GLASS ALCHEMY, LTD.

Conforms to ASTM D 4236

BOROMAX™ USER MANUAL

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FORWARD

During the last six years the lampworking world has seen many changes worldwide. Glass Alchemy, Ltd. (GA) has ardently participated. During this period GA has conducted thousands of experiments, worked with dozens of artists and traveled to countless studios and production shops. GA has had the envious backstage passes to observe the lampworking movement explode. As you, the user of Boromax™, continue to explore the limits of your art we at Glass Alchemy, Ltd. must push the boundaries of what our products can endure. Not only have we produced new colors since the last edition of our User Manual, we have tweaked, altered, rethought and reengineered many of the colors to be brighter and to withstand more time in the torch and kiln—in short to survive the new rigors that the contemporary artist demands.

This, the 3rd addition of our Boromax™ User Manual, is full of cutting edge (even revolutionary) information that we hope you will find helpful (and even stimulating).

Glass Alchemy's mission statement "Enhancing the world through vision, creativity, and innovation" has kept us on the forefront of new color development and methodology in the field of colored borosilicate art glass. GA is proud of its role as a leader in the science behind the evolution of the art of lampworking.

WORKING WITH GLASS ALCHEMY BOROMAX™ COLORS

Prior to the revolutionary work at Glass Alchemy, there was little reliable information available to lampworkers on the science of using pigmented glass. Many flameworkers could not get their silver colors to strike, colors would turn "muddy," rubies would become livery and greens would turn red or crack. A method for adjusting the flame to neutral (neither reducing nor oxidizing) and verifying that it was indeed neutral did not exist. We at Glass Alchemy have spent a great deal of time and effort to develop methods and information for borosilicate glass artists based on scientific fact.

As you read about the various colors, please keep in mind that the spirit, effort and research at Glass Alchemy has created most of the colors used in borosilicate today. The bright Crayon colors were first developed by Henry Grimmett at GA and remain the highest quality and widest selection available. The Sparkle colors were first developed by GA and tested two full years prior to introduction. We feel our Sparkle colors contain the most consistent aventurine flakes available in an extremely stable base. The GA chrome opal and transparent glasses represent the finest, least problematic and most researched chrome glass on the market. As you read about the polychromatic glasses you will discover there are many options available when working silver colors to achieve your desired end results. If you have not yet tried all of the Boromax™ colors, we urge you to experiment inside and outside of your favorite palette. As you experiment your technical questions are welcome—simply e-mail tech@glassalchemyarts.com for diagnosis of a problem or to understand how to repeat the great results you just got.

Not only has GA created revolutionary new colors, the team continuously improves production techniques resulting in consistent, straight, round cane in 4mm, 7mm and 12mm diameters along with frits of uniform size and shape that are free from tramp metals (contamination).

PHASE SEPARATION, CRYSTAL GROWTH AND NUCLEATION

The process of manufacturing borosilicate glass involves the melting of sand grains (silica crystals) with various fluxes added to achieve the proper coefficient of expansion (COE) along with colorants. This is followed by cooling the mass at a given rate to achieve a certain transformation temperature (t_g) at which point the batch is "vitrified" or free of crystal structures—it is now glass. (This is the state you, the artist, receive the glass.)

By controlling the application of heat while lampworking you have the ability to remanufacture this mix of materials. The materials stay well mixed at high temperatures because of the energy involved. However, as you allow the temperature to drop below the softening point to the annealing point the glass appears to harden. The large molecules can no longer move freely and create a rigid framework, yet, the smaller molecules can still move around and separate out into pools of similar materials. For this reason the rate at which you cool each individual piece of glass determines many of its properties. If held at temperatures near 1150° to 1250°F for extended periods the process of separating into pools of similar materials can become detrimental to your work piece. This process of segregation is known as “phase separation”. In some extreme circumstances this molecular pooling has the potential to create several new types of glass in your work piece often leading to “divitrification,” a situation where crystal structures start to form. When performed with knowledge and a trained hand, one can use this process to their benefit. Controlled phase separation can be used to strike certain colors by creating nuclei and allowing the growth of crystals to generate various colors. This is a critical concept to understand, it has different implications with the different pigments discussed in this manual.

Growth of crystals is a time/temperature relationship. The growth rate is slower at temperatures below the annealing point and reaches a peak at temperatures around 1250°F. Above 1250°F the growth rate drops off again, much like a bell-shaped curve. At the annealing range of 1035°F to 1065°F (depending on the brand of clear or color you are using), the artist has tremendous control of the color outcome. If the glass is taken to a white heat (very liquid state), the crystals will melt and the glass will unstrike. GA recommends flame striking for silver colors and kiln striking for ruby colors.

Ruby colors, which are created with a reduced copper as the colorant, also strike because of crystal growth, but the course of action is slightly different than the silver colors. In the colorless form, the copper is distributed as colloidal atoms, called pyrosols. As the glass is heat-treated the copper starts to form crystals, and as the heat soaks deeper into the glass, chromophores (visible color cells) form and the glass becomes a deeper red. If the chromophores grow too rapidly or with varying heats, a non-uniform dispersion of particles can be generated. If the chromophores form in various shapes and sizes, it will result in uneven absorption of light wavelengths. This condition is referred to as “liveryness”. This is why kiln striking, to ensure even heating at the proper temperatures, rather than torch striking is recommended.

TORCH SETUP

When working with many colored glasses the flame chemistry is very important. It is possible for the fuels to react with the glass and change the color or other characteristics. Some reactions can even cause the glass to crack. For this reason GA suggests that you work your colors in a neutral flame unless you are trying to produce a definite effect that requires an off balance flame.

Obtaining a neutral flame can be complicated by a poor torch setup. If you play with the mathematical formulas that give us insight into the behaviors of the gasses as they pass through the torch, you will discover some very helpful information. Consulting the Bernoulli Equation (energy per unit volume before the torch = energy per unit volume after the torch) we discover that as the gasses pass through the torch the velocity increases and the pressure drops (for a fun graphic example, see www.home.earthlink.net/~mmc1919/venturi.html). In other words, increasing the pressure increases the speed at which the gasses pass through the working zone a.k.a. the heat transfer zone. The thing to keep in mind about the softening of the glass is that **it is the transfer of heat from the burning gasses to the glass that is important.** This happens at the point of contact of the glass and flame—the balance of the flame is heating the room. The most efficient transfer happens when the available energy in the heat transfer zone is high. If the gas is whizzing by the glass without contact you are running up your fuel gas bill. The goal is to increase the heat transfer while decreasing the amount of gas you are burning. Low pressure (slower velocity) and more volume (available energy) at the point of impact results in more transfer of heat.

In general, large diameter hoses and lower pressures work better than small diameter hoses and high pressures. Larger supply hoses insure that you have enough gas available to meet the demand of the torch especially when you open the valves more turns. The lower pressure allows you to open the valves wider because you are not generating high velocities and the evil twin, turbulence. Lower pressure also allows you a wider range of flame mixes when adjusting the valves. You use less fuel overall and more energy (measured in BTUs) reside in the heat transfer zone.

Small diameter hoses can result in pulsations of the flame. Increasing the pressure of the fuel gas to prevent these cavitations often results in a longer reducing zone in the flame forcing you to work further out in the flame. Increasing the oxygen flow to compensate for the increased fuel gas will result in high velocities. High velocity flows are not as efficient in heat transfer and can result in the dulling of the glass from carbon impingement. Smaller torches can be set up with short runs of standard twin welding hoses, which are readily available in most hardware stores. Larger torches, on the other hand, should be equipped with larger diameter hoses, so that the gasses they demand are available and obtaining a neutral flame is possible. Larger diameter hoses are most easily found at hose specialty shops.

SETTING A NEUTRAL FLAME

Glass Alchemy recommends that you always work with a neutral flame—it helps maintain consistency and vibrancy in your work. A neutral flame also helps to prevent the cracking in chrome colors associated with reduction and eliminates the problem of ionic colors changing from one “species” to another, i.e. changing from green to red, or from blue to gray.

To test for a neutral flame, Glass Alchemy suggests that you heat a rod of 987 Amazon Night to a warm orange glow and allow it to cool. The resulting color of the rod will indicate whether or not your flame is neutral. You have a neutral flame if the 987 did not change color. If the stick is a light sky blue or has a metallic sheen, the flame is reducing (has unburned propane) and needs to be adjusted. The most common fix (say 70% of the time) is to decrease the propane content.

- If the surface of the glass looks like an oil slick, decrease the propane at the torch
- If the surface of the glass is heavily metallic, decrease the regulator in ¼ pound increments
- If the surface of the glass is sky blue, it is especially reducing. Decrease the propane at the regulator in half; i.e. decrease from 2 pounds to 1 pound of pressure.

In the remaining cases the proper course of action is to increase the oxygen flow to burn the “extra” propane in the flame.

