

Some types of crystals are produced exclusively by our company. You can buy them only from us!

ABOUT



↑ *Lab grown Pigeon blood ruby*



↑ *Lab grown Colombian emerald*



↑ *Synthetic rutile*



↑ *Lab grown bi-color corundum*

RG Crystals is one of the world's largest suppliers of lab grown rough stones in the jewelry market and is a leading expert in the field of single crystal growth. For more than 25 years, our company's technology team has enhanced and supplemented known methods of growth and recrystallization of crystals. Thanks to the innovative technologies used by our experienced team, our company is able to offer a wide range of products.

The range of the RG Crystals is so wide and diverse that it requires detailed comments to accompany the catalogue of products which present a basic outline of crystal growth and explain the obvious differences in the quality, manufacturing process and hence prices of similar stones. This will help the buyer to become familiar with all varieties of the stones available on the market.

If necessary, you can always get the full detailed technical specifications for the produced crystals by contacting us.



CREATED CRYSTALS AND IMITATIONS

Crystal is a solid body of material consisting of atoms arranged in a specific order in space. Each natural mineral contains a strict order of atoms in the crystal (crystal lattice) and as a result their physical and chemical properties are unique. Two minerals with the same composition and properties do not exist.

Lab grown or synthetic crystals are those not obtained in nature, but produced in the laboratory.

There are a large number of materials used in jewelry, but they do not have the composition and properties of natural stones. These materials resemble the natural crystals in appearance only. There is a special name for such materials — imitations.

Imitations are materials that have only external resemblance to natural stones, and in structure, composition, and properties are completely different, usually made from cheaper material.

The most common imitations used in the jewelry industry are glass, plastic, ceramics, and cubic zirconia. Cubic zirconia is a crystalline zirconium oxide. In nature, there is a mineral with the same chemical composition and properties called baddeleyite. But it would never occur to anyone to call and sell a cubic zirconia as synthetic baddeleyite. Baddeleyite is rarely found in

nature and very few people are interested in it. But the high refractive index and dispersion, similar to those of a diamond, as well as the possibility of producing any color from it, have made the cubic zirconia the most popular and sought-after product. Unfortunately, besides its brilliance, it is nothing like a natural diamond. Therefore, it is a cheap, mass produced, but beautiful diamond imitation.

The main focus in the production of lab grown crystals is ensuring the most accurate reproduction of the composition and structure (crystal lattice) of a natural crystal. This requires the simulation of all processes and conditions associated with the formation of this mineral in nature, but within the laboratory. The workings of the natural world have not been fully studied and understood, so imitating it, and even more so reproducing its processes, which have taken millions of years, within the laboratory and in a short time is a laborious, complex and expensive task. Therefore, there is a gradation of manmade crystals in the degree of approximation to the natural stone, and hence the price.

The closer the growth method is to the natural process of crystal formation, the more complex and expensive it is, but the resulting crystals replicate the natural crystal more accurately.

In this review we describe popular technologies and methods of single crystal growth. Each method of crystal growth has its own approximation to the desired goal: the complete match of the result with its natural counterpart.

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SOLID-PHASE GROWTH TECHNOLOGY

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The existing technology of crystallization from the solid phase is not widely used to obtain colored gemstones. We will not focus on it in this review.

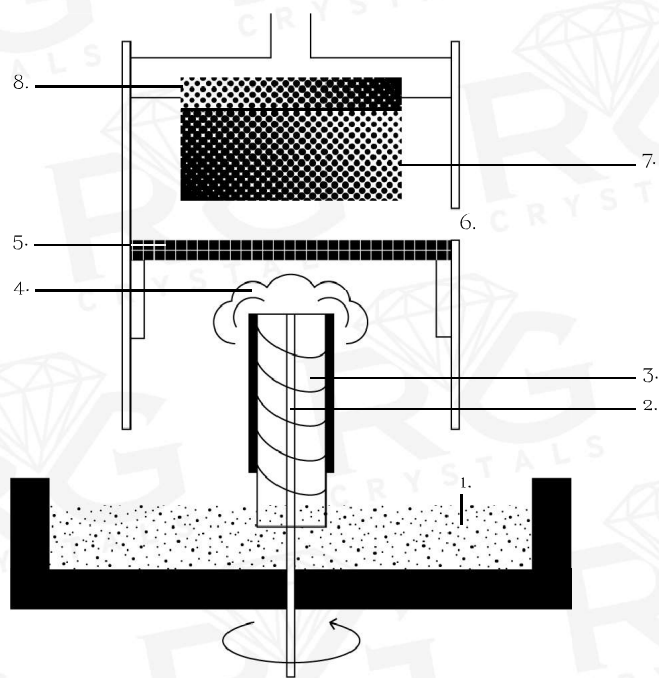
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GAS-PHASE GROWTH TECHNOLOGY

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Crystal growth using this technology is carried out at high temperatures in closed or semi-closed growth crucibles. It includes sublimation (transition from a solid state to a gas state bypassing the liquid state) of atoms of the material acting as a source located in the hot area, as well as the transfer of active vapors through the growth chamber and their deposition on a substrate located in a relatively cold zone.

