Projects in the Pipeline

High purity quartz: a cut above

With limited competition and few high-grade resources worldwide, the market for high-purity quartz should be a tough nut to crack. Yet with leading producers working side-by-side and others focusing on targeted end-market specifications, progress has been steady even throughout the challenging financial period of late. Emma Hughes, Deputy Editor, takes a closer look at these projects.

Quartz is one of Earth’s most abundant minerals and occurs in many different geological settings. It is best known for its use in glass manufacturing, yet different types of end-markets require differing levels of silicon dioxide (SiO$_2$) content. Very few deposits can be classified as high-purity quartz (HPQ), which can be defined as having at least 99.995% SiO$_2$ content.

According to one of the market leaders, US-based The Quartz Corp. (TQC), what is really important when looking at HPQ, is what makes up the other 0.005%.

“It’s rare to see SiO$_2$ even quoted on the specification sheet, the main focus is always on the non-SiO$_2$ content of the quartz, particularly the alkalis and transition metals,” the company told IM.

The industry standard for HPQ is defined by a product marketed as Iota, mined by Sibelco, a Unimin Corp. subsidiary, at Spruce Pine in North Carolina, US. Iota has set the high-purity benchmark for the rest of the HPQ market and contains 20 parts per million (ppm) of impurities as standard, equating to 99.998% SiO$_2$.

Sibelco’s purest grade, Iota 8, is 99.9992% SiO$_2$ in composition, containing only 80 parts per billion (ppb) of impurities.

A selection of HPQ projects

Sibelco/Unimin

Unimin Corp. is the world’s largest producer of high-purity quartz, but the “confidential nature” of its business means it was unable to provide comment on its operations when contacted by IM.

Producing an industry-benchmark product, Sibelco’s Iota quartz is the product of choice for semiconductor production as it exhibits properties that make it ideal for the manufacture of fused quartz crucibles used in the Czochralski (CZ) process.

The same can be said for its preference in the production of mono-crystalline silicon solar cells, which have the highest efficiency among commercial-scale photovoltaic (PV) products as well as crucibles for CZ single crystal silicon growth.

Iota quartz is also used for the production of all types of quartz lighting, including automotive xenon, halogen, HID and UHP lamps.

The Quartz Corp.

TQC is a 50/50 joint venture created by Imerys SA and Norway’s Norsk Mineral. TQC is a merger of Imerys’ US subsidiaries, KT Feldspar and The Quartz Corp.
and The Feldspar Corp., with quartz producer Norwegian Crystallites, to form a new quartz, feldspar and mica unit.

The company operates from Spruce Pine, US, as well as Norway, and its products are designed to meet specific end-market requirements.

“The products from Spruce Pine meet the standards required by the semi-conductor and solar industry; the products from Norway are tailored to meet the requirements of the optical and lighting industry,” the company told IM.

The Quartz Corp has permits to produce 30,000 tpa HPQ at its plant in Norway – which processes Spruce Pine and Norwegian quartz – however, the company is not producing at those levels today.

“Like most companies in the HPQ industry, our sales peaked in 2011 due to the boom in the solar industry, the solar production bubble burst in late 2011 and it has taken almost two years to remove the excess inventory created in the supply chain and consumption is now returning to normal levels,” the company told IM.

**Spruce Pine**

Situated in the heart of the Appalachian Mountains in North Carolina, US, the Spruce Pine mining district has long been a source of mineral wealth.

The granite rocks were first recognised for sheet mica, which was used as electrical insulation in early vacuum tube electronics. Now, however, HPQ is a big focus for mining companies including Unimin and The Quartz Corp., although the deposit is also recognised for its feldspar content.

The alaskites of the Spruce Pine district were created approximately 375m years ago from magma several miles below the earth’s surface. Nowhere else in the world have the mineral forming processes yielded an equivalent HPQ ore, meaning those working at the Spruce Pine's deposit dominate the HPQ market.

However, others are working on HPQ projects in other locations (see table 1), developing a product specifically designed for individual market uses.

Smaller developers include Russia’s KGOK JSC, Creswick Quartz Pty Ltd, Australia; I-Minerals, US; Momentive Performance Materials, Germany and the US; Nordic Mining, Norway; and Mauritanian Minerals Co., Mauritania.