Note: By definition reducing agents lose electrons. Carbon is an oxidizing agent because it gains an electron. Some lampworking books, especially European, refer to the nature of the flame and call a flame rich in carbon “oxidizing,” which is scientifically correct. The American lampworking model, for whatever reason (probably because a handful of artists created the convention based on the fact the oxygen was turned down), refer to what the flame does to the rod (not to the chemistry of the flame) and call the same flame as above a “reducing” flame. When reviewing the literature, it is important to understand that these two conventions exist. Again, from a scientific point of view a carbon rich flame is oxidizing (because it wants oxygen) and it reduces the glass by taking oxygen from the glass. We elected to continue with the American lampworking convention of calling the flame “reducing” because of its widespread use in the field and will continue this convention until such time as a group such as GAS or ISGB elects to standardize the definition within the industry.

THE NUMBERING SYSTEM

Glass Alchemy, Ltd. created a color numbering system based on chemical properties of the glass. Through the numbering system, an artist may gain insight into the composition of the glass and thereby have a sense of the color and its working characteristics even before purchasing. Therefore, the artist can use the numbering system to aid in color selection, reduce the risk of ordering colors they can't use and achieve more control over design decisions.

The First Number
The first identifying number of all GA colors is based on the **ROY G BIV** spectrum, providing the artist with an easy way to identify the color.

The Second Number
The second number indicates the primary colorant, so that the artist can anticipate what the final result will look like.

The Third Number (in a color with four numbers)
Due to the increasing complexity of some formulations we've developed, some colors now have more than one primary ingredient. The third number indicates that there is a second colorant.

The Last Number (in all colors)
At one time, GA wanted the last number to reflect the chemical saturation level, but it was not possible to follow through with the scheme. If the color name itself has a number at the end of the name, as with colors in the Cobalt Series, then this is a clear indication of the level of metal coloration and density of color.

		Red	**O**range	**Y**ellow	**G**reen	**B**lue	**I**ndigo	**V**iolet	**B**rown	**N**eutrals
		100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**
Cadmium	**0**	*104*	*204*	*304*	*406*				*804*	
Cobalt	**1**					*516*				
Cobalt/Copper*	**2**				*421*	*521*				
Copper	**3**	*138*	*2383*		*436*	*531*		*738*		
Chrome	**4**				*446*	*546*				
Sparkle	**5**				*458*	*558*				
Rare Earth	**6**				*461*				*864*	
Manganese	**7**						*672*	*775*		*974*
Silver	**8**		*2383*	*381*	*489*	*585*	*683*	*786*		*987*
**	**9**									*9992*

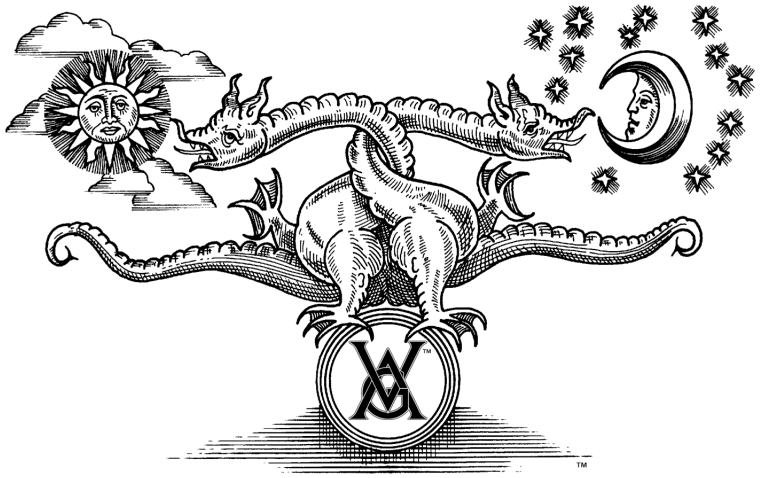
Red = 100
Orange = 200
Yellow = 300
Green = 400
Blue = 500
Indigo = 600
Violet = 700
Neutral Browns = 800
Black/White = 900

0 = Cadmium
1 = Cobalt
2 = Reserved for Future Use *
3 = Copper
4 = Chrome
5 = Sparkle or Precipitated Chrome
6 = Rare Earth
7 = Manganese
8 = Silver
9 = Unusual Colorant **

* 2 originally indicated a combination of copper and cobalt, but that has since been changed. Please note that 2 now indicates this in only a few colors such as 421 Phthalo Green and 521 Phthalo Blue.

** Currently indicates unusual colorant or complex chemistries.

COLOR GROUPINGS



COLOR DESCRIPTIONS AND TIPS

This section contains information about each individual color. Working tips, as well as insight into the chemistry, are provided for each color. Please see the Health and Safety section for detailed information on the colorants used.

Note: An asterisk after the color name or number indicates that the color is available in frit as well as rod/cane.

WYSIWYG

Transparent/Translucent WYSIWYG Colors

Copper Greens: 421, 436, 521, 531, 833
Many green colors are produced with unreduced copper. If these colors are worked in a reducing, carbon rich flame, the copper will react with the flame causing red streaks and splotches. Encasing helps to protect the copper from reduction. On the other hand the ability to create red in green colors can be used to the artist's advantage to create interesting effects using dots, overlays, raking or other techniques.

While the red streaking is reversible by adjusting the torch, it can be difficult to correct especially if the piece has been completed. Reheating part of the work piece to white hot can be detrimental to the final shape, especially if the piece is "detailed". Once an area is covered by another glass it cannot be reversed. Make sure to test for a neutral flame prior to using.

The copper greens can be used beautifully with dichroic glass.

421 Phthalo Green (pronounced thā-lō)
The primary colorants are cobalt and copper.

421 is a beautiful and pleasing, green-blue transparent color leaning toward the green side of 531Teal.

436 Dark Emerald (see the article in Vol. 3, Issue 4 of *The Alchemist*, glassalchemyarts.com)
The primary colorant is copper.

436 is verdant, and bright. This is a luxurious green and well loved by many lampworkers. Encasing the Dark Emerald can protect the copper from reduction. However, if you struggle with the properties of copper and want a "no fuss" green use 4646 Paris Green.

521 Phthalo Blue (pronounced thā-lō)
The primary colorants are cobalt and copper.

521 is an agreeable, blue-green transparent color that takes advantage of glass' ability to both transmit and reflect light.

531 Teal (see the article in Vol. 3, Issue 4 of *The Alchemist*, glassalchemyarts.com)
The primary colorants are cobalt and copper.

531 falls right in between 521 Phthalo Blue and 421 Phthalo Green. It is a blue-green transparent color that takes advantage of glass' ability to both transmit and reflect light.

833 Beryl
The primary colorant is copper.

833 is a transparent olive-green. Earthy and rich, this color adds an innovative dimension to the GA transparent palette.

Tips:
- 833 is a retro color that works well in jewelry.
- This old-world formula does not like a lot of heat. While it does not sublime like a Crayon, Beryl does release oxygen if heated to around 2000°F. It works well in most flames but a neutral flame is recommended. Try to work it in a cooler flame. (About 1" further out in the flame.)

Rare Earth Greens: 461, 4641, 4642, 4646*
These green colors do not have copper, so they will not turn red, even with reduction. Rare earth colors can be used as tints over other colors to create subtle shifts in reflected and transmitted light. For example, over white, they create pastels, over a cobalt color or over 546 Peacock* it will change the look of the blue. Use rare earth colors over 9958 Disco Sparkle but do not mix them—the rare earth formulas melt the metal flake in Disco (not pretty).

461 Kryptonite
The primary colorant is a rare earth, Praseodymium, and is an ionic colorant.

461 is transparent neon green.

Tips:
- 461 Kryptonite greatly enhances the color of dark striking silvers.
- The thicker the application of 461, the darker the color. Gathered into a marble, the color can become quite intense.
- Consider this color for fish bodies and large jellyfish.

4641 Paris Green Lite
4641 is a tint color and can be used in place of clear to create subtle differences.

Tips:
- Use rare earth colors over disco sparkle but do not mix them the rare earth formulas melt the metal flake in disco.

4642 Paris Green 2
4642 is a bottle green color.

Tips:
- 4642 works well over 9958 Disco Sparkle or 9995 Sno White.

4646 Paris Green 6*
4646 is a dark bottle green.

Tips:
- 4646* is outstanding for line-free blowouts.
- It holds color better than transparent copper greens when drawn into stringers.
- Be careful not to overheat 4646* due to its heavy color saturation.

Cobalts: 510, 511, 512, 514, 515*, 516, 592
Cobalt blue has always been one of the most appealing colors in glass. The Cobalt blues at Glass Alchemy are made from finely milled cobalt, which is mixed into the batch using three separate processes to ensure an even distribution and consistent color throughout the rods.

Cobalt glass has a higher viscosity than colorless clear in the same flame. This is not because the cobalt thickens the glass but due to the cobalt emitting infra-red, therefore cooling more rapidly. For this reason, cobalt glasses require more energy to melt, they cool much faster and, in levels of high saturation, they work "stiff." GA adds a flux that softens the glass in the temperature range above 1800°F, to mitigate the stiffness of Cobalt 5* and 6.

As compatibility is not simply a function of COE but is also affected by the cooling rates between two different glasses, those with a high concentration of cobalt can crack at the joint when used with a slow cooling glass. If you think you may have experienced cracking due to this difference in cooling rates, make sure to A) apply more heat to the cobalt side of the joint, rather than the slow cooling side of the joint (this is similar to welding metals of 3/8 inch to 1/8 inch, where you apply most of the heat to the thick metal, not the thin metal) and B) increase annealing times to release stresses between the two glasses.