This method produces synthetic moissanite (which has a natural analogue of SiC carborundum, but has become popular as an imitation of natural diamond), as well as synthetic diamonds (CVD diamonds) and a number of technical crystals, semiconductors and abrasive materials.



1. powder | 2. rod | 3. screw | 4. powder in gaseous state | 5. graphite plate | 6. opening | 7. growing crystal | 8. seed crystal

4-5



1 Synthetic moissanite

— A simplified diagram of sublimation process

MELT GROWTH TECHNOLOGY

Methods of growing crystals from the melt are the most widely used to produce gemstones. The essence of the technology is that crystal growth occurs from its own melt because of the temperature gradient in the crystallization zone. This technology allows large quantities of gems to be produced in the shortest time possible. The quality and cost of produced crystals vary depending on the methods used.

3a. Skull crucible — p. 8–9

3d. Stepanov process — p. 18–19

3b. Verneuil process — p. 10–13

3e. Kyropoulos process — p. 20–21

3c. Czochralski process — p. 14–17

3f. Floating zone — p. 22–23

CRYSTALLIZATION FROM SOLUTION

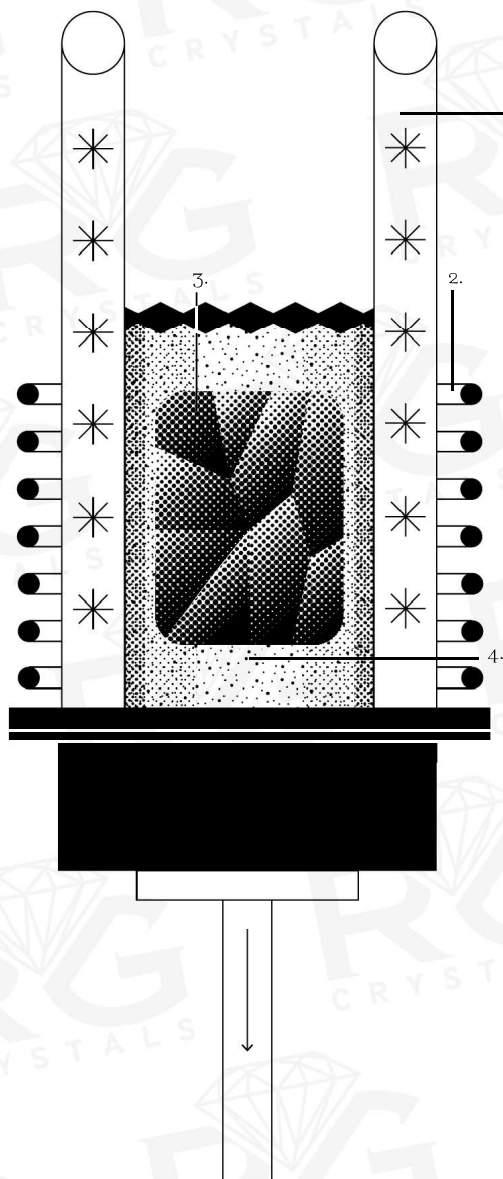
We usually refer to substances mixed together in water as a 'solution'. However, from a chemistry point of view, a solution of substances in another substance in a liquid state can be called a mixture. If uranium is dissolved in liquid mercury, from a scientific point of view this is considered as a solution of uranium in mercury. Therefore, the flux method is considered as a solution-growth method. A substance of the required composition is dissolved in the melt of a completely different substance, which does not participate in the formation of a given crystal lattice, but serves only as a means to obtain individual atoms from the initial charge.

4a. Flux method — p. 24–25

4b. Hydrothermal method — p. 26–29

Skull crucible

Cold container method



1 Cubic Zirconia Canary Yellow



1 Cubic Zirconia Green Yellow Light



1 Cubic Zirconia Topaz Blue Light



1 Cubic Zirconia Papaya Dark



1 Cubic Zirconia Royal Diamond



1 Cubic Zirconia Mars Stone Light

The inventions of Soviet scientists allowed crystals to be produced with ultra-high melting points. The mixture of the desired substance is placed in a chamber with actively cooled walls, after which a melt is created only in the center of the mixture (depending on the specific process by laser, induction or microwave method). The temperature gradient is created by moving the heating element relative to the chamber.

