Uncoated Ruby 14

Ruby Advice

A while back we were speaking with two very qualified representatives of two of the largest resellers of colored glass in the world. When we asked each of them what was the best solution for processing uncoated ruby, they both had the same answer – use coated ruby.

This isn't bad advice. The problems go away and the light output is greater. But, there are times when you can't take this advice because the color was specified. You want and need the subtleties of this jewel-like color. This color is truly red as opposed to when it goes bad and turns brown in the middle of the tube. This odd color is created by blue light inside ruby glass.

Let's first examine what the problem is. You process this uncoated ruby tube just like you would any normal piece of glass. Fill with neon, tip off, and the tube looks beautiful on the burn in table. This lasts for about 20 minutes. Then you notice the middle of the tube dimming, it becomes hot – maybe even too hot to touch. Light output continues to drop, and you begin to cry.

Why did this happen? The best explanation that we have heard goes something like this. The amount of energy associated with making light – on an atomic scale – is tremendous. Even though the particles are small, due to their velocities, these things flying around inside the tube have a large impact and have a "scrubbing" action on the inside of the tube. This "scrubbing" can loosen impurities that did not come out during the limited bombarding time. The electrodes do a great job of cleaning up most of these impurities as they come off, but this could be a long time considering the tremendous amount of contaminants that can be liberated from uncoated ruby. One of our sources said that he had never seen a tube not burn in, but the customer does not want to look at this expensive brown sign for maybe a couple of months. This does not do anything good for the life of the sign either.

Cause and Effect

Ruby has this problem because there are compounds that must be used in manufacturing the ruby color. Different companies that add coatings to our tubing use various proprietary processes to clean and coat the glass. These variations produce different results. Some experts we spoke to believe that the ambient conditions when the glass was made has a big effect on the glass and ultimately on your processing success. There is no one solution that will guarantee success, however, there are many things that we can do that will dramatically increase the probability of success.

The easy solution is to use coated glass. The theory here is that the coating / binder layer "seals" the glass wall to some degree. This is just enough so that whatever impurities get "scrubbed free" will get cleaned up by the electrodes before a critical amount accumulates. Once this particulate builds up you will start to see your brown tube emerge again. So you will not have the color you really want either, but this is very rare to happen in coated glass.

The next best method is to set yourself up for success by keeping the glass sections short. Around 6 feet or less shows good results. The reasoning is you will always have some impurities coming out of the glass. The more glass you have, the more impurities you will have. It seems like electrodes can "getter" about 6 feet worth of this trash – assuming you do a good job with the other variables.

Still Seeking a Solution

We keep referring to these impurities in the glass as the cause of all these problems. This leads us to two avenues for a solution. One would be bombarding in a way that gives these impurities plenty of time for "extra scrubbing" at or above the temperature that the offending material becomes gaseous. The other possible solution might lie in physically cleaning the glass with some chemical cleaner. Both of these avenues have strong devotees who are very serious and specific about how all this should be done. We have limited our tests to three different methods that have shown some success over time. As ridiculous or arbitrary as the specifics in each method may seem, there are some groups behind it who will come to your shop and convince you if you do not believe. No, just kidding, but each of these camps are successful with the methods that they are using. This is at least more successful than people who have no method.

The Tests Results

In all tests we used machine drawn glass, 15 mm tubing in lengths of 10 feet. All tests started with a preheat partly to end up with a better tube, but mainly to drive off the initial volatile moisture and impurities in order to have better control over the pumping process. This was pumped at 2 Torr, heat to 125˚C, cool under vacuum to 60˚C, backfill with air to 2 Torr, and follow electrode manufacturers' processing instructions. All burn in was done on 30 mA transformers. Using a clean manifold, good pumps (including diffusion pump), and full gauges including IR temperature gauge gave us good repeatability throughout all tests.