510 Cobalt Lite
511 Cobalt 1
512 Cobalt 2
514 Cobalt 4
515 Cobalt 5*
516 Cobalt 6

Tips:

- When using heavily saturated Cobalt colors focus more of your heat on these colors so that you don't overheat the other colors while trying to get the Cobalts hot enough to work.
- Remember to always work Cobalt colors in a neutral flame, especially heavily saturated cobalts, such as 515* and 516. Any reduction can lead to a gray, streaky surface.
- There is a tradition of using heavily saturated blues such as 516 as black. We suggest using 9479 Raven* because it is a truer black, especially in thin work or stringers

592 Brilliant Blue
In 592, GA altered the refractive index to make the blue appear brighter and some say that it "dances with the light."

Tips:

- Use of a neutral flame is best for 592, however, in a reducing flame 592 tends to resist turning gray.
- A great color for all applications, it has become particularly popular for coil-pots, beads and sea animals.

Manganese Purples and Browns: 773, 775*, 864
Manganese yields a purple or brown tint. These colors are very creamy and cooperative.

773 Grape
775 Dark Plum*
The primary colorant is manganese.

773 Grape and 775 Dark Plum*, almost equal in color strength, are different blends of the same chemicals. Grape is about half strength of 974 Black (Violet)* whereas Dark Plum* has a black-pink tone, hence the reference to Plum in its name. These two colors each offer a different hue of purple for your color palette.

Tips:

- Both colors create appealing pastels when laid over 9995 Sno White*
- Dark Plum* frit is a very soft shade but works extremely well in a frit blend to open up the other colors in the blend.

864 Sienna
The primary colorant is manganese.

Sienna is about the color of iced tea. It can be used as a tint or gathered and used in solid sculpture. This color was reformulated in 2006 to be easier working and provide a higher refractive index or brilliance in your piece.

Tips:

- The larger the gather the denser the color will appear. Encase another color with this tint and change the hue. Sienna will soften the look of the bright Crayons.

Black Colors: 8475, 931, 974*, 993
The black colors are usually heavily saturated colors that have been designed to achieve the deepest, richest hues possible, while still remaining compatible with other glasses. Always work these colors with a neutral flame, as heavily saturated colors can be more prone to “graying” and other reduction-related surface issues. 8475 Black Walnut and 974 Black Violet* have the highest resistance to reduction. (For an opal black use 9749 Raven*.)

8475 Black Walnut
The primary colorants are chrome and manganese.

8475 was released in 2005 and was quickly embraced by users due to its buttery character and sumptuous sable tones.

Tips:

- Available in 12mm and 4mm.
- 8475 is great for inside or outside work.
- It pulls down to exceptional stringers.

931 Black (Green)
The primary colorant is copper.

931 can be blown-out to an amazing dense forest green color,

Tips:

- 931 has a very high chemical saturation level. The higher the copper content is, the denser the color and the greater the tendency to develop red streaks in a carbon-rich flame. It works best in a neutral flame.
- Avoid extensive surface working. Prolonged working at lower heats tends to lead to surface divitrification in highly saturated copper colors.

974 Black (Violet)*
The primary colorant is manganese.

974 Black (Violet)* is the customary black used in many studios. When blown-out or pulled down in stringers, 974* will yield a dark transparent purple.

Tips:

- 974* is almost impervious to reduction and works willingly with all flames; however, we recommend that a neutral flame be used.
- We have encountered situations in which this color has reacted with some dichro. It appears that when dichro is stretched and the quartz layer loses its integrity, the manganese reacts with the metals of the dichro and cracking may occur.
- When using with another highly saturated color test your application process first. If cracking occurs, separate the 974* and the other color with a thin layer of clear. It is a rare occurrence, but we have had reports of cracking when using Black (Violet)* with highly saturated colors from other color manufacturers.

993 Black (Blue)
The primary colorant is cobalt.

993 is a saturated blue black. It is a bit denser black than 974* and is susceptible to reduction due to the cobalt content.

Tips:

- Use neutral flame to avoid reduction (turning gray).
- If a reducing flame is required, keep the work hot and do not allow it to cool below 1400°F while working.
- 993 is a great color for inside work.

Opal WYSIWYG Colors

Crayon Colors: 104*, 106, 204*, 208, 301, 302, 304*, 403, 406, 804
The primary colorant is cadmium. The Crayon colors are colloidal colors.

All of the Crayon colors contain cadmium, which gives these colors unique working properties. Cadmium sublimes into a gas, well above the softening point but just below the working temperature that most lampworkers work at, causing bubbling and blistering. To prevent this, work the rod farther out in the flame, encase the color, or adjust the flame to a cooler setting. You can adjust to a bushier flame, which is cooler because all of the propane does not burn, or an oxidizing flame, which is also a cooler flame since it is oxygen rich and turbulent. Be careful not to overheat the work area, especially when using a pre-mix center fire type torch. **Note:** while you can turn the propane down or off on some pre-mix center fires you can not turn off the oxygen or the torch will be damaged.

If you accidentally sublime a small patch, it is possible to fire polish the section, which will smooth out the glass. This “patch” will be colorless, allowing the color from below to become visible, in effect “repairing” the area.

Once a Crayon color is applied to a larger piece of glass, it generally can be worked more aggressively. The larger piece acts as a “heat sink” and pulls heat away from the Crayon color, helping to prevent sublimation. Remember not to focus the heat on any given “spot” for very long. Instead, it is important to keep the heat spread out by moving the piece around in the flame.

We have researched and investigated the cadmium glasses very extensively. From the effect of the weather on the glass to the health risks to the artist to the employee manufacturing the glass for you. Refer to the section on Health and Safety in the back of this manual. If you have used the colors over

the years you can testify to our improvements. If you are new to the medium, be assured we will continue to improve the cadmium colors.

104 Red Crayon*
104* is a lipstick red, seductive and alluring. It is the Crayon color richest in unbound cadmium, and therefore it requires the greatest skill level to work. Also available in 4mm and 12mm rods.

106 Indian Red Crayon
106 is a deep, dark red. 106 is bound with selenium and is much easier to work.

204 Orange Crayon*
204* is bright, vibrant and easy to use. Also available in 4mm and 12mm rods.

208 Dark Orange Crayon
208 Dark Orange was poorly named and therefore has been mostly unexplored by artists; it is a bright vermillion or tangelo color and a better name would have been Fire Orange.

301 Acid Yellow Crayon
301 is a bright, lemony yellow with excellent working properties. Also available in 4mm rods.

Tips:
- Try mixing 301 with three to five parts clear to make a translucent yellow that exhibits a unique “luminosity.”

302 Rasta Gold Crayon
302 is a golden honey yellow, darker than 304 Yellow Crayon. Also available in 4mm and 12mm rods.

304 Yellow Crayon*
304* is a “school bus” yellow with a slight hint of orange. Also available in 4mm and 12mm rods.

403 Chartreuse Crayon
403 is a very workable green-yellow. Also available in 4mm rods.

406 Olive Green Crayon
406 is an earthy green.

Tips:
- Try encasing 403 or 406 with 510 Cobalt Lite, one of the lighter Paris Greens or Kryptonite for tonal variations.

804 Chocolate Crayon
804 is the color of a chocolate chip. 804 is the Crayon color richest in bound cadmium and, therefore, is one of the easiest to use.

Tips:
- 804 is a good color match with 446 Agua Azul*.

Tips for all Crayons:
- Excluding the two greens, 403 and 406, the cadmium colors organize from dark to light in this way. 804 Chocolate, 106 Indian Red, 104 Red*, 208 Dark Orange, 204 Orange*, 302 Rasta Gold, 304 Yellow*, 301 Acid Yellow.

- Mixing with three to five parts clear will make the color translucent, allowing the light to enter the glass rather than reflect off the surface.
- Work Crayons further out in the flame and review the article in *The Alchemist* Vol. 2, Issue 4 "Working with Crayons", on-line at www.glassalchemyarts.com.
- Fire-cut the raw end of the rod to further alleviate the initial sublimation that can occur on the sharp edges.

Turquoise Colors: 441*, 444*, 445, 446*, 447, 541, 546*, 548*
The Turquoise colors include a range from light green to deep blue colors. They are creamy and easy working but should not be manipulated in a reducing flame. Chrome is the primary colorant for this series of formulas and all the colors in the Sparkle series, except Disco Sparkle. To avoid problems the torch must be set up properly to achieve a neutral-to-oxidizing flame. Carbon and chrome have a curious relationship in the flame—carbon bonds with the chrome and creates a new glass that has a COE of 56. The new glass is no thicker than a few nanometers but it is enough to cause incompatibility. The excess carbon will also bore microscopic holes into the glass that when encased release air—those mirror reflections that can sometimes be seen around a deeply encased chrome color where cracking has occurred.