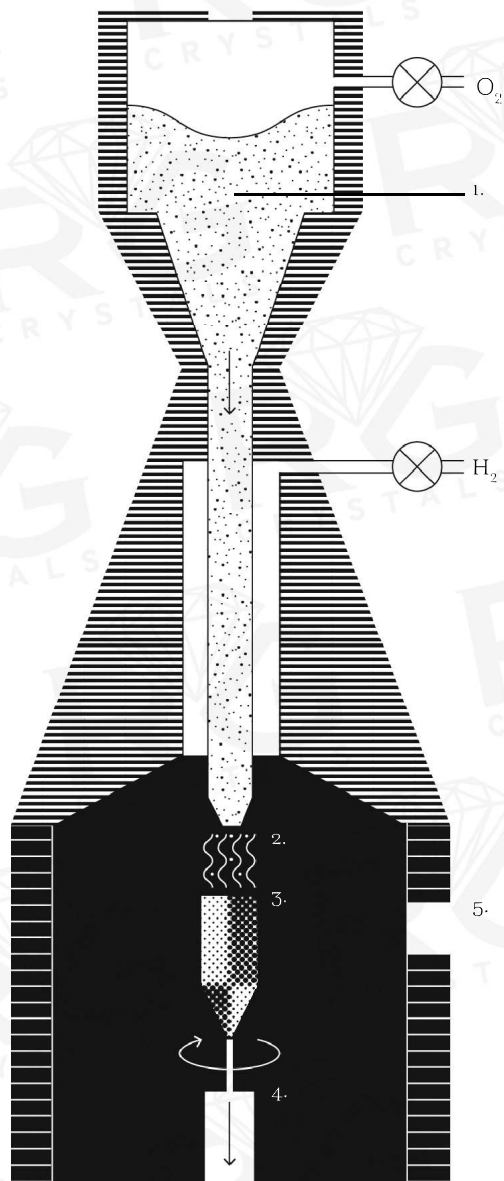
This method is the crucibleless method of producing crystals. The mixture remains solid near the chamber walls, thereby protecting the chamber walls from melting and keeping the melt in the center.

This method makes it possible to produce crystals (for example, cubic zirconia — a mass produced imitation of diamonds) whose high melting point (above 3000°C) makes it difficult to choose a suitable crucible material.

*
RG Crystals produces more than 100 colors of cubic zirconia, as well as cubic zirconia with exclusive physical properties, for example, with a specific weight of 10–50% above standard.

Verneuil process

Flame fusion



→ Examples of the crystals are on the next page

The very first method of crystal production used on a commercial scale is named after the scientist-engineer who published a description of the technological process. This method is most commonly used for growing crystals of corundum, rutile, spinel, and some other compounds. Powder of the required chemical composition together with powders of dye substances (the so-called chromophore ions) are placed into the flame of a hydrogen burner, melted and dripped onto a seed of the desired crystal. Crystallization occurs in the zone of contact of the melt and the seed in the volume of the fallen drop. As a result, single crystal boules grow (round and without any crystallographic outlines) of several centimeters or more in diameter, depending on the material and the requirements of the customer.

The advantages of this method are: simplicity, high production speed, low material costs compared with other methods.

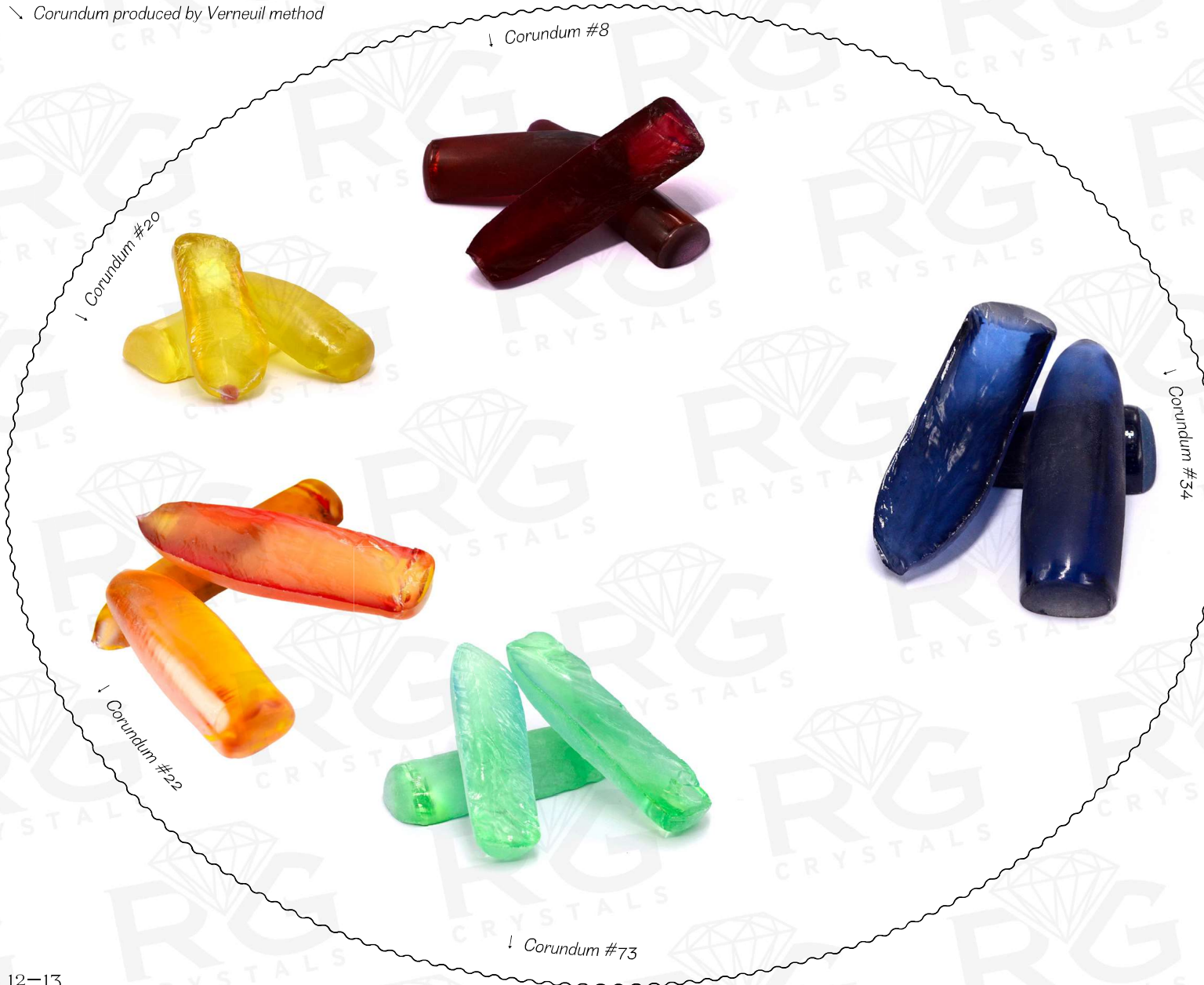
Disadvantages of the method: the presence of uneven color in the resulting crystal, microparticles of unmelted mixture, a large number of internal stresses, deformation of the crystal lattice. These disadvantages are a consequence of the rapid growth rate and unstable crystallization zone.

