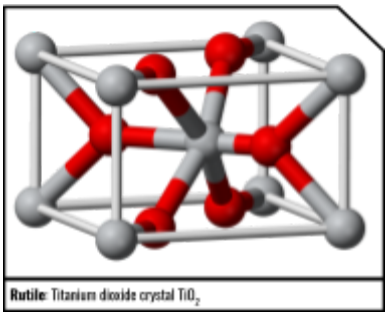
Anodizing Is Awesome!

2023 revision by Brian Skellie, with special thanks to Bill Seely & Jonathan Loveless

1) What is Anodizing? Surface cleaning and passivation by oxygen


Rutile: Titanium dioxide crystal TiO_2

Anodizing is a process where a coating is built up on the surface of certain metals (titanium, niobium, tantalum, aluminum, magnesium and zinc) by heating, with chemicals, or by electricity. In the case of titanium, the coating that is built up is a transparent glass like layer of titanium dioxide crystals. Titanium dioxide TiO_2, which is also known as titanium oxide, occurs naturally on the surface of titanium.

Anodizing the surface of titanium can be done by the use of heat but the results are not easily controlled and the color range is limited. The most common method is to form an oxide layer on the surface with electricity.

This is done with a variable power supply in which an electrode is connected to the positive side **(+ anode)**, and one to the negative side **(- cathode)**. Both are then submerged into a mildly conductive solution, thus completing the electrical circuit. The piece that is to be treated is connected to the positive side and reacts with oxygen, and that is why the process is called “anodizing”.

2) How are the different colors achieved? Light and crystal size

Anodizing does not involve any dyes or pigments. The color on the surface is apparent because light reflects through the created oxide layer to create a color. Without the presence of light that color wouldn’t be there.

Light reflects off of the surface of titanium. When a piece is highly polished and not anodized, it reflects its mirror finish. When a piece is anodized, the light has to reflect off of the metal surface and also the surface of the added crystalline oxide layer. The clear crystal filters the light waves passing through it and causes interference in the light reflected. This causes the light to reflect in a color.

The color that is apparent on an anodized piece of titanium depends on the thickness of the oxide layer that has been applied to it. The thickness of the oxide layer that is formed during the process depends on the voltage of electricity that has been applied to it. You will note that the current flow reduces as the oxide forms and virtually zero when the surface reaction is complete**.**

If you are anodizing more than one piece and you want them to be the exact same color, it would be a good idea to anodize them all at the same time. You may not get a color match if you do them on separate occasions without precise controls.

Thicker and/or larger pieces to be anodized may take longer and sometimes increased voltage to achieve a similar color to their thinner, smaller counterparts.

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3) What will you need to start anodizing? The shocking details

- An anodizer (A variable power supply 0-120VDC with at least one Amp of current[1])
- A cathode (A sheet of non-corrosive metal like titanium or stainless steel. A scrap piece of Ti with a larger surface area than the piece being anodized will work well)
- An anode (The piece of jewelry being anodized and a reactive metal contact)
- A submersion tank (This should be made of glass or plastic) not necessarily larger than common jewelry
- An electrolytic solution (TSP, TSP-PF detergent, baking soda, or Epsom salt dissolved in distilled water)
- Electrodes (All anode circuit parts that contact the electrolyte solution must be Nb or Ti: rods, wires, clips, jigs, tweezers or hooks to hold or touch the jewelry with)

It is possible to build your own anodizer. You can find information about this on the internet. It is much easier to buy an anodizer from a company that sells them already built. I get my kit from Reactive Metals. It comes with the anodizer, electrodes, stainless steel cathode sheet, instructions, and a pamphlet with detailed info about anodizing.

4) Which voltage achieves which color? It varies a little

The more voltage that is applied during the process, the thicker the oxide layer that is achieved. The voltage range used in this type of anodizing is usually between 15-120V. The colors are in approximate ranges, and **will differ slightly for your set up**, so make your own chart for reference voltages to note the differences between Ti, Ti alloy and Nb. It is good to start a little lower and turn it up gradually.

Color	Copper	Dark Purple	Dark Blue	Light Blue	**Shiny!**	Yellow	Fuchsia	Blurple	Teal	Green
Voltage range	8 – 10 V	15 – 16 V	18 – 20 V	27 – 30 V	40-45V	48 – 50 V	62 – 63 V	72 – 75 V	81 – 85 V	91 – 92V

This chart represents the voltage ranges that I use. I can usually achieve the color I am after within these ranges, however I always start out lower and work my way up. This will vary for you based on the solution and size of your cathode and submersion tank, and how well and how recently the jewelry was polished.

For Nb only, an opalescent color appears after green.

You can change the color of an anodized piece to another color of a higher voltage. It is possible, for instance, to turn a dark blue anodized piece to light blue, yellow, or to any of the colors of a higher voltage. It is not possible, however, to turn that dark blue piece to a purple or a copper color. If you wanted to do that, the oxide layer would have to be stripped off through polishing followed by steam cleaning.

