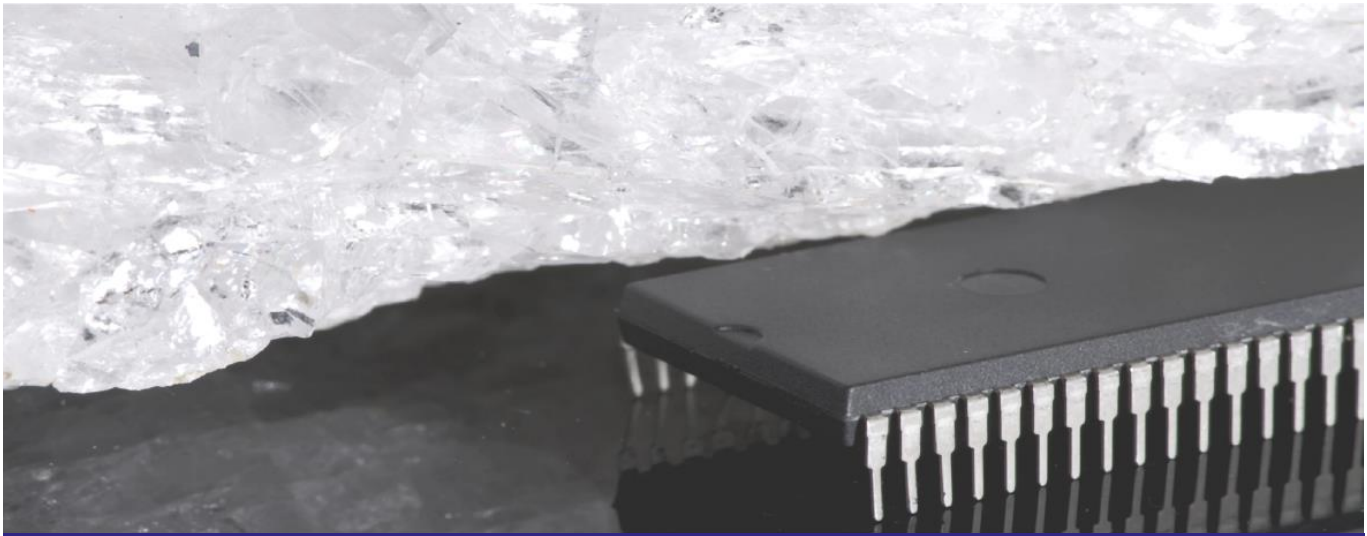

Evaluation of High Purity Quartz Resources: High Purity Quartz Processing

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Introduction

Conversion of raw quartz into refined High Purity Quartz (HPQ) products involves mechanical, physical, chemical and thermal processing technologies.

Pre-processing

Depending on the specific characteristics of the quartz deposit, one or more preparation stages may be required prior to physical separation of impurities can be performed:

- Initial crushing
- Sensor-based sorting (SBS)
- Comminution
- Classification to product particle size

In the **initial crushing** step, mined quartz lumps are high-pressure washed and crushed to produce granules in the centimeter size range. Classification then provides closely defined size fractions beneficial for further processing.

ANZAPLAN projects have proven the effectiveness of **sensor-based sorting** for the processing of high purity quartz. The technique separates the liberated components of raw materials on the basis of various parameters, such as differing color (or transparency) and shape, chemical composition, and density, and may improve, or even replace, costly selective mining or hand sorting practices. Even in size fractions below 40 mm, in which manual sorting is not economical, down to the 3 to 5 mm range, sensor-based sorting can now be used with high efficiency. This technique may be applied to remove discolored quartz fractions to improve chemical purity. Analogously, transparent quartz can be separated from fluid inclusion-rich milky quartz, thereby often improving melting characteristics and impurity level (Figures 1 and 2).

