SIMS Analysis of C and N Fluences in Genesis Samples

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Motivation of This Study

- C and N lie in the region of first ionization potential (FIP) that defines the onset of elemental fractionation relative to the photospheric abundances. The photospheric abundances of these elements relative to low FIP elements (e.g., Fe, Mg) are presumably well known.

- Improved models of the FIP elemental fractionation are crucial to evaluating the magnitude of possible isotopic fractionations of the solar wind relative to the Sun.
The sensitivity to measure C and N in Genesis samples by SIMS exists, but several attempts over the past couple of years have failed because of instrumental background and surface contamination.

The best attempt to date on C and N with our new Cameca 7f-Geo.

Combined FIB and NanoSIMS approach for “backside” profiling.
Two Sources of Background

12C Profile from 13C Implant

“surface”

“asymptotic”
Reduce “Asymptotic” Background

After overnight pumping & Si-sputtering

\[ {^{12}\text{C}}/^{28}\text{Si} \]

"Surface"

"asymptotic"

1st day
Analytical Conditions – 7f Geo

- Primary beam: Cs+, 10 keV, ~9 nA
- Secondary HV: -5 or -10 keV
- MRP: ~6000 → $^{29}\text{Si}^{13}\text{C}; ^{28}\text{Si}^{14}\text{N}$
- Field aperture: 50 µm
- Raster size: 100 micron
- Sputtering rate: ~ 5 Å/sec
- Overnight sputtering Si
$^{12}$C Profiles in Control & 60342

![Graph showing $^{12}$C profiles with different depths and concentrations, labeled as 60342 sample, OU199 control, and theoretical solar wind.](image-url)
$^{15}$N Profiles in Control & 60342

![Graph showing $^{15}$N profiles with depth and apparent N/cc.]

- **OU199 -- control**
- **60342 -- sample**
- **theoretical solar wind**
Backside Profiling – Solution for Surface Contamination?

Gu et al. (2004)
“Micro-scale” backside profiling? --preparing samples for NanoSIMS with FIB

(SEM images from Caltech FIB)
Analytical Conditions – NanoSIMS 50L

- 7 detectors set up for masses: $^{12}\text{C}^-$, $^{13}\text{C}^-$, $^{16}\text{O}^-$, $^{18}\text{O}^-$, $^{28}\text{Si}^-$, $^{14}\text{N}^{28}\text{Si}^-$, and $^{15}\text{N}^{28}\text{Si}^-$
- Cs+ beam current on samples (FCo): ~ 15 – 30 pA
- Raster size: 3x3 µm (2x2 µm gating)
- Sputtering rate: ~4 -- 8 Å/sec
Profiles of an $^{15}$N & $^{18}$O Implant– HRL99, 9
Spot-1 on the FIB Cut-out of $^{13}$C Implant
Spot-1 on the FIB Cut-out of $^{13}$C Implant
Spot-4 on the FIB Cut-out of $^{13}$C Implant
Spot-4 on the FIB Cut-out of $^{13}$C Implant
Spot-1 on the FIB Cut-out of Flight Sample 60342

contamination?
Spot-2 on the FIB Cut-out of Flight Sample 60342
Spot-2 on the FIB Cut-out of Flight Sample 60342
Possible Causes for No Implant Profiles

- FIB “grazes” away the top layer of the $^{13}$C implant
- No $^{13}$C implant along the edge being cut out.
More Possible Causes for No Implant Profiles

- Backsides of the FIB cut-outs are not parallel to the sample surfaces
- FIB cut-outs are not mounted parallel to the substrate surface.
Summary

Low "asymptotic" background can be achieved in SIMS instruments for C and N. However, an apparent surface contamination component makes SIMS analysis of C and N fluences in Genesis samples extremely difficult, despite serious attempts to clean the samples.

Our best profiling attempt to date indicate the presence of solar wind C and N in Genesis samples, though no quantification can be made.

Backside profiling of Genesis samples with combined FIB and NanoSIMS techniques could provide a new approach for measuring C and N fluences of solar wind.