In between Light Blue and Yellow is a near-white **Shiny** reflective surface where the color wavelengths cancel out. This is a favorite for customers who want a piece look brighter than plain mirror polish, or can be adjusted to match other white

[1] Available through piercers.com/anodizer with additional body jewelry specific training and support.

metals such as steel or white gold jewelry. You can guarantee the color, and anodize the jewelry again to the same or higher voltage.

The quality and consistency of the oxide layer formed largely depends on the quality of the surface finish. When we anodize a piece of jewelry, we sometimes do not get the result we want on the first try because Ti oxidizes in air after it is polished. The piece should be re-polished and steam cleaned to be anodized a second time. Etching should be avoided.

Getting a polishing wheel and a steam cleaner can be to your advantage when anodizing.

5) What are the benefits of an anodized surface? Pretty colors!

- Color choices with the option to pattern, complement and contrast
- Customize multicolor effects such as stripes, fades, rainbows, oil slick, polka dots, and more in seconds.
- Color code to more easily differentiate parts and sizes
- Form a cleaner, smoother, more durable and biocompatible surface by removal of microscopic embedded debris and passivation, according to the ASTM F 86 *Standard Practice for Surface Preparation and Marking of Metallic Surgical Implants*.

6) ⚠ Safety

- **NEVER** touch the anode to the cathode when the power is on!
  This may cause your electrical circuit to short out, and may cause you to receive an electric shock or short-circuit arc weld the jewelry.
- When your anodizer is not being used, shut the power off and put a cover over your submersion tank. Unplug the unit and remove the power cord if it will not be used for a long time.
- It would be a good idea for the anodizing station that you set up to be in a well ventilated area, as very small amounts of hydrogen and oxygen gases are a byproduct.
- Because you are dealing with electricity, the use of thick rubber or synthetic utility gloves not just exam gloves is recommended. I prefer to use neoprene or nitrile chemical handling gloves.
- Worn body jewelry can be re-anodized using disposable contacts, tank and cathode to isolate the biohazard. Both cathode and anode contacts can be made of Aluminium foil, and the tank can be small 2oz plastic cups.
- You should not attempt to polish worn customer body jewelry with a wheel. A single use polishing cloth should do the job to strip the old surface, or your customer can do it themselves at home with plain toothpaste and a motorized toothbrush or soft cloth if needed.
- DO NOT etch wear surfaces of body jewelry without extreme precaution, as it can make them much less smooth.

7) Useful Websites brnskll.com/shares/anodizing ||| fb.com/anodization ||| mrtitanium.com ||| reactivemetals.com

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Some frequently asked questions:

Do I need to use an ultrasonic to clean my jewelry before anodizing? No

Cleaning the jewelry with detergent, alcohol or a steamer first can help get the brightest results. If you anodize every piece to clean and passivate to the appropriate level of the ASTM F86 standard, you won't usually have to use an ultrasonic. Anodizing gets matter off the surface and cleans down to one millionth of an inch with oxygen, and may also neutralize endotoxins.

I anodize every piece of jewelry right before use so that the surface finish is free of debris that an ultrasonic alone can't remove. I rinse with a spray of distilled water or steam, then sterilize it with my Statim autoclave. I choose not to use an ultrasonic cleaner because the vibrations can damage the polish of body jewelry unless the pieces are disassembled and kept separated in non-marring cups or jigs.

- You can have your favorite manufacturers anodize everything immediately after polishing to the first low voltage light brown/bronze color before they ship.
- That makes sure it is all Ti or Nb, clean enough to anodize again, and seals the surface finish so that it does not oxidize in air with random crystals that interfere with high voltage anodization if it sits around in stock for a long time.

Do you find a stronger or weaker electrolyte solution works better for you? It depends on the goal

- **Stronger** solutions conduct electricity better and work well for lower voltages spectrum colors, however this will overexpose Ti at higher voltages, and you are more likely to have to do more polishing if you make a mistake.
- **Weaker** solutions slow the current so you can get higher spectrum colors, especially for anodic painting with a sponge or brush for high voltage effects.

I tend to make the solutions at 3 to 5% concentration of electrolyte to distilled water by weight and dilute if needed for anodic painting. Liquid TSP is the easiest I have found to mix with distilled water to make a clear solution, otherwise I mix the powdered electrolyte then let it settle. The solution does not spoil quickly, so I mix a gallon at a time. The solution should be filtered regularly to remove debris that sheds from jewelry, and discarded if it takes on an unusual odor or gets contaminated.

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How can I make multicolor patterns? Anodic painting /spot anodizing with a handheld cathode

Only the part of the jewelry exposed to the electrolyte will change color.

- Masking, such as an o-ring or bit of tape covering a piece of Ti will prevent anodization of the masked area and allow you to create patterns.
- Contact with an electrolyte moistened cotton swab, sponge, toothpick or paintbrush which is wired to the cathode can anodize spots, and be used to make fades, patterns, and oil slick effects.

  ⚠ Use heat shrink tubing, electrical tape or plastic insulation for handheld cathodes to prevent shorts.

What about black? For Nb only: heat treat to black with a blowtorch, followed by polishing