Avoid keeping chrome colors in the kiln for extended periods of time. If holding these colors in the kiln for an extended period, it is best to "garage" at 975°F, rather than at the annealing temperature of 1050°F. You should not hold these colors (or strike other colors in the same piece) at temperatures above 1075°F; you run the risk of creating aventurine (crystal growth) at elevated temperatures. We have seen extended times at striking temperatures or higher lead to breaking, checking and shearing. After keeping your piece warm at 975°F during construction, the temperature of the kiln should be elevated to 1050°F to anneal the completed artwork.

Research continues to improve the quality of chrome colors in the GA palette. Our current research in chrome based colors is focused on preventing cracking under all extremes. Today, there are some artists experimenting successfully with fusing and we have been working to extend holding times in the kiln. As of the close of 2006 the majority of our palette can withstand 4 – 5 remelts without diminishing the integrity of the glass. We have increased the chrome colors' endurance to withstand 3 remelts. What this means to you as a lampworker is more working time and less losses, especially when you work in a neutral flame.

Note: Colors 4484, 5486 and 5488 are separated out as the Chameleons due to their silver content.

441 Alchemy Mint*
441* is a pale opaque green that can develop slightly darker green veins.

Tips:
- Enhance the shade of this gentle green by encasing or mixing it with one of the transparent greens such as 461 Kryptonite, 436 Dark Emerald or 4646 Paris Green 6*.
- Consider using 441 Alchemy Mint* in a frit blend with Agua Azul* and Peacock*.
- For a variegated look as in foliage use with 444 Clover*.

444 Clover*
444 is the color of grass. Also available in 4mm rods.

Tips:
- If 444* is going to be worked hard at higher temperatures and then be subjected to ongoing high heats as the balance of the piece is shaped and worked for hours, then consider encasing the color prior to use.

- If 444* is going to be exposed to prolonged periods in a reducing flame, consider encasing first.
- Use of this color as a "dot" in a deep-encased situation is not recommended, especially on a curve, such as a vase bottom.

445 Turquoise
445 Turquoise is a green turquoise color and has been laced with a touch of copper, which develops wisps of red. This color can be used to add an organic quality to your work.

Tips:
- Try designing a piece using 445 Turquoise with 132 Jasper Red or 106 Indian Red Crayon for a contrasting organic look.

446 Agua Azul*
446 is a teal blue shade and is a very easy-working color, which can be worked on both the inside and the outside. Also available in 4mm and 12mm rods.

447 Spanish Moss
447 Spanish Moss is an enchanting mossy, gray-green earth tone that is great for solid color coil-pots and sculptural work.

541 Persian Blue
541 Persian Blue is a translucent blue that seems to glow as the light enters it and is suited for surface work.

546 Peacock*
546* is a blue-green opal that is creamy and smooth to work—one of the best in the palette. Also available in 4mm and 12mm rods.

Tips:
- Use Peacock* with browns and blacks to add brightness to the contemplative darks.
- Use with bright oranges, reds and yellows to create a playful look.

548 Twilight*
548* is a dark blue that is creamy and smooth to work. Twilight is named for the blue shadows that surround you as the sun drops past the horizon. Also available in 4mm and 12mm rods.

Pastel Colors: 5192, 5195
Bibidibobidiblue and Lapis are based on a new technology. The primary colorant evolves oxygen at 1500°F, just above the softening point. Materials have been added to react with the evolving gasses to keep your piece nice and smooth. Be careful not to heat a large area too fast or you may defeat the system. Do keep your heat well distributed in the piece while trying to avoid a small hot spot.

5192 Bibidibobidiblue
5192 is a remarkable sky blue color. Also available in 4mm rods.

Tips:
- 5192 is great for stringers and murrini work. It also works very well in large coil pot applications.
- To heighten the intensity of 5192 encase with 510 Cobalt Lite or change the hue by encasing with other tints.

5195 Lapis
5195 Lapis is the same as 5192 Bibidibobidiblue with the addition of more cobalt to create a dark, midnight blue. Also available in 4mm rods.

Tips:
- 5195 is great for stringers.
- Lay 5195 Lapis down with its compliment 204 Orange Crayon for a dazzling color effect.

Black: 9749*, 9992
Most blacks are saturated greens, reds or purples, Raven* is a blend of all three—the surface reflection changes dependent on the type of light (natural, halogen or incandescent), the angle of incidence, and the thickness of the Raven application.

9992 Portland Gray is based on a novel technology. Smooth and creamy to use it fills a major gap in the colored borosilicate palette. 9992 is very reliable and can be drawn down to stingers or gathered for large sculptural work.

9749 Raven*
The primary colorants are manganese and chrome. Also available in 4mm rods.

9749 Raven* is an opal borosilicate black color. The color reflection is reminiscent of the colors seen on a black raven's wing.

Tips:
- Work hot in a neutral-to-oxidizing flame. Avoid a reducing flame.
- Raven will phase separate if held at temperatures above 1100˚F for too long.

9992 Portland Gray
The double 9s in the code indicate the development of an unusual colorant. This color was created with a completely new technology.

9992 was the first opal gray borosilicate rod.

Tips:
- Use any kind of flame on this color.
- Reducing can generate darker shades.
- 9992 can sometimes develop specks on the surface; however, they do not affect compatibility and melt in when worked.

White: 9995*
9995* is a rich white not based on micro bubbles or refractory ingredients such as zirconia allowing it to be drawn down to small stringers that retain their color and physical strength. We anticipate the research for improvements will be ongoing through 2009.

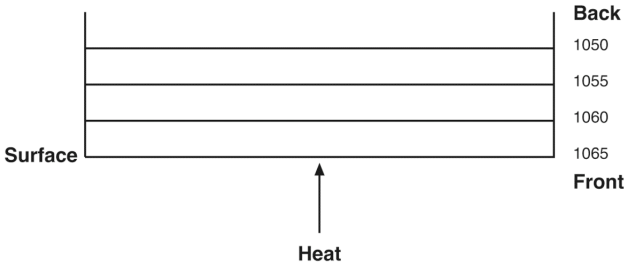
9995 Sno White*
9995 is a vibrant white. Work in the flame as you would any heat sensitive color, a little further out in the flame. Also available in 4mm rods.

Polychromatic Colors

(silver-based formulations)

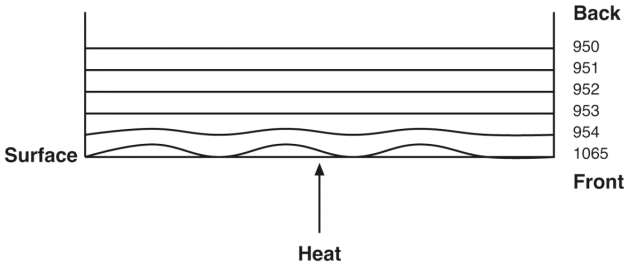
All silver colors should be worked at hot temperatures to create, form and assemble the elements. Once your piece is formed switch to a lower heat, just above the annealing temperatures 1075°F to 1125°F, to grow the silver crystals. The smallest crystals are invisible. As they grow they will create a yellow color. **In order of increasing size, the silver crystals will become orange, ruby red, red-purple, purple, blue then green.**

When working with silver colors, you will want to pay attention to the temperature profile that you are creating within the glass piece you are working on.



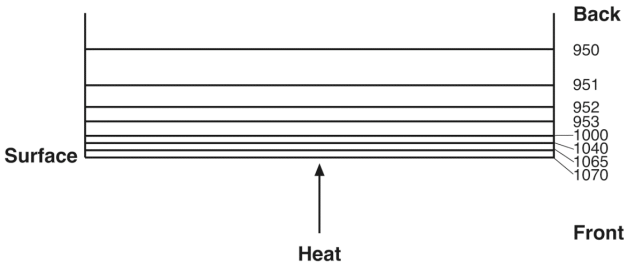
DEEP COLORS

From the scale above, note that the heat penetration is deep.



HAZE

From the scale above, note that the heat penetration is only on the surface and inconsistent.



SKYSTALS

From the scale above, note that the heat penetrates the surface and immediate subsurface, but is not deep. Also note that the heat is consistent.

Once you start recognizing the heat profile, you will have gained another level of color control. For example, if you let the core temperature drop and then reheat only the surface, the silver crystals will grow faster in this top layer than the layers just below. If the heat is uneven, you create a “veil” of color

on the surface called haze. On the other hand, one can use the heat profiles to determine that they can intentionally create a "veil" of color by creating skin crystals, or what we call skystals. The process that creates skystals is: work the piece hot so that no color develops, then pull the piece out of the flame to let the core temperature drop or even go cold, and finally apply an even heat to the surface for a short period of time.

You can create fantastic patterns of color, depending on how even your heat is and what you do to mix in uneven heat. Simple techniques, such as twisting the rod as you heat it, contact with a cool paddle, or pinching with a pair of needle nose pliers, can create great patterns, especially in beads. Also consider using glass itself, such as clear frit, as an insulator. Or try using other silver colors or tints as "dots."

If you want to bring a luster to the surface, bring the glass to 1200 – 1250° F (remember that it is easy to burn a fume off the surface) and treat the surface about 20 seconds. In a neutral flame, the luster will be silver. In the bushy, reducing flame, the luster will be multicolored. This flame will strip oxygen from the silver oxide (Silver is reduced with heat—un-burned carbon will transport liberated oxygen away.) leaving metallic silver on the surface and causing the "sheen." Consider polishing the surface to enhance the brightness.

