# Analysis of Trace Elements in Silicon Dioxide

## with the Prodigy DC Arc


## INTRODUCTION

Silicon dioxide, also known as silica, is a good electrical insulator, has high thermal stability and is resistant to abrasion. For these reasons, silica finds use in the production of glass for materials such as beverage bottles, drinking glasses and windows. It is also used as the primary component in optical fibers used for telecommunication and in ceramic materials such as porcelain and stoneware.

Fused silica, a high purity grade of silica, often refers to silicon dioxide that is 99.4-99.9% pure. At 1830 $^{o}$C, this material has a high melting point which, combined with its dielectric and insulating properties, make it useful in many electronic applications. Its refractory and chemical resistance properties make fused silica useful in producing glass, crucibles, industrial rollers used for steelmaking and electric elements in industrial furnaces.

This application note contains data to demonstrate the ability of the Teledyne Leeman Labs ***Prodigy DC Arc*** to determine trace elements in high purity silicon dioxide.

## EXPERIMENTAL

**Table 1.** DC Arc Operating Conditions

| Parameter | Setting |
|---|---|
| **DC Arc Stand** | |
| Current | Ignite at 6A, hold at 6A for 15s, jump to 15A, hold at 15A for 100s |
| Stallwood Jet | None |
| Analytical Gap | 4 mm |
| **Electrodes** | |
| Sample Electrode | 3/16" diameter with an undercut cup |
| Counter Electrode | 3/16" diameter and pointed |
| **Sample** | |
| Internal Standard | None |
| Integration Time | Individual time gates used |

### Operating Parameters

All standards were prepared for analysis by by mixing with high purity graphite such that the ratio of sample to graphite was 1:1. The mixtures were thoroughly blended with a SPEX mixer/mill for a minimum of 10 minutes before hand-packing into sample electrodes.

All analyses were performed on the Teledyne Leeman Labs ***Prodigy DC Arc*** in air without the use of the Stallwood Jet.

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The sample and counter electrodes were purchased from Bay Carbon Inc (Bay City, MI) and used as received. The sample electrodes used were 3/16" in diameter with an undercut cup (part # S-15). The counter electrodes used for all analyses were 3/16" in diameter and pointed (part # C-2). A 4 mm analytical gap was used and the position of the electrodes was adjusted during the sample burn to maintain a distance of 4 mm between the sample and the counter electrode.

