November 1, 2017, Montreal, Quebec, Canada

REPORT SUMMARY

Gen 1 PUREVAP^{tm} Final Report-Silicon Metal Purity Enhancement

Final Gen 1 PUREVAP^{tm} Purity Enhancement Test

PyroGenesis Canada Inc ("PyroGenesis") has submitted to **HPQ Silicon Resources Inc** ("HPQ") (TSX Venture: HPQ) a report entitled "Final Report-Silicon Metal Purity Enhancement" pertaining to the last metallurgical test completed using the *Gen 1 PUREVAP^{tm} Quartz Reduction Reactor ("QRR").*

THE SALIENT POINTS OF THE REPORT ARE AS FOLLOW:

PUREVAP™ QRR is a new technology (Patent Pending) to produce silicon metal, currently being developed by PyroGenesis for HPQ. This technology uses a combined carbothermic and vacuum process to produce high-quality silicon metal directly from quartz.

To date the technology successfully demonstrated the transformation of quartz directly to silicon and was also shown to be scalable as part of the first phase of process characterization.

For the second phase covered in the report, the focus was on enhancing the final purity of the Si product by investigating various operating conditions, volatizing agents, and quartz sources. Towards this goal, an extensive material characterization trial campaign was preformed to better understand the nature of impurities and their presence in the final Si product.

KEY VARIABLE IDENTIFIED FOR MAXIMUM PURITY OF THE SILICON METAL PRODUCED

Since the start of testing in 2016, the *PUREVAP^{tm} QRR* process was rigorously characterized, and various conditions were tested to enhance the final purity of Si.

Of the 96 metallurgical tests done with the *Gen 1 PUREVAP^{tm} QRR,* the last 46 tests were performed specifically in order to examine the maximum capability of the existing setup.

The highest silicon purity was produced in test #51, measuring 99.97% Si by the GDMS analytical technique. However, it was found later that GDMS might not be the best technique for Si samples produced by PUREVAP^{tm}. For the final Gen1 test the ICP technique was selected instead to measure the bulk purity of the sample, and using this method the highest Si purity obtained was 99.92%.[1]

The following five (5) key parameters were found to influence the final purity of the Si product:

1. Feedstock quartz Purity: The effect of quartz (SiO_2) purity on the final Si product was found to be significant: the higher the purity of quartz, the higher quality Si product obtained.
2. Carbon Source Purity: Maximum attainable Si purity is hindered by the impurities present in

[1] Pyrogenesis Canada Inc. Technical Memo: "TM-2017-830 REV 00, - Final Report-Silicon Metal Purity Enhancement

the carbon source.

3. Volatizing Agents: The effect of volatizing agents on the final purity of Si was studied; experimental and calculated results indicate that, depending on the quartz (SiO_2) source; the effectiveness of a volatizing agent varies.
4. Operating Pressure: The effect of operating pressure on Si purity was investigated. Results indicate that the maximum impurity removal efficiency is achievable under specific vacuum conditions.
5. Production Yield: The effect of Si production yield on the final purity of sample was studied via experimental observations and calculations. Results suggest that improving production yield would enhance the final purity of Si product.

PRODUCTION YIELD DEEMED FIRST KEY PARAMETER TO BE TESTED WITH *GEN 2 PUREVAP™*

Tests confirmed that the Si production yield of the *Gen 1 PUREVAP*^{tm} played an important role on the final purity of the Si produce, as its maximum production yield was limited to below 10%.

Theoretical calculations, assuming a 100% production yield, estimating the ultimate purity for a series of key tests were calculated based on actual impurity removal efficiency for each test. Overall the result shows that purity of the Si produced under various conditions could range from 3N (99.984 % Si) to 4N (99.996 % Si) for low purity feedstock, to purity close to 5N (99.998 % Si) when using high purity feedstock.

The key to reaching higher production yield is the mode of operation, it has to be changed from a batch process (*Gen 1 PUREVAP*^{tm}) to at least semi-continuous mode, similar to industrial-scale plants which should result in a higher production yield from multiple cycles with Si being tapped out of the reactor after each cycle. The ability to operate semi-continuously may achieve a maximum production yield of 90%, as typically obtained in industrial scale reactors.

FUTURE WORK PROGRAM AFTER YIELD IMPROVEMENT

The *Gen 2 PUREVAP*^{tm} will allow operating at higher and more uniform temperature, which is crucial for higher volatizing rate of impurities.

Also this new setup, will allow performing additional tests and the introduction of more concentrated volatizing agents, or a new agent to globally or individually target impurity elements.

Eventually, depending on the Si quantity produced with *Gen 2 PUREVAP*^{tm}, it might be possible to perform slow cooling on the tapped metal for segregation of remaining metal impurities from silicon phase. Controlled cooling is a key process step because of the large segregation of the impurities between the liquid and solid silicon phases during solidifications.

Si samples produced with *Gen 2 PUREVAP*^{tm} will be analyzed for bulk purity using the ICP method, and the electrical parameters of the High Purity Si will also be tested.

Pierre Carabin, Eng., M. Eng., has reviewed and approved the technical content of this document.


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