Classical **comminution** methods typically utilize jaw and cone crushers in order to reduce the particle size and to liberate the various mineral components. However, these techniques potentially introduce unacceptable contamination particularly in finer product fractions as a result of wear. For high purity quartz, alternative and advanced comminution techniques are, thus, recommended:

- Autogenous grinding
- Electrodynamic fragmentation

Autogenous grinding utilizes the material to be ground (quartz lumps) as the grinding media. In contrast to conventional grinding, no wearable parts made of steel or grinding media made of aluminum or zircon oxide are used during autogenous grinding. This way, contamination of the quartz material is avoided.

Electrodynamic fragmentation is an enhanced technology that liberates quartz crystals in the composite rock largely without contamination and with a low loss of undersize particles. A high-voltage discharge generates shock waves within the quartz lump causing it to fragment along the weaker natural boundaries between crystals (Figure 3).

Figure 1: Transparent quartz fraction after optical sorting

Figure 2: Milky quartz fraction after optical sorting

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Since mineral impurities are mostly located at crystal boundaries, downstream processing is more efficient due to improved liberation.

Compared with mechanical comminution techniques, yields are increased significantly, as well. Moreover, this novel technology is ideal for selective liberation of gas and liquid inclusion trails within the quartz crystals.

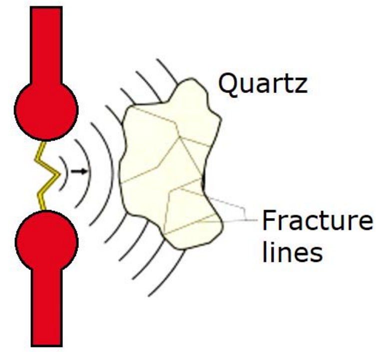

Figure 3: Working principle of electrodynamic comminution

Physical Processing

Impurities liberated during the preparation stage may be separated from quartz due to their differing responses to physical processes, such as:

- Attrition scrubbing
- Magnetic separation
- High-tension separation
- Froth flotation

Attrition scrubbing is applied to clean the surfaces of the quartz particles. Thereby fine particles attached to quartz surfaces, e.g. clay minerals or iron oxide coatings, are liberated and can simply be washed out or removed in subsequent processing steps.

Figure 4: ANZAPLAN technician conducting flotation experiment

Due to paramagnetic or ferromagnetic properties, most heavy minerals can be separated from quartz by **magnetic separation**. Their attraction to the magnet increases with increasing magnetic field strength, whereas diamagnetic quartz, in contrast, is repelled. Since magnetic susceptibility is strong only moderate magnetic field strengths are necessary for separation in the case of ferromagnetic minerals. Higher field strengths are required to remove paramagnetic minerals. Commonly, permanent magnetic belt separators are used in high purity quartz processing.

High-tension techniques separate minerals due to differences in their surface conductivity. The electrostatic separator consists of a heated chamber where the electrodes are located which can generate an electrostatic potential up to 70 kV. Before feeding particles uniformly into the electrostatic field, the material is activated by heating the sample with or without prior addition of diluted acids or polyelectrolytes. The charged particles are then attracted to the respective electrode. A typical example is the separation of feldspar from quartz as a dry alternative to froth flotation.

Froth flotation selectively separates minerals according to differences in their wettability, enhanced or suppressed by conditioning reagents. Separation takes place in a tank filled with an agitated aqueous suspension of quartz (Figure 4). A frothing agent is added, and air introduced to form a rising column of air bubbles. Hydrophobic mineral particles attach to the air bubbles and rise to the surface forming froth whereas hydrophilic (wetted) particles remain below the froth layer sinking to the bottom. Flotation process designs vary in complexity depending primarily on the type of mineral, degree of liberation, and the desired purity of the product.

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Chemical & Thermal Processing

Chemical treatment is an important addition to physical processing methods in order to achieve maximum purity through the removal of surface impurities. Acid treatment and hot chlorination are the main two chemical processes applied.

