Tech Talk

The second of a three part installment, Henry Grimmett gives an insightful look at torch setup.

By Henry Grimmett, Glass Alchemy, Ltd.

Due to the paramount importance of a neutral flame, Part 1 was devoted to setting up the flameworkers torch. To test your torch for a neutral flame use a piece of GA 587 Amazon Night and heat to a "warm" orange glow. Remove from the flame. After cooling, the rod should be the same color, if it shows dusty blue or "oil slick" metallic the flame is reducing. After adjusting the torch valves and trying again if the desired results are not attained, reduce the propane regulator a few pounds and try again. Often the set-up of the torch is the factor controlling the flame characteristics. (see issue 1 of FLOW MAGAZINE.)

This article will explore some important temperature ranges and the most often used colorants in borosilicate glass. An understanding of these metals should improve color control, brightness, reflectivity and workability.

Temperatures:

A vitreous network, glass is formed when upon cooling, a crystalline network is not formed. If the material can cool slowly and form a glass it is considered a "good" glass former. If it has to be cooled real fast to prevent crystallization it is considered a "poor" glass former.

The term crystallization refers to a combination of two processes: nucleation and crystal growth. Crystals require a nucleus on which to grow. This has important implications for the lampworker, especially when working with copper, ruby or silver colors.

The concept that the artist "nucleates and grows crystals" also becomes important when it is realized that the glass manufacturer and the artist are at cross purposes. One is trying to produce a vitrified product, while the other is trying to grow crystals or "di-vitrify" the produce to obtain a certain artistic outcome. For the artist the challenge is to obtain their desired result without creating a piece of art that will self destruct in 6 to twelve months.

In general borosilicate glass anneals in 15 minutes at 1050 F, or 200 minutes at the "strain point" of 975 F. Nucleation occurs over a range of temperatures near the strain point of 975 F.

Crystal growth also occurs through a range of temperatures slightly above the annealing temperature. Just above these temperatures, say 1175 F to 1250 F, is the range in which silver metals can be "flashed" to the surface in a reducing flame and "phase separation" can occur. Phase separation is a process where the glass materials separate from the highly distributed mix of silica, boron, alumina, and colorants into "pools" of ingredients and the "glass type" is no longer borosilicate. This is often identified as "di-vitrification" that doesn't melt back in. Phase separation can occur in the flame or kiln.

Colorants

<u>Cobalt</u>: oxides and carbonates are used to produce the color blue. Cobalt is an ionic colorant. For the flameworker knowing that a colorant is ionic provides a lot of information. First, all ionic colorants are additive. That is the more chemical the darker the hue. This property allows you to mix "down" a dark blue by adding clear or to make a light blue appear darker by building up layers. For instance,to make a blue whale that transmits 25% light (all transmission factors are measured in a 1/4 inch thickness) use 510 Pale Blue, a very light cobalt that transmits 92% light, and gather it up and build a solid whale or use 514 Cobalt 4, which transmits 5% light, and coat a tube with a thin layer and make a hollow whale. Both would transmit 25% light. (See our website for more on ionic colors www.glassalchemyarts.com)

Ionic colorants can also exist in different states of electrical charge. Each state provides a different color. For example, Cobalt is also used to make green and grey. The blue color is a result of having three oxygen's attached to the cobalt, which gives it a certain electrical charge. In a reducing flame some of the oxygen is removed by the unburned carbons of the propane, turning the cobalt from a blue color to a streaky grey-blue. (While greens are produced from cobalt in soft glass we have not been successful on a large scale in borosilicate.) The grey streaks are more prevalent with the higher saturated cobalt colors. Often, a reducing flame will not have an adverse effect on the initial heat. However, if the glass is allowed to cool to a dull orange or cooler, it is most important on the reheat that the flame be neutral to oxidizing.

Copper: oxides, carbonates and sulfates are ionic colorants. Like all ionic colorants, copper colors can be mixed down or built up to change the hue. A flame can also reduce or oxidize the copper to a different color. The colors most associated with copper are green, red and blue. The 421True Green, Phthalo', as well as the striking red's are colored with copper. When working with the green colors made from copper be careful not to use a reducing flame or they will develop red streaks. On the other hand, a nice effect is accomplished by "spin trailing" a wrap in an oxidizing flame, raking with clear, then reducing the color. This will leave green trapped under the clear rake and the exposed copper turning red.