Chinese quartz has not yet been qualified to the lota standard, although producers are working towards this with companies such as Dorfner Anzaplan – an internationally accredited German laboratory with extensive experience on HPQ processing and analysis – to obtain the technologies and processes that can improve quartz purities.

### Table 1: HPQ projects by location*

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creswick Quartz Plt Ltd</td>
<td>Creswick, Victoria, Australia</td>
</tr>
<tr>
<td>Mauritanian Minerals Co.</td>
<td>Oum Agueninea, Mauritania</td>
</tr>
<tr>
<td>Momentive Performance Materials Inc.</td>
<td>Geesthacht, Germany; Hebron, Ohio, US</td>
</tr>
<tr>
<td>Nordic Mining</td>
<td>Kvinnenhead, Hordaland, Norway</td>
</tr>
<tr>
<td>Polar Quartz OJSC; RUSNANO</td>
<td>Yugra, western Siberia, Russia</td>
</tr>
<tr>
<td>The Quartz Corp.</td>
<td>Spruce Pine, North Carolina, US</td>
</tr>
<tr>
<td>Russian Quartz LLC; RUSNANO; KGOK JSC</td>
<td>Kyshtym, Chelyabinsk, Russia</td>
</tr>
<tr>
<td>Unimin Corp./Sibelco</td>
<td>Spruce Pine, North Carolina, US</td>
</tr>
</tbody>
</table>

*This list is not exhaustive

**HPQ end markets**

High purity quartz a speciality feedstock used in a variety of different end markets, including:

**Fused quartz crucibles**

Fused quartz crucibles are used for the manufacture of silicon metal ingots, which can later be processed into silicon wafers for photovoltaic (PV) cell and semiconductor markets.

**Solar**

The solar industry played a big part in HPQ demand in the 10-year period leading up to 2011 as a reduction in the price of silicon (used to manufacture monocrystalline and polycrystalline solar cells) coupled with a push for renewable energy in the US, Europe and further afield, spurred a large amount of solar uptake.

In the last two years, however, the PV industry has taken a knock as reduced government subsidies and a global economic downturn slowed the amount of new projects, which had an impact on the demand for HPQ.

“The market that has demonstrated the greatest volatility of demand has been the solar industry,” TQC told IM.

“The peak for demand in this sector was in 2011 and it is unlikely that we see this level of demand again until 2016,” the company added.

Despite this, Dorfner Anzaplan remains optimistic about the future potential for demand to increase.

“We expect to see consolidation in the PV industry within the next five years, and certainly by 2015, however, because there is lots of solar installation taking place around the world and we think we will be back where we were in 2011 before long,” Haus told IM.

**Semiconductors**

The process for making semiconductors is very similar to manufacturing solar cells – which is one of the reasons many semiconductor companies switched lanes when the semiconductor market slowed in around 2008 when the PV market began to boom.

In this cyclical market, thinner, more efficient product innovation is again expected to drive demand for HPQ.

“New generation 300mm-450mm wafers for semiconductors is driving demand for HPQ-glass-based materials, which are used to manufacture these wafers,” Haus added.

**High temperature lamp tubing**

High-temperature lamp tubing, such as mercury and halogen lamps, uses a high purity quartz envelope to contain the lighting components.

“In the lighting industry, compact fluorescent lights (CFLs) are competing with halogen lamps for market share, but halogen lamps outperform CFLs in colouring and the fact that they do not contain mercury,” explained Haus.

“We are also seeing demand increasing for metal halide lamps for car headlights as automotive ownership increases and consumers opt for high-spec vehicles,” he added.

**Telecommunications**

Haus further explained that in telecommunications, Dorfner Anzaplan is seeing the expansion of the broadband market and increasing investment 3G/4G infrastructure worldwide. HPQ is used in the handling of waveguides for this industry, so the company is also witnessing growth there.
In 2011 TQC invested in improving the flotation processes at Spruce Pine to upgrade the quartz quality and also increased capacity to produce more than the demand of international customers and internal demand in Norway. The company confirmed to IM that any future investment will be dedicated to new product developments only.

“In Norway, we have just successfully commissioned our latest capacity expansion and we will add capacity in a modular fashion as dictated by demand in our different market areas,” it added.

