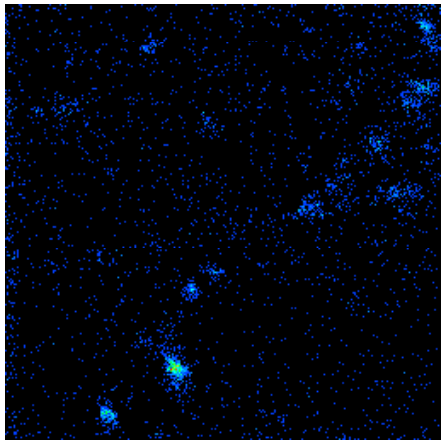
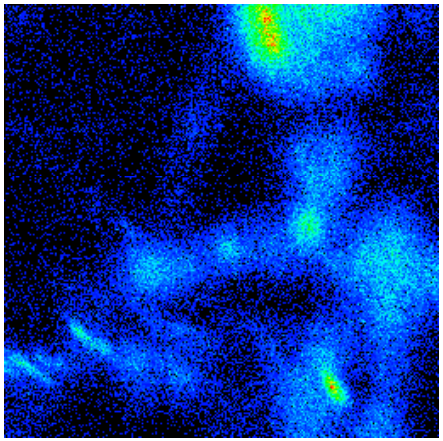


Ca

Field of view 100µm x 100µm

Surface of 60130 – Area 3 no presputtering



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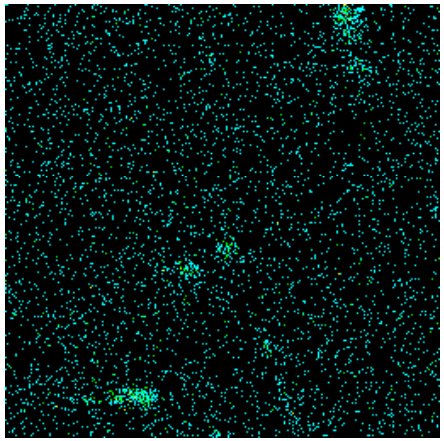

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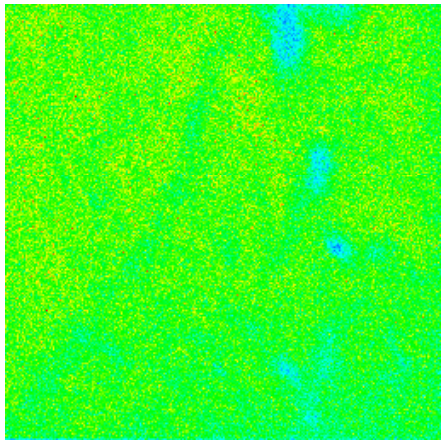

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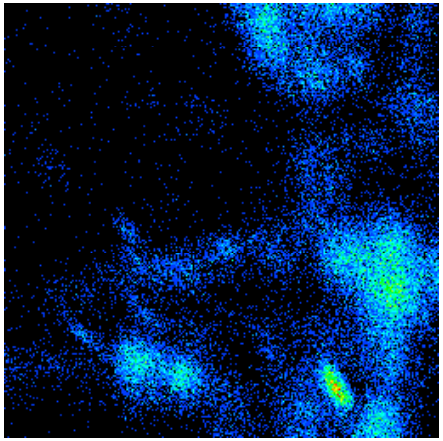

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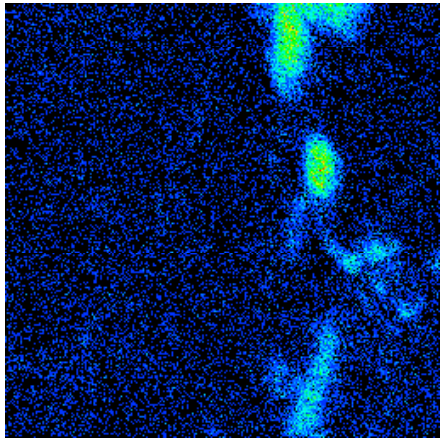

Ca

Field of view 100µm x 100µm

Conclusions

- Surface certainly does have detectable trace elements
- Some only appear after the surface is sputtered, implying that they are buried

Relative element abundances /Si

Corrected using RSFs determined from Au+ and silicate standards