Figure 5: ANZAPLAN technician conducting acid leaching experiment

Within **acid treatments**, regular acid washing of quartz constitutes a soft technique and is capable of dissolving certain chemical impurities on particle surfaces. In contrast, an advanced hydrofluoric acid leaching process at elevated temperatures more effectively removes surface impurities as well as any larger amounts of unwanted mineral matter remaining (Figure 5). Hereby, undesired minerals are dissolved and impurities enriched in micro fissures and along dislocations can be removed due to an increased dissolution rate of quartz in domains where impurities are concentrated. Depending on the targeted final application, either acid washing or leaching may be more economic.

In the **hot chlorination** process, quartz is heated to temperatures of 1,000 – 1,200°C in a chlorine or hydrogen chloride gas atmosphere. Under these conditions, impurity elements located in the quartz crystal lattice can be removed. This refining process is particularly suitable for reducing primarily the level of alkali-metal but also transition-metal impurities to some extent, which face stringent specification limits in semiconductor applications, for example.

Thermal treatment (calcination) of high-purity quartz improves its melting behavior due to the removal of fluid inclusions. If not removed, these inclusions may form bubbles in the final quartz glass, compromising the products' performance. Depending on the type of fluid inclusions, a significant reduction in the bubble content in high purity quartz has been observed during ANZAPLAN's in-house studies. The resulting pressure increase in the inclusions during treatment causes the development of microfractures in quartz particles. Through these fractures, the contained gases, H_2O, and potentially other phases that contribute to bubble formation during later melting can escape.

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ANZAPLAN Services

ANZAPLAN One-Stop Shop

ANZAPLAN offers project development for HPQ, from the first characterization of raw quartz, through the flow sheet development and application tests, up to detailed engineering services, market intelligence and market introduction. Through the cooperation with M.Plan International, ANZAPLAN can also provide geological studies required for technical studies.

With manufacturers requiring HPQ sources to feature certain elemental impurity levels to be as low as only a few ppm or even ppb, a high level of expertise in analytics is required to assess the potential of quartz. ANZAPLAN's unparalleled expertise in this sector lies in the capability and experience in providing these analytical services in-house. Building on this, test work programs are conducted at bench-scale in the laboratory and technical center. Dorfner ANZAPLAN and its laboratory are accredited by the DAkkS-accreditation chamber which is a signatory to the multilateral agreements of EA, ILAC and IAF for mutual recognition. Therefore, analyses and testing by ANZAPLAN are internationally accepted.

Besides laboratory-scale testing, ANZAPLAN is capable to verify the developed processes at pilot-scale to produce HPQ samples of up to 1,000 kg. This includes chemical and thermal treatment of quartz concentrate. All auxiliaries, such as classifiers and drying equipment, have been adapted to high purity conditions allowing the reliable processing of high-purity raw materials on a semi-technical scale. At ANZAPLAN's technical center, samples are produced for customer tests as well as for end-user approval. ANZAPLAN further provides know-how in the design and optimization of innovative tailor-made processing plants.

Through numerous projects ANZAPLAN has earned a renowned reputation in the high purity quartz industry and an expertise which allows it to competently assess high purity quartz deposits and also ultimately approve targeted products with potential end-user customers.

We invite you to contact our experts.

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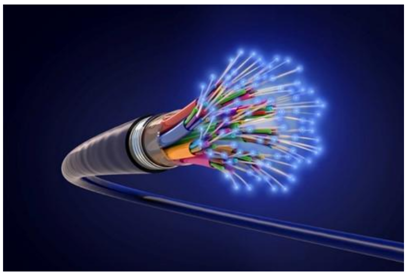

Figure 6: Fiber optic cable consisting of wires made with HPQ

Figure 7: ANZAPLAN's laboratory is fully certified and accredited

All ANZAPLAN services are internationally certified by

- *ISO 5001*
- *ISO 9001*
- *DIN EN ISO/IEC 17025*
- *ISO 14001*

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