A final note about silver colors and striking: They are not all created equal. Some formulas have nuclei in them, while others do not. Just as a raindrop does not form without a speck of dust, or a pearl without a grain of sand, silver crystals do not grow without something to grow on. GA has added nuclei to most of its silver colors to make them easier to use. However, there are times when the artist wants more control, so we also created colors in which one can create the nuclei. For example, in the colors 383 Silver Strike 3 or 385 Silver Strike 5*, you can grow the crystals yourself. When you are ready to create the nuclei, simply cool the color to a slight orange glow, about 950°F, and maintain the temperature for 20 – 30 seconds. Then heat it back up to 1075 – 1125°F and grow the crystals. The longer you hold the piece at the lower temperature, the more nuclei you create and the more intense the final color will be when you grow the crystals.

Crystal growth and color development is a function of time and temperature. Therefore, a reducing flame, per se, does not create the colors. A reducing flame only treats the surface and can create a multi-colored metallic sheen, or if worked intensely, it can create a grayish sky blue surface of reduced silver fume.

Transparent/Translucent Polychromatic Colors

This group consists of all of the colors containing silver and includes the Carnival and Luster Series.

Luster Series: 2383*, 381, 382, 386*, 388, 481, 5186, 5188, 597, 683*, 786*
The name Luster indicates that the surface can develop a metallic sheen. The source of this sheen is silver. To bring these colors to the surface, bring the temperature of the flame to about 1250°F (remember that it is easy to burn a fume off the surface). Treat the surface for about 20 seconds in the bushy, slightly reducing flame.

2383 Persimmon Strike*
2383 Persimmon Strike* can yield golden amber waves of color along with oranges, greens, reds, fuchsias and purples. Its unique chemistry makes it a silver-ruby—the ruby will continue to strike in the kiln. 2383* is absolutely gorgeous alone but astounding over 9995 Sno White*. Also available in 4mm rods.

Tips:

- To develop silver colors strike 2383* in back of flame. Kiln strike to bring up the reds.

- Try pre-working by gathering in a hot reducing flame. Pull out into rod and use.

381 Warm Yellow
381 has crystal growth inhibitors to impede the change of color. For many applications, the color will remain yellow. However, hard-working or prolonged kiln time will cause crystals to grow. Warm Yellow can be used if you require long garage times and want to achieve purple, but it can also yield a blue color, dependent on the working conditions and time.

382 Solara
382 has crystal growth inhibitors, but is designed to work quickly into the orange-yellow to orange-ruby aspect of silver. It is also designed to remain transparent. This is a very "hot" color—it will remain in this color zone for considerable time but can be pushed into purples, blues and greens.

386 Purple Luster*
386* has crystal growth enhancers and has been balanced to cause the color to go straight to a purple sheen. This is an unusual color in that it is an A-B-C (clear-yellow-purple) color. We ship it in the B stage (yellow) and when it first enters the flame, it strikes purple (C stage). After it is heated to a molten state, it strikes clear (A stage). If you place it into the kiln in the B state (yellow), it will strike purple. If you place the color into the kiln in the C (purple) state, it will strike to a very dark purple, almost black. If you place it into the kiln in the A (clear) state, it will do nothing—the temperatures are not hot enough to strike to the purple stage. In the flame, if you have struck from B to C, you can move the glass in and out of the flame to keep it at a warm orange glow (1075°F – 1125°F) and darken the purple to very dark shades. Also available in 4mm rods.

388 Caramel Luster
388 has an additive that causes the glass to always transmit orange and red light. The luster is very modest and can be achieved with a reducing flame. The effects of this color are best demonstrated when a piece is hung in a window where the glass can catch the light and create dazzling patterns when it reflects on the walls. It also works well in any application where there is transmitted light, such as goblet stems, bowls or earrings.

481 Spring Luster
481 is a copper green with silver, which has a lower saturation level than the Carnivals and is easier to control. Its transparent properties add to the character of the copper-silver based color.

5186 Blue Passion
5186 is a smooth-working blue rod that develops a wide range of blue hues, neon-blues, greens, neon-greens and purples. Manufactured to be user-friendly, GA has added copious amounts of nuclei for your enjoyment.

5188 Caramel Blues
5188 is the product of adding cobalt to 388 Caramel Luster. When used with a neutral-to-oxidizing flame, the result is a spectacular play of color with rich earthy undertones. The earthy play of silver in the caramel and cobalt base makes it a good choice with silver or gold findings in jewelry.

Tips:
- 5188 Caramel Blues is a great color for reduction techniques. It is easily reduced and yields a solid, creamy reduced surface.

597 Blue Luster
597 is a transparent cobalt color with a low silver content.

683 Indigo Luster*
683 is a favorite with the "random trail and rake crowd." Purple is the underlying base color so expect to get great purples out of 683.

786 Triple Passion*
786* is a fast-striking silver that produces reliable bright purples. A big favorite for beads and sculptural work, this color develops beautiful purples, blues and greens. Also available in 4mm and 12mm rods.

Carnival Series: 485, 585
Carnival colors have a medium-high chemical saturation level and have a high copper content. The name "Carnival" characterizes the playful exchange between copper and silver. These colors can develop a metallic sheen called luster with orange and red highlights from the copper. To achieve a luster, raise the temperature of the flame about 125 degrees to approximately 1200 – 1250°F. Remember that it is easy to burn a fume off the surface. Treat the surface for about 20 seconds in a bushy, slightly reducing flame. Note that due to the high copper content, the color can become quite streaky if worked heavily in a reducing flame. If this is not the desired effect, make sure your flame is neutral to oxidizing.

485 Green Carnival
The primary colorant is silver. The Carnival Series contains both silver and copper.

The green in 485 comes from un-reduced copper. If reduced, however, the copper produces a range of colors from orange to salmon and red, as well as silver-based hues.

Tips:
- Work 485 like any silver-containing color.

585 Teal Carnival
The primary colorant is silver. The Carnival Series contains both silver and copper.

585 is a playful blue-green color.

Tips:
- Because the Carnival colors contain copper, if reduced, they can provide an orange and salmon-to-red color in addition to hues provided by the silver.

Opal Polychromatic Colors

This group consists of all of the colors containing silver and includes the Amazon and Chameleon Series as well as Aquatic Carnival and Silver Strike 3 and 5. See page 16 for a full description of polychromatic colors.

Lusters: 383 and 385*
The name Luster indicates that the surface can develop a metallic sheen. The source of this sheen is silver. To bring these colors to the surface, bring the temperature of the flame to about 1250°F (remember that it is easy to burn a fume off the surface). Treat the surface for about 20 seconds in a bushy, slightly reducing flame.

383 Silver Strike 3 and 385 Silver Strike 5* have no nuclei. A cool flame will bring metals to the surface.

385*, however, has a higher silver content, making it easier to bring luster to the surface. These colors can be worked very hard but require cooling until the orange glow disappears prior to striking. If you want to create a rainbow of colors, after the glow disappears, hold way back in the flame for 10 to 20 seconds without causing the glass to glow (similar to holding in a kiln at 975°F) to create nuclei on which to grow crystals.

Carnival: 489*

Carnival colors have a medium-high chemical saturation level and have a high copper content. These colors can develop a metallic sheen called luster with orange and red highlights from the copper. To achieve a luster, raise the temperature of the flame about 125 degrees to approximately 1200 – 1250°F. Remember that it is easy to burn a fume off the surface. Treat the surface for about 20 seconds in a bushy, slightly reducing flame. Note that due to the high copper content, the color can become quite streaky if worked heavily in a reducing flame. If this is not the desired effect, make sure your flame is neutral to oxidizing.

489 Aquatic Carnival*

The primary colorant is silver. The secondary colorant is copper.

The green in 489* comes from un-reduced copper. If reduced, however, the copper in the Carnival colors produces a range of colors from orange to salmon and red, as well as silver-based hues.

Amazons: 287*, 487*, 587*, 8387, 987*

Amazon colors all have a high chemical saturation level and were created with “serendipity” in mind. When working with the Amazons, try touching the work with your tools, blow air on them, or do a frit pick up with color or clear—anything that will break up the temperature profile to provide multiple colors. Once you find a method to achieve a result you like, these results can be reproduced for production work.

287 Amazon Bronze*

The primary colorant is silver. The other major colorant is reduced copper.

287* has “ruby” as a base color and was designed to add an ancient look to your work. It can yield a “non-glass” look with pure copper and metal rising to the surface of your piece.

Tips:

- This is a fun color to work with. Work very hot in a neutral flame. Beat this color up.
- Try gathering and mixing in a reducing flame and pull out into a rod before using. This will add a unique character and color to the finished piece.
- Flash in a reducing flame prior to placing into the striking kiln. The color will be a bright red with rainbows of metallic sheen. Once it comes out of the kiln the piece will have an “antique” look with many “spots” of pure copper and silver metal present. If you use a buff wheel and silver polish, the piece will become very reflective and the metallic sheen will be enhanced.
- Prolonged kiln striking intensifies the metallic sheen and darkens the red color.
- Mix 287* with 592 Brilliant Blue to produce colors of the Southwest desert – soft purples and pinks.

