**What you’ll need:**

- E3 Duo™ electronic controller with power supply
- Electroforming solution for copper
- Electroforming brightener
- Glass or plastic beaker
- Copper anode wire (copper coil)
- Copper conductor wire to attach to piece
- Varnish or other sealer
- Conductive paint (graphite, copper or silver)
- Paint brushes to apply varnish and conductive paint
- Distilled water
- Wood chopsticks
- Funnel
- Coffee filter
- Rubber gloves
- Eye protection
- Tape
- Object(s) to electroform: Must be dry and compatible with solution. Note that some gems and stones contain metal, which may cause plating to cover the whole stone or contaminate the solution.

Before beginning be sure to read the instructions thoroughly and follow all safety precautions as listed by the manufacturer on the chemicals.

**Steps for Electroforming with Copper:**

1. Many small objects are suitable for electroforming with copper. Small toys, glass beads, leaves and twigs are just a few examples. If using an organic object, it must be thoroughly dried and sealed prior to electroforming. Materials like bone and certain seashells may seem non-porous, but they still require sealing. The sealer will waterproof the surface, as well as keep the object from breaking apart or contaminating the solution. Another function of the sealer is that it helps the conductive paint (described in the next step) stick to the object, especially if the surface is smooth. There are several products that can be used to seal objects. We use a water-based varnish, but you could also use decoupage medium or a wood sealer. For example: if you have a piece that is hard to coat it may be easier to dip it into liquid sealer (the type sold at hardware stores). Regardless of the product you use, make sure the piece is completely sealed. Apply several coats if necessary to ensure coverage. Let dry. Note: if you want to plate a metal object, you will not need to seal it or use conductive paint. Certain metals like steel, stainless steel, or alloys of tin and lead will interfere with plating. Do not use items made of these metals.

2. Paint a layer of conductive paint over the dried sealer. Cover the piece completely, or selectively cover the areas you intend to electroform. Remember that the paint must follow a continuous line to conduct electricity. For example, you could paint a spiral design or a bezel around a piece. In contrast, if you were to paint separate “dots” on a piece it would require that a common conductor wire be touching all of the dots individually during plating. After applying conductive paint, let the piece dry. Applying high heat from a hand-held dryer after painting may cause bubbles on the surface, so slow drying is best. Apply more paint if needed to touch up any missing areas, and let dry. The conductive
paint allows the object (a leaf in this photo) to become a cathode to which the copper will plate. Note about graphite paint: This paint must be mixed thoroughly before use. It should be the viscosity of cream or acrylic craft paint. The paint will stick to most surfaces; a thin layer is all that is required for conductivity. Thin the paint as needed with distilled water. For smooth objects like glass, apply a sealer to help the graphite paint to stick, or try another conductive paint. See our Conductive Paint Info PDF available on the “Learn” section of our website, for more information about various options.

3. Attach a conductor (copper wire) to the object by wrapping it around or looping it through the object. The wire will conduct electricity during electroforming and must be in direct contact with the dry conductive paint. Some paint can be brushed up over the attached wire to ensure that the wire and object conduct as one piece. The wire can be any gauge. You can use heavier wire to keep a lightweight object from drifting or floating when suspended in the electroforming solution. You can also electroform multiple objects at once if they are relatively small and simple in shape. See FAQs below for more information on multiples.

4. To prepare your equipment prior to electroforming, position a copper coil inside a plastic beaker or glass jar. This coil is the anode, which will deliver the copper to be plated to your piece. Leave some copper exposed at the top to attach the electrode clip.

5. Pour some electroform solution into the beaker. You will need enough to cover your object but more is better to take advantage of the copper from the anode. The end of the copper coil will be exposed at the top (5A). Slide the conductor wire attached to the object between the un-split chopsticks (the tension will hold the wire in place). Adjust the wire so that the object will be centered in the beaker when suspended (5B).