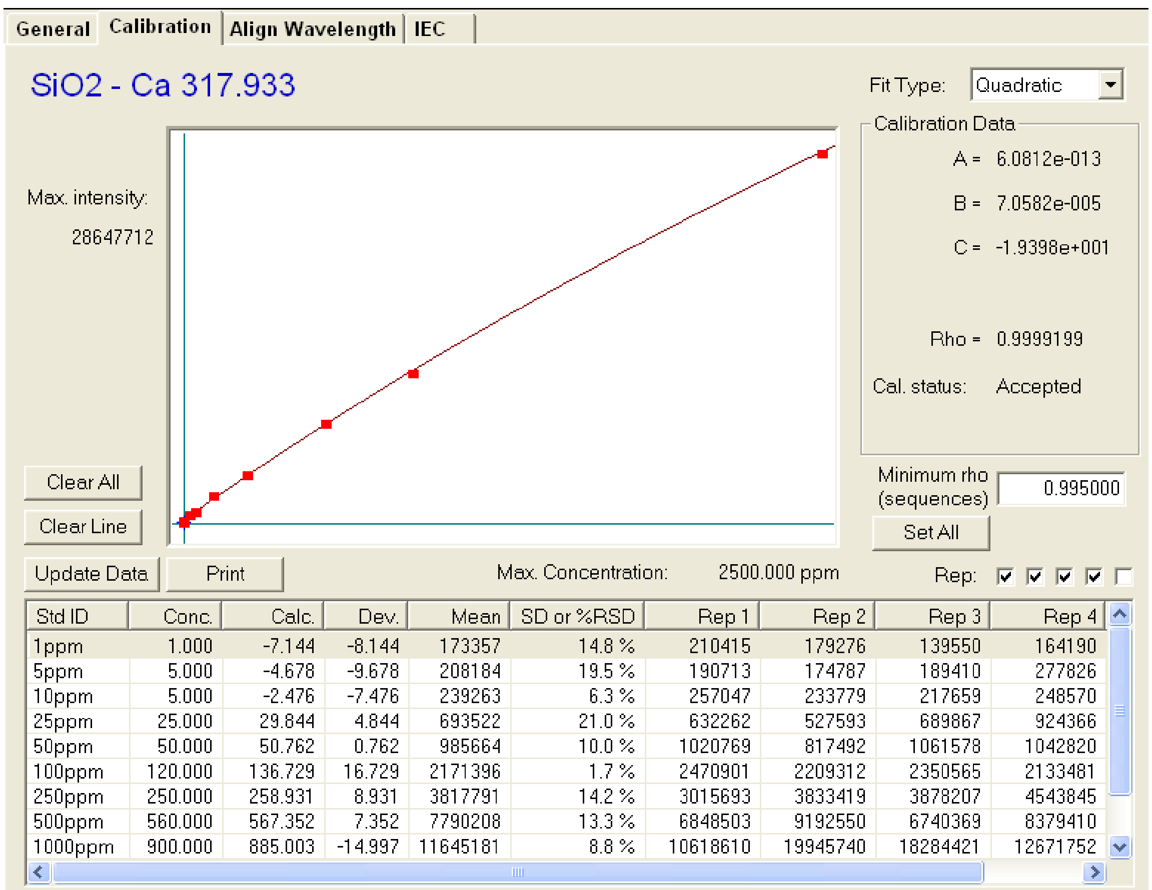
## Calibration Standards

The instrument was calibrated with several high-purity silicon dioxide standards that were spiked with a multi-element stock standard containing 45 elements at 1.21% (MV Laboratories, Inc., Frenchtown, NJ). Calibration standards were prepared in this matrix by serial dilution on a weight-to-weight basis such that the analytes of interest were present at 0, 1.0, 5.0, 10, 25, 50, 100, 250, 500, 1000, 2500 and 5000 ppm in the silicon dioxide matrix. All standards were weighed, mixed and prepared for analysis as described above.

## Calibration Curves

An example calibration curve for elements measured in silicon dioxide is illustrated in Figure 1 for Ca at 317.933 nm. The calibration curve for Ca demonstrates typical precision and accuracy for the concentrations over which the instrument was calibrated.

***Figure 1.*** *Calibration Curve of Ca at 317.933 nm in High Purity Silicon Dioxide*



## RESULTS

### Detection Limits

A study was performed to determine the instrument's detection limits for the elements of interest. Detection limits were calculated based on 3 times the standard deviation of 7 replicate measurements of the calibration blank. Results for the detection limit study are listed in Table 2 in units of parts per million (ppm).

***Table 2.*** *Detection Limits in High Purity Silicon Dioxide*

| Element | Wavelength (nm) | Detection Limit (ppm) | Integration Time (s) | Element | Wavelength (nm) | Detection Limit (ppm) | Integration Time (s) |
|---|---|---|---|---|---|---|---|
| Ag | 328.068 | 0.020 | 0-25 | K | 766.491 | 0.95 | 0-40 |
| Al | 308.216 | 2.5 | 0-60 | Li | 670.784 | 0.21 | 0-115 |
| As | 193.759 | 4.5 | 0-25 | Mg | 277.983 | 0.45 | 0-45 |
| B | 249.773 | 1.0 | 0-115 | Mn | 280.106 | 0.17 | 0-60 |
| Ba | 455.404 | 0.15 | 0-50 | Mo | 313.259 | 0.50 | 0-60 |
| Be | 313.107 | 0.011 | 0-115 | Na | 588.995 | 0.15 | 0-50 |
| Bi | 306.772 | 0.14 | 0-60 | Nb | 309.418 | 0.74 | 0-105 |
| Ca | 317.933 | 1.4 | 0-45 | Ni | 305.082 | 1.2 | 0-60 |
| Cd | 326.106 | 0.59 | 0-25 | Pb | 283.307 | 0.64 | 0-25 |
| Co | 345.351 | 5.2 | 0-60 | Sb | 217.589 | 1.4 | 0-25 |
| Cr | 283.563 | 0.40 | 0-60 | Sn | 317.502 | 0.31 | 0-45 |
| Cu | 324.754 | 0.059 | 0-45 | Sr | 407.771 | 1.2 | 0-60 |
| Fe | 259.940 | 1.0 | 0-60 | Ti | 334.941 | 1.7 | 0-60 |
| Ga | 294.364 | 0.18 | 0-45 | V | 310.230 | 0.082 | 0-60 |
| Ge | 303.906 | 0.15 | 0-35 | Zn | 213.856 | 0.46 | 0-30 |
| In | 325.609 | 0.074 | 0-30 | Zr | 339.198 | 1.7 | 0-100 |

## CONCLUSIONS

The analysis of silicon dioxide using the ***Prodigy DC Arc*** demonstrates that the current-controlled DC Arc power supply, combined with the simultaneous data collection of both peak and background data, provides reproducible sample burns which is reflected in the detection limits obtained for trace elements in a silicon dioxide matrix.

It should be noted that the oxide powder contained Co and W impurities that degraded the detection limits for those elements. The contamination for W was significant enough that a detection limit could not be calculated.