487 Amazon Jewel*

The primary colorant is silver.

487* contains sparkle, in addition to silver, and is very popular with those desiring a rainbow of colors with a sparkle effect. The sparkle is most pronounced when it is thinned, covered in clear or used for inside work.

587 Amazon Lagoon*
The primary colorant is silver.

587 Amazon Lagoon* was designed with the "serendipity crowd" in mind. As GA provides more information on how to "control" color, there have been many who remind us that they like discovering something new each time they open their kiln. GA introduces thousands of nuclei into each rod and so loads the glass with silver that it is beyond control. Also available in 4mm rods.

Tips:
- Touch 587 Amazon Lagoon* with your paddle, use tweezers, twist it with your pliers, use a can of cold air and blow on it, or try clear frit pick-ups... Go wild!

8387 Amazon Canyon
The primary colorant is silver and the secondary colorant is copper.

8387 is an earth tone Amazon color with loads of special effects.

Tips:
- Because of high silver levels, 8387 must be worked in hot neutral-to-oxidizing flame to avoid muddy silvers.
- Allow cooling until orange glow fades, add heat to bring back dull glow to strike. A second strike of this color sometimes yields interesting results.

987 Amazon Night*
The primary the colorant is silver. The other major colorant is cobalt.

987* yields night jungle colors – blue or green with metallic rainbows. It is a fun color to work with. Also available in 4mm and 12mm rods.

Tips:
- Work 987* like any silver color, very hot and in a neutral-to-oxidizing flame. Try flashing in a reducing flame prior to placing into the striking kiln. Use a buff wheel and silver polish and the piece will become reflective and the metallic sheen will be enhanced. Prolonged kiln striking may intensify the metallic sheen.
- We recommend using 987 Amazon Night* to set a neutral flame. See Setting a Neutral Flame on page 4.

Chameleons: 4484, 5486, 5488
Chameleon colors are based on the Turquoise colors (see page 12), with silver added. Previously, all silver containing colors available on the market were transparent. The Chameleon Series were the first opal (non-transparent) colors containing silver. The silver content in these colors is subtle to enhance the base color, not overpower it. These colors are best worked in a neutral flame. To maximize the silver coloration, twist and fold the glass as it is applied. Remember, high heat melts the color, while heat treatment just above annealing develops the color.

4484 Clover Chameleon
The primary colorant is chrome and the secondary colorant is silver.

4484 is a slightly lighter green than 444 Clover with silver added and tends to develop yellows, turquoises and blues.

Tips:
- Use a neutral-to-oxidizing flame to create a range of colors.

5486 Peacock Chameleon
The primary colorants are chrome and silver.

GA added silver to the Peacock base formulas resulting in 5486. This opal silver color allows the artist to develop a wide range of blues, purples and unique green colors.

Tips:
- Use a neutral-to-oxidizing flame.

5488 Twilight Chameleon
The primary colorants are chrome and silver.

GA added silver to the Twilight base formula resulting in 5488. 5488 is so dark that the silver creates subtle differences in shade and hue, providing a very organic look.

Tips:
- Use a neutral-to-oxidizing flame.

Specialty Colors

These colors have such unique properties that they are considered novelties.

Rubies: 132, 138, 139*, 738
The ruby colors are made with reduced copper. We have developed a diverse palette of striking ruby colors to provide the artist with a wide range of options when choosing to work with a striking red. To obtain the density and purity of color you want, we recommend striking all rubies in the kiln to avoid "liveryness" and to achieve an even, deep color. All rubies work best if struck at 1075°F for one hour (+/- 20 minutes).

All of these colors are ionic copper reds. In different valance states (there are three for copper), copper takes on different colors because of the distortion in the shape of the molecule. To obtain the red color, a percentage of the copper is reduced. The difference between 138 and 139* is the percent of copper that has been reduced at the factory.

To flame strike a ruby, first remember that high temperatures melt the crystals (refer to the section on crystal growth on page 2). We recommend two methods:
- For the experienced lampworker, move the piece to the very back of the flame and heat to an orange glow that would indicate a temperature of 1075°F.
- For the less experienced, turn the oxygen almost off—leaving a very fluffy flame—then heat the piece in the flame. It should turn black with a carbon coating. Add back enough oxygen to cause the carbon to glow orange, but not burn off. Keep the work piece in this flame for about 60 seconds then burn off the carbon and check the color. You can also use this technique for 30 seconds as a "pre-strike" prior to kiln striking to reduce the strike time.

132 Jasper Red
132 has a touch of silver that intensifies the thrill of using this ruby.

Tips:

- The copper is more reduced than in 138 Ruby Strike, though not as deeply reduced and 139 Cherrywood*.
- Abandon this color to the flame, it likes to be worked.
- Strike in the kiln.

138 Ruby Strike 4
138 was developed to be very difficult to strike in the flame but to easily strike to a deep transparent red in the kiln.

Tips:

- Work hot.
- Keep the glass evenly heated.
- Strike in the kiln.

139 Cherrywood*
Cherrywood* is a translucent/opal ruby wherein more copper has been reduced to strike to a deep red opal ruby and yet will transmit deep transparent red when kiln struck.

Tips:

- Follow the same tips as Jasper—the more you mix Cherrywood* in the flame, the more organic looking the color becomes.
- Strike in the kiln to expand the vitality of this ruby red.
- 139* frit strikes to a magnificent red in the kiln.

738 Ruby Blues
738 is a ruby that contains a touch of cobalt, and it can yield colors ranging from a light cobalt blue to a deep, ruby burgundy.

Tips:

- Ruby Blues is a great ruby to learn and experiment with. It is the same formulation as 138 Ruby Strike but with the cobalt enhancement.
- 738 has comforting tones of blue that will soften the livery tones to make the glass look stunning.
- Kiln striking is recommended to bring out the ruby reds.
- To retain the blue, shorten the strike time or anneal only.

Sparkles: 4578, 458, 487* (fits in both Polychromatic & Sparkle)**, 552, 555, 556, 558, 559*, 8458, 9958**
Most of the Sparkle colors are true aventurines, precipitated from chrome. To maximize the crystal size and your enjoyment—and minimize chrome cracking—GA pre-fires all of its Sparkles prior to selling. They MUST be worked in a neutral-to-oxidizing flame. Unburned carbon in the flame reacts with the chrome in this glass and causes it to change the COE of the chrome particles.

We find that “tugging” (putting the glass in “tension” not “compression”) Sparkle colors align the platelets to improve the appearance. We also believe that it is necessary to align the platelets to prevent cracking. We have found that when adding on glass, for example, an arm or fin, certain techniques work while others have a high failure rate at the seam. We recommend using a wipe-on/wipe-off technique rather than straight seals at 45/90 degrees. End-to-end seals should be white hot and pressed together and then pulled/stretched to align the platelets. These methods provide the “tug” that aligns the platelets so that they all run in the same direction, rather than colliding with each other.

Sparkle rods have a rough, bumpy surface. This is a side effect of the process we use to introduce the aventurine into the glass. It will melt away as soon as the glass is used in the torch.

4578 Rainforest Sparkle
4578 is a deep forest green.

458 Green Sparkle
458 is a bright grass green.

Tips:
- 458 Green Sparkle has medium-level saturation and can be pulled out in stringers or worked as is.
- Coating 458 with clear glass accents the sparkle.
- It should be worked in a neutral-to-oxidizing flame.

487 Amazon Jewel*
487* contains sparkle, in addition to silver, and is very popular with those desiring a rainbow of colors with a sparkle effect. The sparkle is most pronounced when it is thinned, covered in clear or used for inside work.

552 Aquamarine Sparkle
552 is a vibrant and translucent blue. A favorite as an overlay for other colors, an artist can work this color with ease and little risk.

555 Jupiter Sparkle
555 is a deep-blue Sparkle color, inspired by local Hawaiian waters. Jupiter Sparkle is very popular and easy to use in many applications. Also available in 4mm and 12mm rods.

Tips:
- While it works well on the surface, it has some risk of cracking if deeply encased because of the high chrome saturation. A neutral flame and proper annealing is a must.

556 Atlantis Sparkle
556 Atlantis Sparkle is a beautiful, aquatic blue-green. Its color is similar to that of the Aegean Sea, one possible location of the lost island, Atlantis. This color shimmers and is loaded with sparkles.

Tips:
- 556 works well on the surface, but has some risk of cracking if deeply encased because of the high chrome saturation. A neutral flame and proper annealing is a must.

558 Teal Sparkle
558 Teal Sparkle is a green-blue translucent glass with sparkles and medium-level saturation. This color is easy working and subtle in nature.

559 Neptune Sparkle*
559 Neptune Sparkle* is a deep green-blue opal, which has a very high, apparent sparkle. Also available in 4mm and 12mm rods.

Tips:
- 559* works well on the surface, but has some risk of cracking if deeply encased because of the high chrome saturation. A neutral flame and proper annealing are a must.