The first tests were run to establish some baseline; the tubes were processed like any normal tube, heated to 250° C. In previous tests we have found that heating higher (to the 300° C range) did not have the desired effect of simply more time to pull the impurities out of the glass, but it made the problem worse. Our theory is that rather than simply ripping off the offending stuff on the inside wall of the glass, at higher temperatures, we are drawing this stuff out of the bulk of the glass where there seems to be an unending supply. This may not be a sound theory but it is a model. Most experts on ruby say hotter is not the way to go.

The tube initially looked perfect on the burn in table; no snaking, full red end to end. In about 20 minutes the center of the tube began to darken. Over the next 10 hours the darkness spread out to within 12 inches of the ends of the tube. Clearly normal processing is not good enough.

In our second test we tried to “soak” the glass at 175° to 185°C for 2.5 minutes. The people advocating this method believe that at this temperature the bad stuff is coming out of the glass and it takes some time to get all of it out. This method is an adaptation from oven pumping which seems to have pretty good results with uncoated ruby. This is only workable in conventional bombarding if you are using an IR temperature gauge as thermocouple gauges are usually very accurate on temperature rise, but poor on cooling. Once we got to 185°C, the glass cooled back to 175°C in about 5 seconds and heated back up to 185°C in a 3 second bombarder blast. After soaking between these temperatures, we then heated to 250°C.

On the burn in table this tube also began to degrade at about 20 minutes and at 10 hours was only slightly better than the normal tube.

Our next theory goes back to a method that used to be quite popular, but has fallen out of fashion over the last few years: helium flushing. The beauty of helium flushing is threefold: first, being a noble gas it is a good clean rinse for the tube displacing whatever air may be left in the tube at the end of bombarding with an inert gas; in addition it allows you be able to heat and “scrub” the glass without heating (sputtering) the electrodes during bombardment; its third quality is that it acts as a visual diagnostic tool. If there are significant amounts of impurities left in the tube, the helium will be brighter in the middle of the tube than the ends; if the electrodes were under processed, the helium will be brighter at the ends of the tubes. Yes, really.

In this application (uncoated ruby), we bombed the tubes as normal but rather than filling with neon when cooled, we backfilled with 3 mm of helium, bombarded again for 2.5 minutes at 350 mA. The tubes reached a temp of 190°C at the end of this process. We then let the tubes cool again and filled as normal.

In exploring the helium option, mixtures like 5% helium flushes can make this “last” flush not show any color. It makes sense that would mean the tube is finally clean. It does not on a long tube. There is unwanted matter that comes out more slowly. Although it is improved, it will still turn brown in the middle.

On the burn in table the tubes looked great initially, after 10 hours they were not great, not terrible, but not perfect either. They were slightly dim evenly from end to end and the discharge at the electrode was off color, but not as much as the first two methods. They were slightly warm all over; the others were hot in the middle.

Intuitively you would think that if you were to do multiple helium flushes until there was no color change, this should remove all impurities. In theory after 3 to 6 helium flushes the helium color remains stable. However you will see on the burn in table there is little improvement over the single helium flush. In conclusion, don't waste the time.

Our final test switched over to cleaning the glass out before processing. Some camps go as far as recommending acids, but we don't see that as reasonable for any neon shop to deal with those dangers or disposals. One safer method is to mix 1 part ammonia with 2 parts water and either soak the tubes (for a couple of hours in a rain gutter type trough) or pour the ammonia through each tube several times. Rinse with fresh water and dry with clean dry compressed air. I used the second method.

The tubes were processed as normal. The tubes began turning, like the first two methods, in 20 minutes or so. Over the next 10 hours they never degraded as much as either of them, but they could hardly be called acceptable.

Is There a Solution?

What have we learned from this? Don't use uncoated ruby? That would be too simple of an answer. I think it can be used successfully by combining several tricks together. Remember that all good neon comes from doing a lot of little things right. If we went with our 6 foot tube length limit we might have gotten them all to work, however we have seen that different methods show trends toward better tubes. Combining these methods should virtually guarantee success.

This chapter is an excerpt from:
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