6. Plug in the controller and make sure the top switch is set to EFORM with the power on before submerging your piece. Turn the current knob up and don’t worry about the setting yet. Clip the red electrode from the controller to the exposed copper anode wire as shown (6A). Clip the black electrode to the conductor wire attached to the object. It can be clipped above or below the chopsticks, just be sure to keep the clips out of the solution. Submerge your piece while the current is flowing, placing the chopsticks across the top of the beaker. MAKE SURE THE PIECE DOES NOT TOUCH THE COPPER COIL ANODE (6B). Hints: A few pieces of tape are helpful in holding the chopsticks securely to the edge of the beaker. If the piece drifts or floats after placing it in solution, use a plastic spoon or other non-conductive aid to keep it from drifting.
7. Start with your controller at relatively high current for about a few minutes to get the plating started (SEE THE VARIABLE CURRENT LEVEL INSTRUCTIONS BELOW). This will expedite the coverage of the copper over the graphite paint. Since the graphite paint is water soluble, this boost in current minimizes the amount of graphite that might flake or soak off had the piece been left in the solution longer before plating. The boost in current also helps to minimize contamination. After a minute or two, set the current to a desired level. Large pieces and multiples can be left at a higher current levels (1A-2A). For small pieces and shapes with lots of sharp protrusions and undercuts, reduce the current to the medium or lower end (.04mA-1A). A high current setting deposits metal faster, but faster plating can result in a rough finish with sharper points. If set too high, the copper will not plate well, but rather form a crust on the conductor wire. There is no rule for current setting set in stone. Experiment to see how pieces are plating and adjust the current as needed. You will quickly get a feel for optimal settings after plating just a few pieces.

8. Make sure both lights are on: the green light indicates that the power is on, and the red light pulses like a “heartbeat”. Make sure that your piece is not touching the copper anode throughout the electroforming process. Check the object after 20 minutes to make sure a layer of copper is forming. If you do not want the conductor wire to stick and become part of the finished piece, reposition it after the initial copper layer forms (30 minutes - 1 hour). If the wire sticks again after a few more hours, reposition as needed. With the pictured leaf stem, the wire was left in place, undisturbed to become part of the piece. If your piece looks dull, add a few droppers full of brightener any time throughout the process. Depending on how thick you want the metal, full plating can take anywhere from 2 to 12 hours. Remove the piece when the desired thickness of metal is achieved. This leaf was removed after 3 hours. Rinse the object with distilled water and pat dry. If you get unwanted burrs, they can be sanded or filed down after forming. If your piece is dull-looking it can be polished to a bright shine. See the FAQs section below for more information.

9. You can now use the finished copper piece to create jewelry, or you can proceed to electroplate the piece with other metals. To electroplate nickel over copper, followed by precious metals, you can use various anodes and electroplating solutions specific to those metals. See the FAQs section below and visit the “Learn” section of our website for more information.

10. To clean up and store your solution, strain the used solution through a coffee filter using a funnel to direct the solution back into the bottle for storage. This will strain out most of the larger stray copper particles that accumulate during electroforming. The solution may be reused. Remember that acid depletes, pH levels change and contamination occurs. This requires that the solution be replaced.
* Variable current level instructions

There are a few variables to consider when deciding which current level to use. Small objects need to be electroformed using a low current level and larger objects can be formed using a higher current level. Start with the controller set on a higher current relative to the size of the piece for a few minutes or until the object has an initial coat of copper. For example: If you have small object like the elephant charm pictured (which is 1” in length), start the piece at .50A for a few minutes and then turn the current down to a lower current level in the range of .10-.25A for a few hours to complete the plating. The plating was even and smooth and the copper covered the charm nicely. In contrast, look at the elephant charm on the right. This piece was formed starting at 2A and then left at that level for a few hours. Most of the plating was directed to the conductor wire. The plating was dull and the copper formed a rough crust that crumbled off of the wire. The piece itself did not plate very well. The large driftwood piece (4” in length) pictured below was started at 2A for about 10 minutes and then set to 1A for the remaining 6 hours to plate. The wood piece is large enough to allow for smooth plating at a higher current level.

A general rule of thumb is to deliver .10A of current per square inch for most objects, but experimentation is the best way to see how the copper forms on different shapes and materials. The dial allows current adjustments from .04A to 2A.