8458 Bronze Sparkle
8458 is a unique bronze Sparkle color.

9958 Disco Sparkle
9958 Disco Sparkle is a silvery looking Sparkle in a clear base that mixes well with most colors.

Tips:
- Preheat rod in kiln. Rod can be “shocky” if placed rapidly into the flame without preheating.
- Overheating will release sulfur, visible as a smoke.
- If coil potting, gather the rod and fulcrum mix for two minutes (or use drill) and re-pull rod. Consider mixing in three parts clear or other tint color if exposing large surface area.

Wonkas: 163 and 263
The Wonka colors come in a clear rod with a hint of color when viewed down the core of the rod. These colors will fluoresce (glow) when viewed under a BLB (black light blue) black light bulb. Wonka colors are unaffected by flame atmosphere but fluoresce most intensely when kept fairly thick.

163 Electric Flamingo
The colorant is a rare earth.

This clear rod does not strike to any color; however, it converts UV radiation to a bright **pink** color. The UV bulb must be of the Black Light Blue (BLB) type and should be less than one year old.

Tips:
- 163 can be used with any flame, any heat.
- This novelty color can be used in large murrini, goblets, marbles, and beads.
- The larger the mass of the piece, the brighter the color will be.

263 Atomic Kumquat
The colorant is a rare earth.

This clear rod does not strike to any color; however, it converts UV radiation to a bright **orange** color. The UV bulb must be of the Black Light Blue (BLB) type and should be less than one year old.

Tips:
- 263 can be used with any flame, any heat.
- This novelty color can be used in large murrini, goblets, marbles, and beads.
- The larger the mass of the piece, the brighter the color will be.

HEALTH AND SAFETY

Eye Protection

When lampworking, your eyes are exposed to higher than normal levels of Ultra Violet (UV) and Infra Red (IR) light, both of which can be harmful. Appropriate eyewear needs to be worn for the following reasons as well:

a) To minimize sodium flare
b) To protect the eyes from broken glass
c) To prevent burns of the eyelids

Check with your eye doctor and lampworking supplies distributor to locate a suitable pair of protective glasses for your particular situation.

Ventilation

Tests have shown that when clear borosilicate is heated to 800°F and higher, it begins to outgas aluminum and boron fumes. The flame itself is introducing combustion products, including carbon monoxide. According to one study, chemical reactions are taking place with the moisture and nitrogen in the air, producing other products that include measurable levels of nitric acid. Fumes and gasses from the colorants are also produced. Therefore, proper ventilation is required when flame working.

Simply opening two doors is not proper ventilation. Instead, it is an invitation to possible long-term heath problems. One simple test is to use a strip of tissue paper 6 inches by 1/2 inch. Hold it near the torch head and your face. In both locations, the tissue should deflect at least 45 degrees. Apply common sense to this rule of thumb: If you work along-side several others, you need to see more than 45 degrees; if you bead-work 8 hours a month, on a Minor or other small torch, 5 degrees of deflection is probably acceptable.

Colorant Warnings

The colorants listed below are used throughout the art glass industry—in soda-lime glass, borosilicate glass, and other glass systems. When present, they pose the same risks, no matter what the glass formulation is. **GA strongly believes in the rights of the artist to know what colorants are used in their working materials**. You need to know that some of the chemicals are hazardous. We also believe that every artist should know how to mitigate the risks associated with those materials. Safe work practices are not difficult to design and set up. **Please establish guidelines for your shop and follow them**.

GA is happy to provide Material Safety Data Sheets (MSDS) upon request. Glass Alchemy, Ltd. uses the HMIS™ system to evaluate the hazards associated with using the glass in the flame. This system uses ratings from 0 to 4, with 4 being the most hazardous rating. All GA Boromax™ rods carry the following HMIS ratings:

Health	1 or less	(1 implies some hazard; e.g. some colors also have cancer risk)
Flammability	0	
Physical	1	(Possible cuts and burns)
Other	A	(Didymium safety glasses required)

Glass Alchemy Boromax™ rods and frits also carry the ACMI AP Approved Product Seal. These products are certified by ACMI to be labeled in accordance with the chronic hazard labeling standard, ASTM D 4236 and Federal law, P.L. 100-695. In addition, there is no physical hazard as defined within 29 CFR Part 1910.1200 (c). For more information go to www.acminet.org.

Below, as you read the risks involved with each of chemical, keep in mind that proper ventilation and work practices will allow you to have a safe and enjoyable lampworking experience; no matter how many hours you spend behind the torch.

One last tidbit of information; to the causal observer it may seem that we make a big deal about ionic vs. colloidal colorant. It true, we do. Not only do the two types of colors have different working properties but there bioavailability is quite different. The ionic colorants, except in heavily saturated colors, are bonded in the glass and therefore don't leach as readily or create fewer fumes. Colloidal colors, only being trapped in the glass, leach out at higher rates and are more prone to fuming.

Cadmium
Cadmium is a heavy metal that sublimes at a temperature below the optimal flame working temperature, creating a gas. Acute toxicity from inhalation of cadmium fume or ingestion of cadmium compounds can produce serious illness, particularly in the lungs and GI tracts, respectively. There are several large, ongoing studies of individuals who have been exposed to cadmium, which are shedding light on cancers related to cadmium exposure. Chronic cadmium exposure causes pulmonary fibrosis and bronchitis, producing both restrictive and obstructive changes. This disease progresses even after exposure ceases and leads to shortness of breath. Therefore, when working with cadmium colors, always work in a well-ventilated area.

Cobalt
Cobalt is a heavy metal, and inhalation of cobalt fumes can cause shortness of breath, coughing and pneumonitis. Hypersensitivity appears to be a factor, since lung changes occur at low incidence and are varied in intensity and time of onset. In most cases, the symptoms disappear after exposure ceases. Cobalt is listed by the International Agency for Research on Cancer (IARC) as Category 2B, possibly carcinogenic to humans. Cobalt is known to the State of California to cause cancer.

Copper
Copper puts off toxic fumes when melted. In the reduced red form, the melting point is about 1984°F.

Chrome
Chrome is a heavy metal and is on a lot of lists. In most forms, it is a poison. In some forms, it is cancer causing. These colors should always be worked only in well-ventilated areas. In addition, chrome puts off a very bright white flame and excellent eye protection is required.

Rare Earth
The health warning for the rare earth colors is similar to colorless glass—when torch working, do so only in a well-ventilated area.

Silver
Silver is a heavy metal and can accumulate in your body. If you are fuming, you should use a shield or HEPA respirator, in addition to using proper ventilation. "Overloading the body's natural eliminative system causes the body to store some excess silver in the face; this, over time can result in a pronounced gray complexion. Argyria is strictly a nontoxic, cosmetic condition. However, argyria is quite serious in that it is thought to be permanent, much like a tattoo." See www.silversolutions.com

Manganese
Symptoms of manganese poisoning can range from sleepiness and weakness in the legs to difficulty in walking and uncontrolled laughter. Health surveys of employees exposed to manganese fumes have demonstrated a high incidence of pneumonia in these workers (OSHA).

GLOSSARY OF TERMS

Anneal: A process used to cool formed glass at controlled temperature rates to prevent thermal stresses.

ASTM: An acronym for American Society for Testing Materials. ASTM is a not-for-profit organization that defines the physical properties of materials and testing methods so manufacturers and consumers share a common standard of material behavior. Their efforts are not limited to materials but also define common standards for services, systems and products.

Aventurine: A super-saturated chrome solution (>1%), slow cooled so that the chrome precipitates out as platelets. These platelets provide the sparkle and are called aventurine. 1) If using a green chrome color and you anneal it at too high of a temperature, or slow cool it, you can cause aventurine to form. In almost all cases, this will lead to cracking of the piece. 2) In the GA Sparkle series, the chrome has been fully precipitated to provide you with an extremely stable sparkle-containing glass for your working convenience. 3) Precipitates of other metals, such as copper, are not called aventurines.

BTU: A British Thermal Unit (BTU) is the amount of heat energy needed to raise the temperature of one pound of water by one degree F. This is the standard measurement used to state the amount of energy that a fuel has as well as the amount of output of any heat generating device. You might be able to imagine it this way. Take one gallon (8 pounds) of water and put it on your stove. If the water is 60 degrees F. and you want to bring it to a boil (212 degrees F.) then you will need about 1,200 BTUs to do this. British Thermal Unit (**BTU**) is the measurement of heat created by burning any material. Combustible materials have a BTU rating. Propane has about 15,000 BTUs per pound.

Batch: A quantity of raw materials (colorant, silica sand, calcium, and various oxides) properly weighted and mixed to be introduced into the glass furnace where they are melted at 1500°C.

Blister: A cavity in glass filled with gas.

Borosilicate Glass: A glass whose main constituents are Silicon Dioxide (SiO_2) and Boric Oxide (B_2O_3). Corning Laboratories developed borosilicate glasses in the early 1920s in response to a need for chemically resistant glassware for laboratory work. It is commonly found in the home today in the form of coffee pots and oven cookware. The properties that make this glass valuable are its extreme resistance to chemicals (even the harshest acids do little damage to the glass or its appearance) and the ability to undergo sudden temperature changes without fracturing.

Carnival: A base color that is designed to develop a full spectrum (ROYGBIV) of color in the torch. The base color affects the overall appearance.