However, due to its low cost, this method is widely used for mass production of rubies and sapphires of all colors, including star rubies and sapphires, as well as spinels of blue and green shades.

Corundum and spinel crystals, obtained by the method of Verneuil, have a composition and properties similar to natural crystals. But the resulting structure, as mentioned above, is far from perfect and corresponds to the natural one only by the plane of crystallization (volume of a fallen drop). While between themselves these planes can be either separated by the boundaries of an unmelted mixture or by an uncrystallized mass (ceramics, and not a crystal in its essence), so can they be differently oriented relative to each other.

※ Due to the highly deformed crystal lattice, these stones can be easily identified in any gemological laboratory or, with a little experience, by the buyer himself.

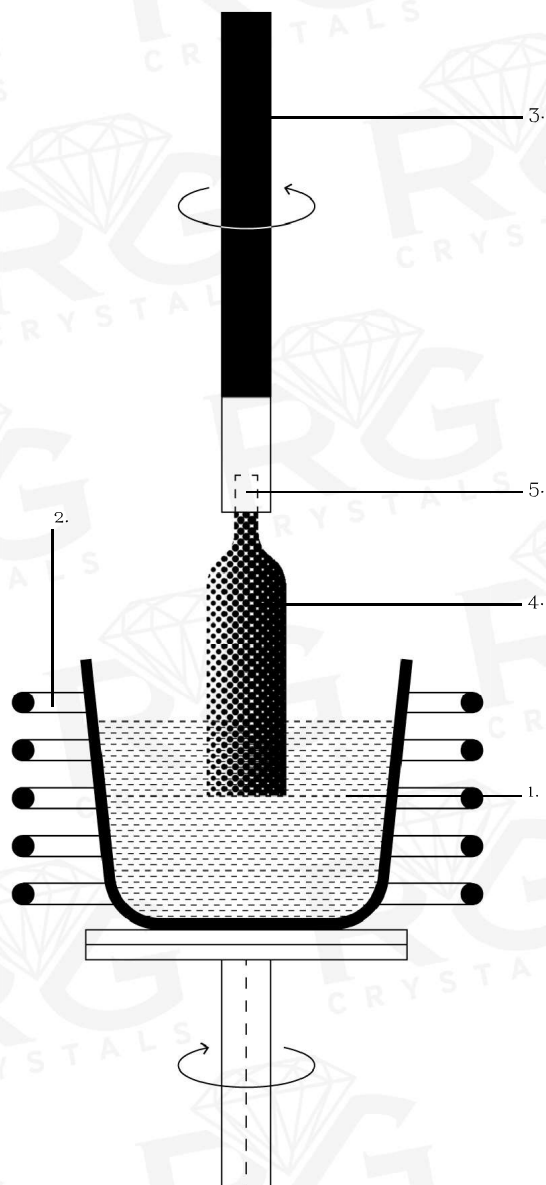
\ Corundum produced by Verneuil method



*
 RG Crystals produces more than 40 different colors of synthetic rubies and sapphires using the Verneuil method.

↓ Bi-color corundum





Examples of the crystals are on the next page

The method of crystal production invented by the Polish chemist Jan Czochralski at the beginning of the 20th century by pulling a crystal out of crucible filled melt is one of the most common crystal production methods. Nowadays this method is used to produce crystals out of almost all substances that melt without decomposition, and cool without cardinal restructuring of the crystal structure (without polymorphic transitions). These are high purity optical crystals for use in the military and laser industry, as well as precious stones, metal crystals (including precious ones), semiconductors and optical ceramics.