TQC additionally confirmed that while its main focus is on the Spruce Pine operation – as no other area is likely to come close in terms of quality – it does have an active exploration group “who test and survey many new deposits each year.”

“So far we have not found any that can match our deposits in Spruce Pine,” the company added.

Nordic Mining
Nordic Mining secured the exclusive rights for investigation and development of its Nesodden quartz deposit in Kvinnherad municipality in Hordaland country, Norway, in 2011. The 600 metre long and 15 metre wide deposit is a high-purity quartz vein containing more than 3m tonnes quartz.

A preliminary estimate for the deposit has additionally shown at least 2m tonnes hydrothermal quartz down to 150 meters above sea level.

Unprocessed quartz from Nesodden meets the specifications for solar silicon production, although it can be further processed to meet the requirements for high-purity markets including optical glass, lamp tubing, crucibles, semiconductors and microelectronics.

Nordic Mining will produce 5,000 tpa HPQ over 30 years from its Nesodden deposit, according to its scoping study.

The impurities in the raw quartz average approximately 42ppm in the raw quartz, which will need to be purified to less than 30ppm or a grade of 99.997% SiO₂, to be considered high purity.

“It has been shown that it is technically feasible to mine the deposit and that high grade/high value products can be achieved by processing the quartz,” Nordic CEO, Ivar Fossum, explained.

The deposit requires further drilling for either JORC or NI 43-101 guidelines to be applicable but the most recent deposit size estimate, given in 2011, indicated a minimum tonnage of 1.2m tonnes high grade (>90%) quartz and 0.77m tonnes quartz in the surrounding smaller areas.

The mine will require $50m investments and “assigning total mining operating and transport (...) the rate per tonne is estimated to vary between $19.5 (strip ratio 2.2) and $25 (complication due to geology) per tonne,” the scoping study outlined.

In January 2013, the company revealed that the project will require further drilling and processing test work as well as investigation of by-products rising from the 51,000 tpa waste (which will include some lower grade quartz) that will need to be disposed of.

“We will put effort into advancing project development in the coming year. Initially, focus will be on commercial issues to position the project towards markets and customers,” said Fossum.

Mauritanian Minerals Co.
Mauritanian Minerals Group Co. (MMC) produces and markets HPQ from Mauritania under a 30-year renewable licence to operate, obtained from the Mauritanian government.

The company’s open pit mine is located 130km from the port of Nouadhibou and stretches over 557km². A geological survey revealed a vast resource of 99.9% purity quartz, capable of producing 100-500,000 tonnes for the first year.

“Our mission is to develop a range of quality and extremely competitive [products] in the global market for high-purity silica,” the company said.

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Table 2: Typical silica sand and quartz specifications, by market

<table>
<thead>
<tr>
<th>Type or application</th>
<th>SiO₂ minimum (%)</th>
<th>Other elements (maximum %)</th>
<th>Other elements (maximum ppm)</th>
<th>Market size (mtpa)</th>
<th>Typical price ($/tonne)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear glass-grade sand</td>
<td>99.5</td>
<td>0.5</td>
<td>5,000</td>
<td>&gt;70</td>
<td>30</td>
</tr>
<tr>
<td>Semiconductor filler, LCD and optical glass</td>
<td>99.8</td>
<td>0.2</td>
<td>2,000</td>
<td>2</td>
<td>150</td>
</tr>
<tr>
<td>‘Low grade’ high purity quartz</td>
<td>99.95</td>
<td>0.05</td>
<td>500</td>
<td>0.75</td>
<td>300</td>
</tr>
<tr>
<td>‘Medium grade’ high purity quartz</td>
<td>99.99</td>
<td>0.01</td>
<td>100</td>
<td>0.25</td>
<td>500</td>
</tr>
<tr>
<td>‘High grade’ high purity quartz*</td>
<td>99.997</td>
<td>0.003</td>
<td>30</td>
<td>&lt;0.1</td>
<td>-5,000</td>
</tr>
</tbody>
</table>

*‘High grade’ high purity quartz, with <30 ppm, is the standard high purity material produced by Unimin Corp. and TQC at Spruce Pine
Note 1: Specific other elements may be limited by application. E.g. Fe₂O₃ <100 ppm for float glass and <40 ppm for low-iron float glass
Note 2: Generally ‘high purity’ quartz has Fe₂O₃ <15 ppm, Al₂O₃ <300 ppm, and alkali and alkali earth oxides <150 ppm
Note 3: In some applications Al₂O₃ can substitute for some SiO₂, e.g. up to 1.5% Al₂O₃ in float glass
Note 4: Limits can vary according to the composition of other raw materials in the application

End markets for MMC’s product include solar thermal energy, automotive glass and construction, as well as high tech industries including medical ceramics, LCD touch screens and laboratory equipment.