**Troubleshooting and FAQs**

**How is this product different than traditional electroforming or plating devices?**

The E3 Duo™ controller is a revolutionary substitute for a power rectifier. It was designed for small jewelry projects and can be used with all kinds of plating solutions and anodes suitable for plating a variety of metals. The controller contains a micro-controller, which monitors and self-adjusts the current without user intervention. This saves a great deal of time and effort. It is also a fraction of the size and weight of a traditional rectifier, making it handy for classes and small studios. It is unique in that it contains two distinct microprocessor programs, one for etching that is based on POWER levels and the other program is for electroforming and plating which is CURRENT based.

**Can I plate multiple objects at one time?**

Yes, but make sure they are similar in size and shape so that they electroform uniformly as the copper is distributed to each. Attach each object to its own wire, and then twist all the wire ends together so they share a common stem (think of leaves growing on a tree branch). Position the objects away from each other so they don’t touch each other or the copper anode coil during electroforming. Another way to plate multiple pieces is to wire each piece onto a common copper rod so that all of the pieces are positioned in a row suspended from the rod. Rest the rod over a rectangular shaped vessel lined with a copper anode (sheets or wire). This will allow you to form individual pieces at once on a large scale. Visit the “Learn” page of our website for our tutorial on plating multiples.
Can I electroform polymer clay or wax or other materials?
Yes. This is the best part about plating. As long as a coated object will hold up in water, it should work. Polymer and wax make excellent cores for plating. We have had students who have successfully plated difficult objects like feathers, leather cord, and even a fragile gecko skeleton.

The importance of turning on power and current before submerging a piece
Having the power and current on before submerging a piece minimizes the amount of conductive paint that might flake or soak off had the piece been left in the solution longer before plating. It also helps to minimize contamination. The prepared piece on the left (covered with sealer and water-based graphite paint) was placed into the copper plating solution without turning on the current. It was left it there for about 5 minutes before turning the controller on. The result wasn’t good; the piece didn’t plate very well and the copper was a very dull salmon color. The piece on the right was a similar charm (small rubber toy) and was prepared in the same manner. However, for the piece on the right, the controller power was turned on with a high current level. The prepared piece was then submerged to begin the plating process. It was left it on 2A for just about a minute and then it was set to a medium current setting until finished (several hours). The result was a beautiful, shiny piece with a thick deposit of copper.

The controller is working, but my piece isn’t electroforming.
Most of the time, the problem is a bad connection with the wire that is attached to the object. Reattach the wire, making sure the conductive paint and wire are touching, and that your object is properly sealed and painted. If the wire plates but not the object, then the wire is not in proper contact. The other problem may be the electroforming solution. Plating solutions must remain pristine and will not work as effectively if contaminated. Use fresh solution or strain the particles out, adding more brightener as needed.

The controller stopped working or the current level shows (0.00)?
Always test the controller first before assuming it is broken! The way to test the controller is to first plug it in and see if the green light is on. This means that the power is working. The next step is to test the controller for current. Do this by turning the dial up a bit and then touching the two clips together to see if the red current light pulses, along with numbers appearing on the display panel. If the power and current are working while touching the clips together, then you have a problem with your set up, such as solution contamination or weak conductivity to your piece. It is often the case that the solution is contaminated, which will throw off the balance of the chemical and acid ratios. Another factor could be that your conductor wire is not in good contact with the piece or is directing electricity away from the piece. Visit the “Learn” page of our website to read PDFs with detailed information about maintaining your solution and about the importance of keeping the current running as you electroform.

My project is a dull color and appears grainy. It doesn’t look like copper. What’s going on?
If your solution starts forming or plating with a dull, rough, salmon-colored finish, add 2 full droppers of brightener during the plating process to restore the smooth, bright finish. Another cause could be that the current level is set too high. Turn the current level down and see if the piece becomes shinier. If you are using solution that has been used before, replace the solution, as it will lose the ability to plate smoothly as the acid levels are depleted. Acid is vital for bright, shiny copper. A warm environment is also helpful. Agitation is beneficial in addition to warmth. Organic materials leaching into the solution can also cause poor plating. Be sure to seal objects completely. If you see black areas on your piece that are not plating, rinse the piece, re-seal, and reapply conductive paint. After drying, electroform the piece again and this usually solves the problem. If your finished piece is formed with a layer of copper that is has a flat dull copper color, it can be brushed and polished to a bright shine. A brass brush alone can do wonders as you can see on the skull charms below. Visit the “Learn” page of our website to watch our video about burnishing dull copper.
**Why is my copper piece turning dark after electroforming? How do I keep the nice shiny copper color?**