This method enables the creation of large crystals of high purity and orderly crystal lattice, and as a result, more accurate equivalents of natural stones.

The idea of the method is to place a seed crystal directly above the surface of the melt. When the seed crystal comes into contact with the melt surface, it is rotated and then slowly lifted at a carefully controlled speed. Heat reduction through the crystal while maintaining a constant melt temperature leads to gradual crystallization. The material crystallizes on the seed and grows downwards as it is pulled out of the melt. The equality of the

crystallization rates and crystal pulling speed contributes to the formation of a regular and continuous crystal lattice.

※ It is almost impossible to distinguish the crystals obtained thus from natural ones by only using simple methods (refractometer, polariscope, microscope, spectroscopy, etc.). Crystals grown by this method belong to a group of high-quality expensive synthetic stones, which are also called recreated or cultivated stones (created or cultured gemstones).

For identification it is usually necessary to use complex equipment to make an extensive spectrum analysis. We strongly recommend that you contact a certified laboratory for accurate results!

↘ Spinel produced
by Czochralski method



↑ Corundum produced by Czochralski method

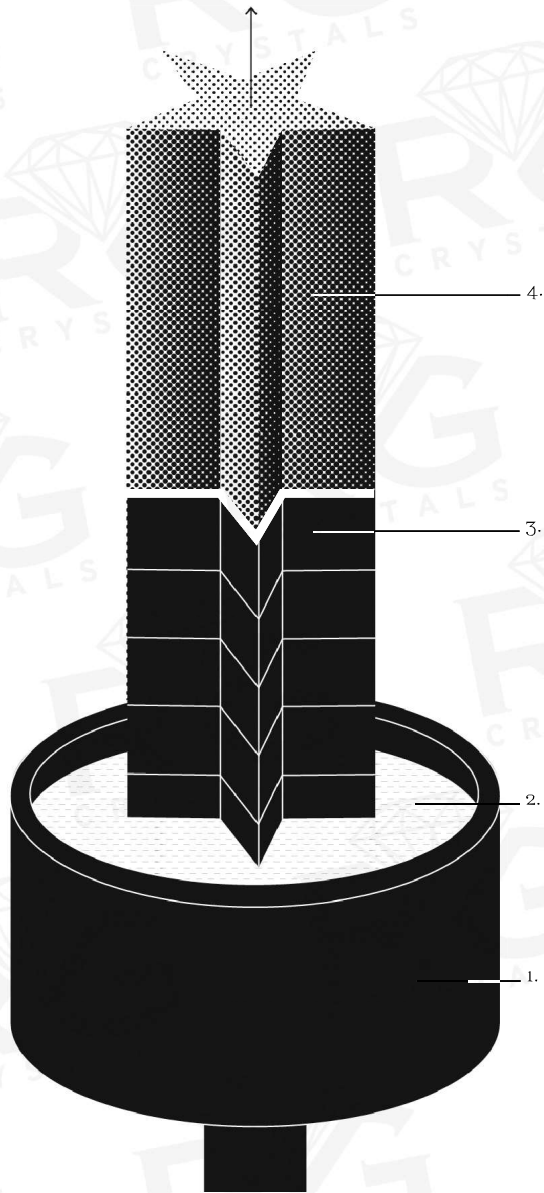
* Technologists at RG Crystals have modified and perfected the Czochralski technology to produce a wide range of crystals. The company grows and supplies spinel crystals of top red, pink, neon and blue colors, rubies of such popular colors as Pigeon blood and Royal red, blue sapphires weighing 0.2 to 6 kg of various saturation, alexandrite (a type of chrysoberyl mineral with a color change depending on lighting), yttrium-aluminum garnet of a wide range of colors, including the most popular tsavorite color.