Reducing with a high temperature (holding the piece closer to the torch head) will usually give a more of a salmon red. A cooler temperature red is more of a ruby and in-between temperatures yield a brick red. Reduced coppers, exemplified by ruby reds such as 138 Ruby and 287 Amazon Bronze, will grow crystals while being worked. This re-heat is called striking and when done in a kiln all the crystals grow uniformly to form "chromaphores". The longer the soak time for striking the larger the chromaphores become and the darker the color becomes. When "struck" in the flame there are many different shaped crystals that can occur and they don't grow uniformly. The results is a "livery" brown color that detracts from the ruby. Because the light is bouncing in all directions the glass appears to be "opal" (opaque) to reflected light but will transmit at reduced levels. In general livery rubies are considered inferior as they are not as bright. If it is necessary to strike in the flame then it is best to "bob" in and out of the flame to keep a "warm", even orange glow, but not a "hot" orange glow. With practice, controlled crystal grow can happen.

Silver: is a colloidal color. Colloid colors are finely divided materials suspended in the glass matrix and are not affected by a oxidizing or reducing flame in the same way as an ionic colorant. They don't lose or gain electrons (oxygen) and change colors. In the case of silver, it changes color as a function of the size of the silver crystal. When the crystals are real small, they can't be seen and there is no color. As the crystals become larger, they give the glass a yellow color.

If pieces are coming out of the kiln yellow and purple is the desired color, they need to be struck for additional time. If they are coming out blue, then the crystals are too large to produce purple.

Selective striking, use of clear frit, cold air, cold tools and trailing are all methods that can be used to produce a variety of colors from the same silver cane. Working the piece hot, evenly and then striking in the kiln will yield a solid color; unless you sandblast or grind through the top layer, exposing a different color due to the insulating properties of glass.

The secret to getting the silvers to work each time is simple in theory, yet takes practice. At GA we have formulated most of the silver colors to "strike" easily. To intensify the strike or to strike some of the older silver colors on the market you need to nucleate the glass. To form a rain drop there needs to be a speck of dust, a nucleus. To grow a silver crystal there needs to be a nucleus. In a color like 383 or 385 Silver Strike there are no nuclei provided. To get the full potential of the color it is necessary to create them. First, build your piece. As the piece nears completion, it is necessary to remove it from the flame a few inches and allow the piece to cool to a "warm" orange glow (about 975-1000 F). Try and maintain this temperature 15-20 seconds. The longer, the greater the number of nuclei will be created and the richer the color will be when the crystals are grown. Now place the piece back into the flame to "color" it. The crystal growth occurs at temperatures between 1050 and 1150 F. Be careful with these temperatures as borosilicate will "phase separate" at temperatures from 1175 to 1250 F. (Check the website of the manufacturer for your clear glass for a precise range; the color glass separates at similar temperatures but each color has it's own unique range.)

After nucleating the glass, rather than striking in the flame, the piece can be placed into the kiln for striking. If clear dots, frit or trailing was applied then different colors will develop reflecting the amount of time the crystals have to grow based on the different amounts of "insulation" that was applied.

Chrome: is another ionic colorant. However, when reduced it doesn't change colors. Rather, it cracks. In a reducing flame the exposed Cr_2O_3 is reduced to a thin shell of $Cr0_2$, much like an M&M candy.

When coated in clear, results in the micro-fine cracking from the stress of the two different expansions. Generally, when working with chrome colors do not overwork them, reduce them or over anneal. When annealing avoid temperatures above 1060 F and avoid extended soak times. Chrome is one of the "poor" glass formers and in borosilicate it doesn't enter into the glass matrix very well. Cladding chrome colors helps in the sense that it reduces the amount of damage you can do as you adjust torch setting for various reasons.

Cadmium: is a colloidal colorant. The various cadmium colors are a blend of cadmium and cadmium sulfate. The higher the cadmium, the lower the cadmium sulfate, the redder the color. This is important to know because cadmium (not cadmium sulfate) sublimes (turns to gas) at 1750 F. Flameworkers brought up on borosilicate generally work with the glass between 1900 and 2000 F, while those from a soft glass background tend to work their borosilicate glass at about 1700 F.

To work the cadmium colors it is necessary to work at lower temperatures. To accomplish this; turn the heat down and work in the same location of the flame or use the same flame and work further back in the flame. Another route is to encase the crayon in clear or another color. With some practice, albeit a little slower, you will be able to work the cadmium colors with little difficulties.

Summary

When working colored glass, compared to clear, the flame atmosphere is of utmost importance. To obtain the proper flame the torch has to be set-up with this in mind. In the scientific glass world the schools and large corporate firms hired Master Plumbers to do the necessary calculations and installations. Even if the job wasn't done properly the torch probably got "hot enough" and it worked. The artist can't be satisfied with this result and generally doesn't have the budget. This creates the proverbial Catch 22.

Remember, high volume hoses, low pressure allows laminar flow. Test for neural flames and if necessary reduce the propane at the regulator. To maximize the silver colors learn how to nucleate the glass. Kilns are superior to vermiculite. Digital controllers are a must for the person making a living from glass working.

Part Three will explore individual colors, tricks and annealing. ▪