How to tell *if* a surface is coated, and *which* surfaces are coated

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Introduction

How can you tell which side of an optic is coated? Let's say you consult the print and it says Side 1 should be coated. So which is Side 1? Assuming your design team anticipated this question, you should be able to find an edge arrow, fiducial mark, distinctive bevel, or an asymmetrical configuration to guide you.

But there may be no indication. Even if there is, you may have reason to distrust it: Could the part have been marked incorrectly, coated incorrectly, or perhaps not coated? When you need an independent confirmation, you can use some simple "tricks."

Background: Surface reflections in general

The reflection from an uncoated front surface of any transparent substrate will be colorless at any angle of incidence. This is true of colored substrate materials as well. The front surface reflection from a deep ruby gemstone, for example, is water-white. It is easy however to get distracted by the colors coming from beneath the surface and you must be certain that you're looking at the first surface reflection. An uncoated rear surface may appear colored because of subtractive filtering from a coating or colored substrate in front. Conversely, when viewed in total internal reflection, the back surface may appear uncolored even if it is coated.

The brightness of an uncoated first surface depends upon the substrate's index of refraction. A metallic coating is far more reflective than any transparent substrate. Dielectric coatings usually have a distinct color and a different brightness (either greater or lesser) than the substrate.

Metallic coatings are absorptive and may be made of different layers. A silver coating, for instance may have a chromium binder layer and will look distinctly darker when viewed from the chromium side. A "protected" or "enhanced" metallic coating has a dielectric top layer and therefore shows some color change at high angles of incidence.

The various cases

The various cases can be grouped by coating type, substrate material characteristics, and substrate configuration.

The configuration may be

- Thick plano parallel
- Thin plano parallel
- Plano, wedged
- Curved surface(s)
- Multifaceted
- Buried coatings (as in prisms)

The substrate may be

- Transparent and clear
- Transparent and colored (as in filter glass or ZnSe)

- Opaque

And the coating type may be

- Metallic
- Dielectric

Clear thick plano substrates

Assuming a transparent substrate, how can you tell which reflection is from the front surface?

Hold the part before you below eye level and with its polished faces horizontal.

Look at the reflection of a diffuse light above and beyond the optic.

The top surface's reflection goes all the way to the far end of the top side.

The bottom surface's reflection is both shadowed and terminated by the edge before reaching the far end of the top side.

If the far edge is uncolored, the top side is uncoated. If the far edge is colored, the top surface is coated.

Remember that the back side may be coated or not – we're only discussing the top side.

For parts that have a coating mask so that the edge of the coating is not at the edge of the part, the previous method may not give an unambiguous answer or may take a more practiced eye. In this case hold something slim and handy such as a pencil or paperclip above and beyond the part to cast a shadow, and look at the shadow's double image. The farther shadow is reflected from the top surface and is filled with light reflected from the bottom surface. The nearer shadow is reflected from the bottom surface and is filled with light reflected from the top surface.

If the nearer shadow is colored, the top surface is coated.

Clear wedged plano substrates

Beware of wedged optics because they can reverse the relative positions of the shadows from top and bottom surfaces. To maintain proper separation of the shadows hold the thick edge toward yourself. Here's a simple way to find the thick edge: Look through the optic at a distant straight line like a doorframe, and rotate the optic in your hands. The image of the doorframe as viewed inside the optic will jog away from the thick side.

Clear thin plano substrates

In the case of very thin parts where you can't separate the surface reflections, you need another trick: If you wet a surface, an uncoated surface's reflection simply gets darker while a dielectric coated surface's reflection usually changes color (and may also change intensity, either lighter or darker). You can use a dab of alcohol that will evaporate quickly.

NOTE: A change in white light intensity on one side will change the SATURATION of the color visible from the other side. Don't let this fool you. If the wet side is dielectric coated, it will change HUE. Pink and red are different saturations; blue and green are different hues.

Metallic coatings on clear thin substrates

If the coating was made with a binder layer such as chromium against the substrate, the coating will appear noticeably darker when viewed from the back side. If the metallic coating is protected or enhanced by a dielectric overcoat layer, hold it up to a light at a high angle of incidence. A pale tint is usually visible on the coated side, while an uncoated surface remains untinted.

If you're still uncertain, a contact method will work. Simply touch the front surface near its edge with a nonabrasive pointer such as the back end of a plastic pen or the corner of a credit card or business card as you view the contact at an oblique angle with illumination beyond the pointer. You should be able to see a gap if the coating is on the back, even on very thin substrates.

> Note: Metallic coatings are easily scratched. If you *think* one surface is coated with metal but want to make sure, reduce your risks by contacting the other surface.

Clear curved substrates

If the optic has substantial lens power the reflections from the opposite sides will be noticeably different in size and may move in different directions as you tilt the optic. This should make it easy to identify which reflection is which. Choose a small source such as a single bulb and examine its reflection from the top surface for color. If the optic has little power and is thin, use the shadow method across its center.

Multifaceted clear substrates

Prisms and polygons can be especially tricky because of multiple reflections and total internal reflection (TIR). TIR can make a back surface reflection appear uncolored even if it is coated. Also, TIR reflections are so bright that they tend to mask other surface reflections. Try to find an orientation in which the surface of interest is in front and separated from other reflections, then look for color shifts with the several methods described above.

Partially transparent colored substrates

What if the substrate is not fully transparent? If it is colored, such as filter glass or ZnSe, turn the part over to study both sides one by one but only consider the top surface using the shadow trick. Even strongly colored filter glass has an absolutely white reflection from the uncoated side. Metallic coatings seen from the back side show the substrate's color.

Buried coatings

Beamsplitter cubes have a hypotenuse coating that looks the same from both sides. In most applications it will perform the same in either orientation. But for high power, or reflection of beams outside the visible band, or extremely critical wavefront requirements for the reflected beam, it may be important to avoid double-passing a glue layer.

The first tip here is to look for coating overspray on the hypotenuse outer edges. This will only occur on the coated half of the cube. If you have overspray on both halves, the prism was assembled incorrectly: Only one hypotenuse face should be coated. In the absence of visible overspray the situation is more problematic and outside the scope of "quick tricks."

Opaque substrates

When you can only see the front surface things are simpler if not always easier. If a germanium or silicon substrate looks green or pink, you can be sure you're looking at a dielectric coated surface. If you have a monochromatic light available, tip and tilt the opaque optic in front of it. A surface with dielectric top layers typically shows moving fringes or changes in intensity due to interference while an uncoated surface will not. (Luckily most visibly opaque optics are coated for the infrared and have thicker coating layers, enhancing this effect.)

But sometimes opaque substrates – quite reflective by themselves – are given metallic coatings. If the metallic coating is protected or enhanced by a dielectric overcoat layer, hold it up to a light at a high angle of incidence. A pale tint is usually visible on the coated side, while an uncoated surface remains untinted.

If you have a symmetrical opaque optic with both sides polished, an unprotected metallic coating, and the edge is not marked, ask yourself how you got into this mess. Then look for the margin of the coating. It usually shows up as a difference in brightness or tint along a well-defined borderline. Germanium, molybdenum and silicon are dark silvery, GaAs is a bit bluish, beryllium is yellowish, copper is reddish gold, silver and aluminum are mirror-like, and gold is, well, gold.

Conclusion

By applying a few simple techniques and naked eye observation, you can identify the coated side of almost any optic.