↓ Alexandrite produced by Czochralski method in incandescent light



↑ Alexandrite produced by Czochralski method in day light



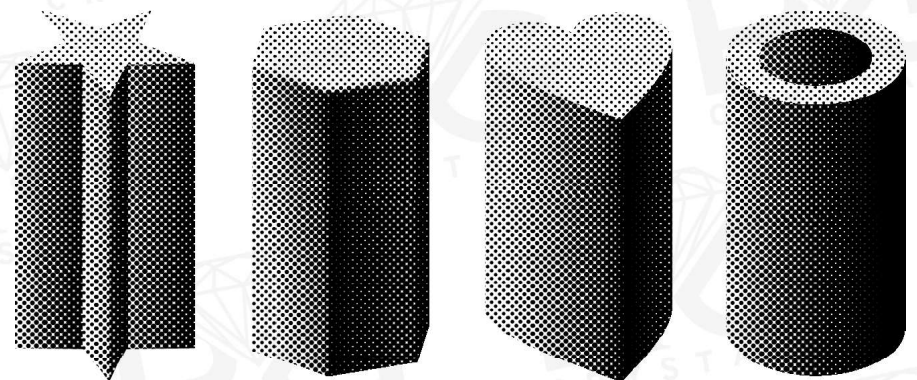


1. crucible | 2. melt | 3. shaper | 4. crystal

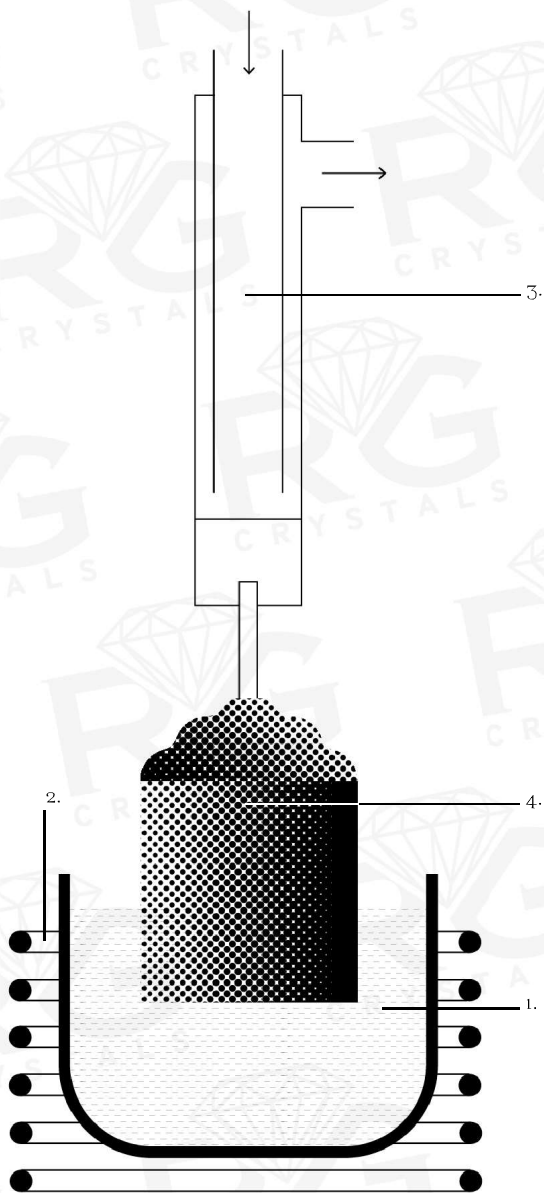


1 Corundum produced by Stepanov method

Obtaining single crystals of a given section and shape minimizes production waste during further processing of the material. The Stepanov method, developed in the USSR in 1938, is one of the modifications of the Czochralski method, which uses a mold near the melt surface to provide the necessary shape to the crystal. This method is widely used to produce a specific crystal of metal with uniform cross section, semiconductors and products from leucosapphire (tape, pipe, rods, etc).



1 Variations of crystal shapes that can be produced by Stepanov method



↑ Corundum produced by Kyropoulos method



↑ Corundum produced by Kyropoulos method

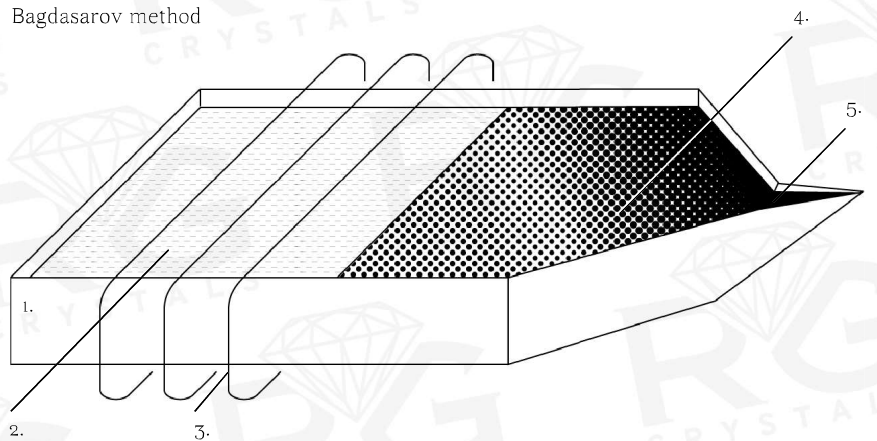
The difference between the Kyropoulos process and the Czochralski method is that in the Kyropoulos process, the crystal is completely immersed in the melt and grows from the center to the edges of the crucible. Thus, the crystallization zone is below the melt level, whereas in the Czochralski method it is above the melt level. As the crystal expands, it is gradually pulled out of the crucible to avoid contact with the walls. The driving factor of crystallization is the cooling of both the melt and the crystal.

The Kyropoulos process was developed to produce crystals of enormous size. For example, a colorless sapphire boule produced by RG Crystals can reach 80 kg, whereas by comparison, ruby crystals only reach 6–8kg.

※ Crystals grown by this method belong to a group of high-quality, expensive lab-manufactured stones, which are also called recreated or cultivated stones (created or cultured gemstones).

