CHEMICAL ETCHING FOR PLASTIC NUCLEAR TRACK DETECTORS

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INTRODUCTION

Chemical etching for plastic nuclear track detectors (CR-39) and Thermoluminescence measurements were performed per established techniques currently used by the Space Radiation Analysis Group (SRAG) at NASA/JSC. Work objectives included working with the sodium hydroxide(NaOH) etching solution, etching the plastic nuclear track detectors, measuring the detectors pre-and post-etch. The goal was to calculate the bulk etch and prepare the detectors for storage for future analysis. Over 150 CR-39s were etched successfully and the bulk etch values were analyzed for accuracy using the standard errors and error propagation.

Introduction to Space Radiation Environment

The Space Radiation Analysis Group (SRAG) focuses on ionizing radiation in space and the protection of crew members from this kind of radiation.

There are three naturally occurring sources of space radiation in Low Earth Orbit (LEO):

Types of naturally occurring radiation at LEO
Galactic Cosmic Radiation (GCR)
Soar Particle Events (SPE)
Trapped Radiation
Secondary particles

CR-39 PROJECT

Efficiency of TLD, OSL, and CR-39
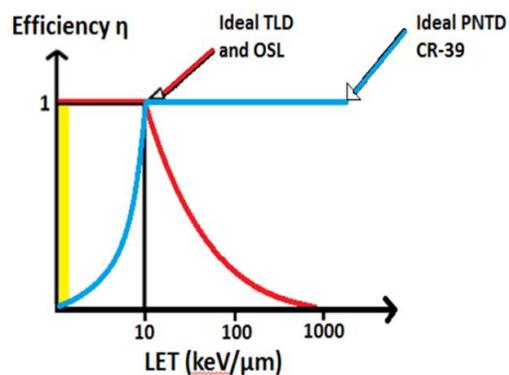
What is contained in a CPD

CPD content	Description
Thermoluminescence Dosimeter(TLD)	20 TLD of different batches Measures absorbed dose over time Dose of record for astronauts
OSL (Optically Stimulated Luminescence)	6 OSL Measures absorbed dose over time Dose of record for astronauts
PNTD (CR-39)	2 PNTDs Can characterize the type of particle that passed through Bulk Etch used to generate LET spectra

CR-39 diagram

Before Etch

After Etch
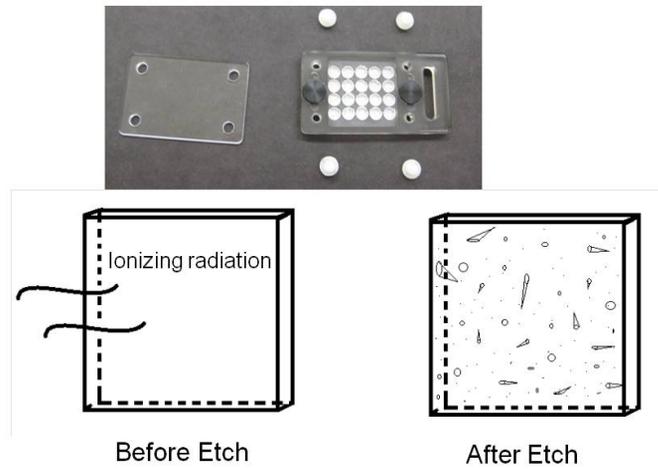
When charged particles pass through the CR-39 material it breaks the molecular bonds and leaves a highly reactive path along the trajectory.

The paths are revealed as etched cones through chemical etching. The shape and size will determine the type of particle that passed through it

Bulk Etch Calculation

The bulk etch B, the thickness removed from PNTD CR-39 by etching, can be calculated by:

$$B = \frac{(m_1 - m_2)T_2}{2m_2}\left(1 - \frac{pT_2}{2A}\right)$$

Where :

m1 = detector mass before etching

m2 = mass after etching

T2 = detector thickness after etching

p = detector perimeter

A = detector area

Etching procedures

- The CR-39 are engraved with a flight and name.
- Two holes are drilled into each of the CR-39 detectors.
- The thickness and mass are recorded using a calibrated scale and micrometer
- Then they are suspended in a CR-39 hanger.
- The hanger are placed in a plastic container of NaOH solution and immersed in a water bath for 38 hours.
- The CR-39 plates are dismounted and dried. Then the mass and thickness are measured again.

Bulk Etch contribution to Dose Equivalent

Etch Rate Ratio is found by using the CR-39 tracks and the Bulk Etch value

$$S = \sqrt{\frac{1 + 4\left(\frac{a}{2B}\right)^2}{\left(1 - \left(\frac{b}{2B}\right)^2\right)^2}}$$

The differential fluence is given by:

$$F = \left(2\pi A \cos^2 \delta_{cut}\right)^{-1} \frac{dN}{dLET}$$

The differential dose is given by:

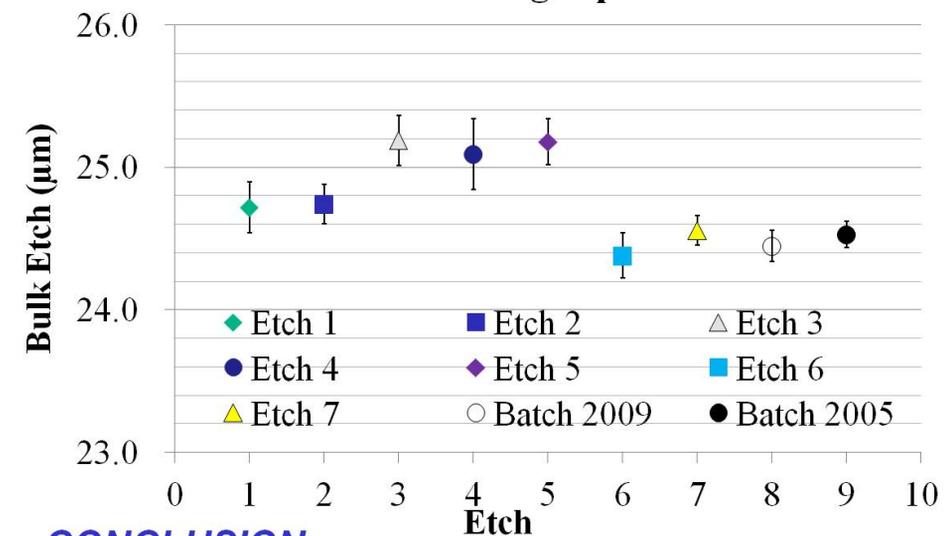$$D = 4\pi \times 1.6 \times 10^{-9} \times LET_\infty \times F$$

The integral dose equivalent(H) is given as:

$$H = \int D(L) \times Q(L) dL$$

RESULTS

	ETCH1	ETCH2	ETCH3	ETCH4	ETCH5	ETCH 6	ETCH7
Average Bulk Etch (μm)	24.72	24.74	25.19	25.09	25.15	24.38	24.56
Standard Error	0.18	0.14	0.17	0.25	0.16	0.16	0.41
Relative Error	0.71%	0.55%	0.69%	0.98%	0.64%	0.64%	1.6%

Bulk Etch Averages per Etch

CONCLUSION

The calculated bulk etches from this summer are within approximately 1% of the bulk etches from 2009 and older. Therefore indicating that the etches, and bulk etch calculations were done correctly and accurately.

ACKNOWLEDGEMENTS