Copper is vulnerable to the air and minerals, which will oxidize the surface. Be sure to only rinse it in distilled water. Thin your graphite paint using only distilled water. To keep the copper from oxidizing, there is a spray called Nikolas Spray Lacquer – Clear, which is preferred by many jewelry artists. Some use clear wax or varnish. Many prefer to let nature dictate the color and let the piece oxidize. If you want to remove the oxidation, use a jeweler’s pickle solution or a solution of citric acid as you would to clean any other copper surface.

**If I want to add more copper to an object, can I put it back in the solution to continue electroforming?**

Yes. Clean the copper well before electroforming an object a second time. Use a pickle solution or a purchased electro-cleaner to remove oxidation before electroforming again. If you would like to add more copper to the object, simply re-plate. If there are missing areas that did not plate well, re-apply varnish and conductive paint to the object before re-plating. Visit the “Learn” page of our website to watch our video about re-plating.

**My piece has little burrs or sharp points on it.**

As your piece is electroforming, loose bits of copper may settle on the surface, causing bumps or sharp protrusions. To eliminate these burrs, follow these steps: 1. Keep the current at a low setting. 2. Don’t rush to take your piece out. Extra plating time will often smooth out the rough spots. 3. Strain the solution periodically and change the orientation of the object occasionally. 4. Use an anode bag. Polypropylene is a good choice. These can be found from plating suppliers. Place the bag between the coil and your object. This will keep the stray particles from settling on your piece.

**Can I plate over base metal or old jewelry pieces with gold, silver and other metals?**

Yes. The E3 Duo™ controller works great for plating metal objects or old jewelry. You can plate with nickel, silver and gold, just to name a few. Jewelry making suppliers sell a variety of plating solutions with instructions detailing which anode is appropriate to use and how long to plate in the solution. Simply substitute the E3 Duo™ controller in place of a plating rectifier when following the directions using the correct anode and timing. Set the controller to a LOW current level (.05-.1A) for most plating solutions depending on the size of the piece. You won’t need to use conductive paint, as a metal object is already conductive by itself. Each metal calls for different steps, solutions, anodes, equipment and safety concerns. Plating takes quite a bit of training and knowledge so be sure to research the steps of the particular metal and solution you want to use before committing to plating.

**Brief Overview of Plating:**

Plating is the process of applying a thin layer of metal over metal. To prepare a piece for plating the piece must be cleaned with an electro-cleaning solution and then dipped in acid prior to plating. The piece must also be rinsed with distilled water between solutions to avoid contamination. The piece then goes through a series of steps involving heating and agitating the solution (if called for) as the metals plate. Jewelry making suppliers sell plating station units which can provide heat and agitation to certain beakers where needed. Rio Grande sells the *Midas Six-Station Plating System* for this purpose.

Certain metals cannot be plated over one another without a barrier layer of metal between. For example, a layer of nickel should be plated between copper and gold to keep the copper from migrating into the gold. RioGrande.com has great charts on their website, which can be found with each plating solution, to show you the proper plating sequence.

Along with the knowledge of the steps and becoming familiar with the characteristics of each plating solution, the most important consideration is SAFETY. When you get into plating various metals you can be dealing with very dangerous chemicals. For example, 24K gold is available in non-cyanide and cyanide formulas. The cyanide is what makes the gold so rich and beautiful, but it can be fatal if misused. You need to wear a NIOSH mask, proper gloves, apron, goggles, and use a fume hood for ventilation just to name a few of the safety precautions.

Electroforming takes experimentation and practice. As with any jewelry-making technique, trial and error are part of the process. The more pieces you electroform, the more comfortable you will become with the art of forming and plating.

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For more help, project ideas, and supplies, visit [www.sherrihaab.com](http://www.sherrihaab.com)