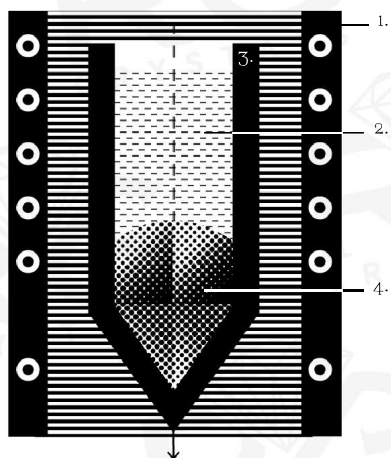
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Bagdasarov method



1. boat-like container | 2. powder/melt | 3. heater | 4. crystal | 5. seed

Bridgman method



1 Alexandrite produced by Bagdasarov method in incandescent light (left) and in daylight (right)

Floating zone

Directional crystallization

* RG Crystals uses this method for production of alexandrite crystals (crystal sizes reach 150×80×30mm), green chrysoberyl, yttrium-aluminum garnet, as well as for recrystallization of low-quality natural rubies.

This method enables the creation of crystals of high chemical purity. Powder of the desired substance is poured into a boat-like container and melted. In the pointed end of the boat-like container (in its "prow") a seed crystal is placed, which melts together with the charge. Thus, the growth of the crystal occurs upon contact with the walls of the crucible containing the melt. Then the melt begins to cool, and the most intensively cooled part is the narrow area of the crucible, because crystallization centers arise there. The pointed end is used because it increases the probability of single crystallization center formation, since the volume of the melt located in the pointed part of the crucible is small. In addition, in the case of the formation of several crystallization centers, one of them having the most favorable orientation for growth suppresses the growth of the remaining embryos. Over time and as the crucible moves with the melt relative to the heater, the crystallization front moves towards the melt and gradually the entire melt in the crucible crystallizes. At the same time, all impurities present in the melt and not involved in the formation of a new crystal are pushed back by the crystallization front to the opposite end of the boat (to the "stern") and

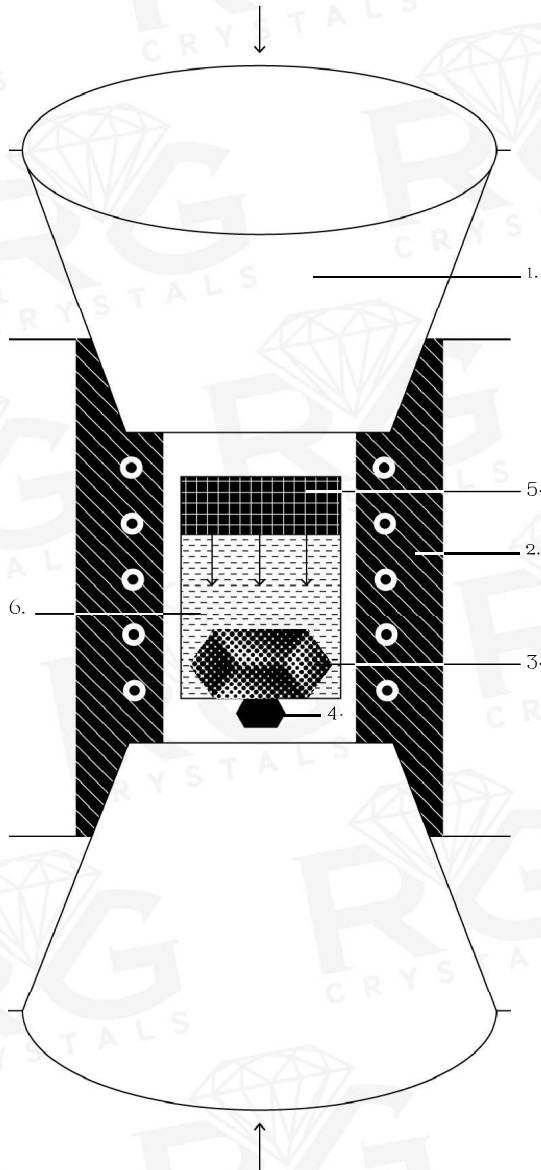
crystallize in the narrow "lower" part of the crystal. Thus, the crystal is purified by itself. Depending on the location of the crucible with the material relative to the heater, horizontal and vertical methods of directional crystallization are distinguished.

Vertical method — movement of the boat-like container and the heater occur vertically. This is called the Bridgman method.

Horizontal method — the boat-like container and the heater move relative to each other horizontally. This is called Bagdasarov's method, named after the Russian scientist, H. Bagdasarov.

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1. hydraulic press | 2. heater | 3. growing crystal | 4. seed |
5. graphite | 6. melt

One of the methods of this technology was developed specifically for the creation of diamond crystals and is known as technology of high pressure and high temperature (HPHT). The temperature of the process is about 1500°C, and the pressure in the chamber reaches 50–70 thousand atmospheres.