Celsius: Temperatures expressed with the Celsius scale are based on a division of one hundred degrees between the freezing point and boiling point of water.

Chemical Saturation: The colorants range from 0.05% to 7%. The more colorant added to create the color, the less likely the rod will behave like clear glass. Since the compatibility of the glasses is dependent on factors—such as the glasses having similar cool-down rates, from high to low temperatures, and the viscosities in two (or more) glasses at the same temperatures be the same—it stands that the higher the saturation of colorant, the greater the possibility of developing internal stress in the work piece. Knowing that a color has a high saturation of colorant helps decision-making regarding order of application, annealing cycles, and much more.

Chromophore: Coloring agents can be very powerful. 1 atom in 10,000 atoms of clear glass may be enough to produce the illusion that the glass is blue. This grouping is called a “chromophore.”

COE or Coefficient of Expansion: A measurement of how far the molecule within a given substance expands and contracts when the substance is heated and cooled. COE is one of the important factors (although, not the only factor) that determine compatibility between two glasses or substances. COE is also known as Coefficient of Thermal Expansion (CTE) and Liner Expansion Coefficient (LEC).

Colloidal: Finely divided particles trapped in between other particles so they don’t sink.

Colorant: Usually an insoluble powdered substance used to produce a desired color or hue.

Compound: A substance formed from two or more elements that are chemically united in fixed proportions.

Crusher: A device that uses hammers or rotating drums to pulverize a material into smaller fragments. This is used in glass manufacturing to produce cullet, frit and powder.

Crystals: Formed by the solidification of a substance. Crystals have a regularly repeating internal structure, external plane faces, and can be 4, 5 or more sided.

Cullet: Recycled glass used in the manufacture of new glass.

Dichroic: Dichroic means two colors, and this glass appears to be different colors when viewed from different angles or in varying degrees of illumination. Dichroic glass is created by adding a thin layer of metallic oxides which transmit certain light wavelengths while reflecting others, causing an iridescent effect.

Divitrification: 1) To deprive, wholly or partly, of vitreous character or qualities; 2) to undergo a change in texture from glassy to crystalline.

Fire Polish: A technique used to eliminate surface flaws and increase the overall strength of the glass, thus preventing future cracking. The glass is heated in a soft flame at temperatures just below softening point, around 1400°F. Only the surface is heated, so that the work piece does not lose its shape. At this temperature, the surface of the glass can move small distances to eliminate surface imperfections.

Flux: A substance that aids, induces, or otherwise actively participates in fusing or flowing, a chemical additive that lowers the required melting temperature during the manufacture of glass or improves the flow during fabrication.

Frit: Ground glass, ranging in particle size from gravel-like to a fine powder. Frit is sometimes used as a raw material in glass manufacture, and sometimes as a coloring agent or for decorative effect in hot glass crafts like lampworking, blowing and fusing.

Fused Glass: When heated to the proper temperature, two pieces of glass will flow into each other so that upon cooling they form a single unit. The two pieces need to be compatible.

Fusing: Glass-fusing is the process of using a kiln to join together pieces of glass.

Glass: Any substance having a non-ordered, non-crystalline molecular structure when cooled to a point below transformation temperature (Tg). Most common glasses are silica-based and melted with soda, lime and sometimes other components (boron, alumina and potassium). Most glasses are also hard, shiny and transparent or translucent.

Glassworker: An individual who forms glass into various shapes and objects. This term generally applies to the working glass in its hot, liquid form.

Hard Glass: These are glasses that are characterized by having a high softening point in the range of 1900°F to 2200°F and need a great deal more heat to manipulate. Borosilicate glasses generally fall into this category.

Ionic Colorant: These elements are found in the transitional area of the periodic chart and include such metals as cobalt, chrome, manganese, nickel, copper and iron. The ionic colors can exist in several oxidation (or valance) states and provide the lampworkers with several different colors. This is why your copper-green rod can give you red streaks when your flame is reducing in nature.

Lampworker: A glassworker that manipulates glass rods, tubes, frits, and powders by heating them in a high temperature bench torch (a high powered Bunsen burner) to produce objects. This is in contrast to other glassworkers who produce objects by gathering or ladling molten glass out of a melting furnace.

Lehr: Pronounced “Leer,” is an oven of various designs that slowly cools glass objects from forming temperature to room temperature. Glass's property of low heat conductivity makes it very vulnerable to quick temperature changes and produces stresses that fracture the object. Slow cooling allows the heat to be dissipated evenly throughout the entire mass and avoids producing stress. Lehrs vary in design between a simple box that is cooled by a digital controller, to massive devices where the glass travels on a steel mesh belt through zones of decreasing temperature.

Luster: A base color that is designed to develop a partial spectrum (YGBIV) of color in the torch. The base color affects the overall appearance of the multicolored sheen.

Nucleate: In assembly reactions were the first steps are energetically less favored; the reaction is much faster if a pre formed seed is used to nucleate growth.

Nuclei: A seed on which crystals can grow.

Opal or Opalescent Glass/Opaque: Any glass into which a material has been introduced at the raw materials stage, causing a degree of crystallization to occur and creating opacity in the glass. The degree of opacity is variable, depending upon composition and temperatures used in the manufacturing process.

Polychromatic: Term used by GA to indicate that a cane can develop many different colors or even multicolored metallic sheens on the surface of the glass.

Powder: Glass that has been crushed to a size that resembles wheat flour.

Pyrex™: The brand name for a class of borosilicate glasses developed by Corning Laboratories.

Pyrosols: The precursors to chromophores; colorless.

Redox (Reduction-Oxidation Reactions): An oxidation-reduction reaction is a reaction where electrons are transferred between two reactants. The substance that is oxidized is called the reducing agent. The substance that is reduced is called the oxidizing agent. Historically, oxidations were first defined as the combination of oxygen with some other element or compound; reductions were defined as the loss of oxygen from a compound. This simple definition works fine for the loss of oxygen from a metal oxide in the smelting process, which is very similar to what happens during lampworking.

Reduce: Some artists enjoy this effect, others don't. For example cobalt colors can go gray, while copper greens and blues can develop brick red streaks. To mitigate this, adjust the propane in your flame (decrease it) and use an oxygen rich flame.

Refractory: A dense ceramic material commonly used for high temperature applications.

Rod: Glass that is in the form of a thin cylinder that resembles a long pencil. The dimensions of this shape are 3/16" in diameter by 10" long.

Seed: A term used by glassworkers to identify tiny air bubbles in a glassy body. Small air inclusions are very undesirable by glassmakers and consumers.

Skystals: With silver colors, this is the purposeful development of crystals on the surface of the glass only. Unplanned or uncontrolled growth on the surface is referred to as haze or scum.

Soda-lime Glass: A glass whose main constituents are Silicon Dioxide (SiO2), Sodium Oxide (Na2O) and Calcium Oxide (CaO). Sodium Oxide is called Soda Ash in its raw form and Calcium Oxide is likewise called lime, hence the name "Soda-Lime." This type of glass formula is as old as glassmaking and lends itself to broad industrial uses due to its inexpensive material costs and ease of working in its molten form. Most decorative art glasses are made from this general formula and can be found around the household in the forms of drinking glasses and plate glass windows. Soda-lime glasses are not very chemically durable and are subject to fracturing from quick thermal changes.

Softening Point: The temperature at which a glass loses enough viscosity that it stops acting like a brittle solid and begins to flow like a liquid.

Soft Glass: These are glasses that are characterized by having a low softening point in the range of 1200°F to 1500°F. Soda-lime glasses generally fall into this category.

Stone: A general term used to indicate an inclusion that is a different composition from the surrounding glass. Typical stones come from furnace ceramics and under melted chemicals used in glass making.

Stringer: Thin glass strings, most commonly used for inside/out or trail and rake applications.

Striking: Indicates that a second "heat" brings out the color. The final color is affected by the duration and environment (oxidizing/reducing) of the second heat. Oven striking is usually at 1075°F. Rubies generally require more time than silver colors. If striking a piece that has both colors, you can pre-strike the rubies in the flame or work the silver colors very hot, so that there is no color development prior to placing in the kiln.

Sublime: To pass off in vapor, to volatilize from the solid state without apparent melting, said of Cadmium, which does not exhibit a liquid form on heating.

Thermal Expansion: Change of material size as a result of temperature change.

Tinted Glass: Transparent glass with a consistent color throughout

Transmittance: Ratio of light or heat that can pass through the glazing surface.

Valance (Valance State): This is a somewhat outdated concept in chemistry. It is a number that tries to predict with how many neighboring atoms a certain atom can form a chemical bond with. For redox reactions, it has been superseded by the concept of oxidation number.

Viscosity: The property of a fluid that resists the force tending to cause the fluid to flow. The lower the viscosity, the runnier a fluid is. Water has a very low viscosity, honey a higher viscosity and a cooled glass a very, very high viscosity.

Vitreous: Of the nature of, or resembling, glass.

Wipe On/Wipe Off: Sometimes called “double wipe” is a method where glass is first applied to a surface and while still soft the application rod is pulled back through the glass and pulled away from the surface. The technique is used to create fish fins, bird wings or similar structures.

Our frit jar label. Also available as a t-shirt.

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