Creswick Quartz Pty Ltd

Based in Victoria, Australia, Creswick Quartz has been conducting operations since 1996. The company processes quartz from old gold mine tailings at its own processing facilities.

In the past, Creswick Quartz has supplied lower-purity quartz to end markets including glass manufacture, composite stone, silicon metal, water filtration, ceramics and agriculture.

In future, Creswick Quartz hopes to build a new processing plant to introduce ultra-pure quartz material, which has been confirmed by independent analysis. This quartz deposit is thought to be low in impurities, especially boron and phosphorus. Physical and chemical treatment has revealed tailing purity of 99.995% SiO₂, which could eventually reach purities of 99.999% SiO₂.

The volume of above-ground quartz is in excess of 1m tonnes and is thought to be of uniform quality. The licensed area below ground is around 300km².

Applications for this material include semiconductor and crucibles and upgraded metallurgical-grade silica (UMG-Si).

Customers are mainly based in Victoria; however, the company has now begun to supply end-users outside the state.

I-Minerals

Idaho-based I-Minerals is developing two projects at its Bovill Kaolin deposit, which produces several mineral products including feldspar, halloysite, kaolin and quartz. The quartz developed here displays three levels of purity in excess of 99% SiO₂, with the highest grade defined as HPQ at more than 99.98% SiO₂ purity.

End-markets targeted by I-Minerals include sodium silicate, paint, solar glass, optical glass, art glass, glass bulbs and liquid crystal display (LCD) glass.

HPQ processing

Beneficiation of raw quartz into refined high-purity products is required to minimise the specific impurities of the individual raw quartz. This process is often adapted depending on the end-use application the producer has in mind, as some uses require a higher-purity product than others (see table 2).

According to Dorfner Anzaplan, the internationally accredited German laboratory with extensive experience on HPQ processing and analysis, some HPQ applications are becoming more restrictive in their specifications for very low boron and phosphorous content.

‘It is very difficult to analyse such small parts per billion amounts of these impurities, so you need a lot of experience of working with HPQ to be able to do this,’ Dr Reiner Haus, Dorfner Anzaplan managing director, told IM.

‘The key to analysis is not only the ability to measure the levels of impurities in the quartz but also the sample preparation. Lots of mistakes can be made when preparing samples which can introduce impurities into the HPQ,’ he added.

Speaking more specifically about HPQ processing requirements, Haus explained that there is no standard technology route to making HPQ.

“For HPQ, you have to investigate the composition of the quartz very carefully and develop a process design based on the specific characteristics of the quartz,” he told IM.

HPQ pricing

Unlike some industrial mineral markets, competition in HPQ is limited, meaning pricing remains fairly steady. However, this mineral does not come cheap.

Speaking at the Middle East Industrial Minerals conference in Oman this November, Haus told delegates that one tonne of quartz can be equivalent in price to one automobile at almost $10,000 for outstanding high-grade qualities.

Dorfner Anzaplan noted that it usually notices a year-on-year increase in HPQ prices, while TQC told IM that further increases could soon be on the horizon.

“Excluding the 2011 solar boom, which created a price bubble in some segments as demand exceeded supply, the market price for HPQ has been stable overall. However, external cost inflation (such as the cost of HF acid/fluorspar, which is a large component of total product cost) could justify an upward adjustment of HPQ prices in the future,” the company said.

Anzaplan agreed that the solar industry has had some impact on prices in the last two years but noted that “we think that this will return to levels we have seen in the past”.

The company added that changes in prices for the chemical aids used to process HPQ may influence product prices, but that these are mostly stable for now.

“Fluorspar used in the treatment of HPQ has seen some movement, however, and changes in the price of HF will impact HPQ,” Haus concluded.