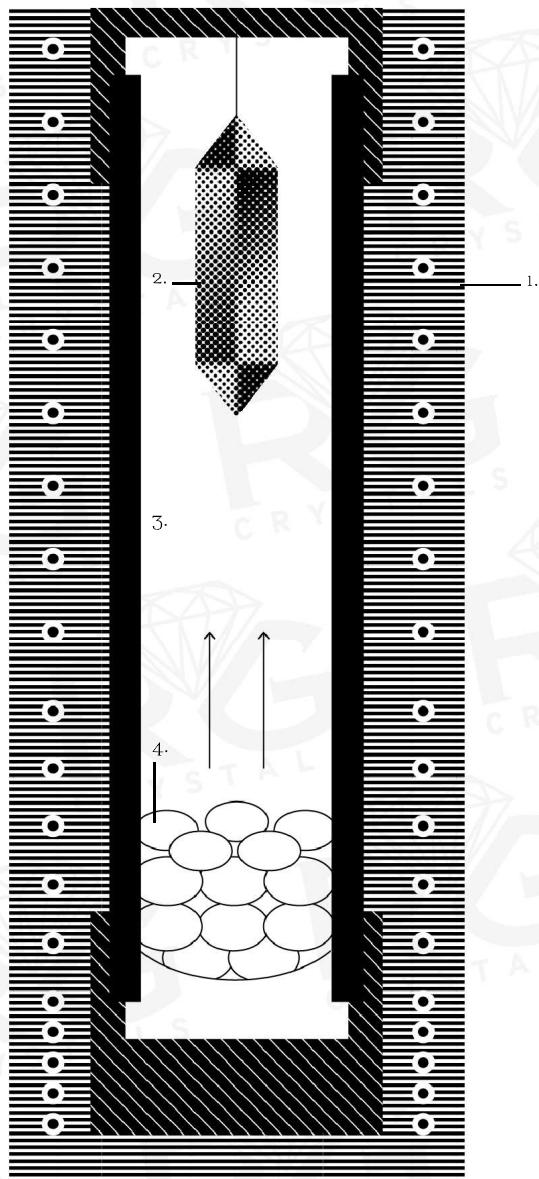
The hydraulic press compresses a special growth chamber, inside which there is a melt of metals and graphite (the starting material for creating diamonds). One or more seeds (small diamond crystals) are placed on the substrate. An electric current flows through the chamber, heating the melt to the desired temperature. Under these conditions, the metal serves as a solvent and catalyst for crystallization of carbon on the diamond seed. This method mimics the natural process of diamond formation from graphite and other allomorphic modifications of carbon, so the crystals of HPHT-diamond are extremely difficult to distinguish from their natural counterparts.

The flux method is closest to the natural formation processes of emerald, ruby and sapphire elegant colors (yellow, padparadscha, etc.) crystals. However, RG Crystals had to abandon the

use of this method, as the low growth rate and the inability to control the process for 3–6 months made it unreasonably expensive and unpredictable.



1 Diamonds produced by HPHT method



Examples of the crystals are on the next page

The initial material (charge) is placed in an autoclave, the volume of which for some crystals can reach several cubic meters. Seeds of the desired material (thin plates on which growth will occur) are placed in the crystallization zone. Water with various salts serves as the solvent of the charge to facilitate its dissolution. The water becomes an extremely aggressive environment at temperatures above 600°C. Heating continues until the beginning of the active dissolution of the charge. The temperature gradient between the dissolution zone and the crystallization zone facilitates the transfer of atoms from the charge to the seed. The growth of a new crystal on the seed begins. The process speed ranges from 0.1 to 0.5 mm per day, depending on the type of crystal grown.

Proper control of the metastable phase in the conditions of crystal growth, maintenance of high temperature gradients and other methods enable the quality of the obtained crystals to be no less high than that achieved to produce crystals using the flux method, but in a shorter time and with more stable results.

This method facilitates the ability to grow considerable volumes of crystals of quartz, beryl (including emerald) and corundum in a short time and at

reasonable cost, leading to a deservedly wide distribution and use worldwide for synthesis of industrial crystals which cannot be produced from melt.

Improvements in the hydrothermal method, introduced by highly qualified technologists of RG Crystals, have led to the ability to lab-manufacture crystals of higher quality and accurately reproduce the top colors of natural emerald from the popular deposits of Colombia, as well as to reproduce such a rare natural mineral as bixbite (red beryl).

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Crystallization from solution

Hydrothermal method

Emerald produced by hydrothermal method

Quartz produced by hydrothermal method



Crystal Growth Technologies

p. 4-5 1. Solid-phase
growth technology

p. 4-5 2. Gas-phase
growth technology

p. 6 3. Melt Growth
Technology

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p. 7 4. Crystallization
from solution

p. 24-25 4 a. Flux method

p. 26-29 4 b. Hydrothermal method

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1 Lab grown bi-color corundum



1 Paraiba color beryl



1 Synthetic rutile



1 Lab grown Royal Blue sapphire

Please note, that all diagrams and photos in this review are for information only and may not be accurate. If you have any questions about our products, please contact one of our offices.