

Cleaning your Sensor

Are those spots you're seeing, or have the dreaded dust bunnies inhabited your camera?

This article applies to all Nikon-based digital SLR bodies (D1, D1h, D1x, D2h, D2hs, D2x, D2xs, D3, D40, D40x, D50, D70, D70s, D80, D100, D200, D300, S1, S2, S3, S5 Pro, 14n, 14nx, and SLR/n). It probably also applies to other DSLRs, as well, but since I don't test them I won't speak to applicability of this information for them.

New intro (please read): this page was first put up soon after the D1 came out and professionals started coming to me asking what those black spots they kept seeing in their images were. When Nikon essentially punted on cleaning ("don't touch your sensor"), I wrote the original of this page mocking Nikon with my famous Wendy's Knife cleaning trick. While my tongue was heavily in cheek with that article, the technique I described worked. Indeed, it worked better than any other solution on the market at the time and was copied without attribution by others, including at least one commercial product.

But a lot has changed over the eight years that we've all been shooting Nikon DSLRs. And today things are even more complicated than ever before (and Nikon still tries to disclaim in the US that you can clean your sensor by touch *despite* selling products that show you how to do just that in Japan).

With the introduction of the D300, we have yet another variant in cleaning: a camera that purportedly cleans itself. It does a modest job at that, but you'll still have to clean it by hand at some point. Moreover, all of the sensors Nikon uses now have a special tin oxide coating, which some claim can be removed by using the wrong products or techniques. Thus, I've revised this page once again. Please read it in its entirety, even though the basics are all boiled down into five simple steps in the middle of the article. *And away we go...*

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My legal counsel wants me to run even longer legal disclaimers than Nikon, but I'll keep it simple: **when you work on your own camera, you do so at your own risk. I try to provide accurate, useful information that reflects how I work, but I can't be held liable for what you do with that information. Use the procedures listed here at your own risk.**

Why do only some photos have dust spots?

Dust spots don't usually show up on your photos unless two conditions are met:

1. The dust is located over a bright area, such as the sky.

It happens to all of us: eventually you'll find an image that, on close inspection, seems to have gotten the freckles (see example, below). No, you don't have bad photosites on your CCD, you have dust on the filter that sits over the sensor.

Don't go trying to eyeball the dust on your sensor filter, though (I'll have more to say on that later in the article now that items like the Sensor Scope are available). Most small spots that show up on your lens are not visible to the naked eye (the largest Nikon photosite is less than 10 microns in size, and several hundred of those could fit on this hyphen: -. Or put another way: if you made your 6mp D70 sensor as big as a football field (100 yards wide) each individual photosite would be about an inch square in size. You're just not going to see an individual dust particle with your bare eye (though you may see bigger things, like hairs and pollens). Simple put, it doesn't take a giant glob of dirt to make your camera exhibit the dreaded spots--itsy bitsy and invisible dust particles can be just as annoying as something you can see.



A simple enough scene in Southern Utah. I was testing out a lens and thought the delicate clouds and fall foliage would give me plenty of detail to look at (they did).



I've brightened and enlarged the very middle of the shot. Now you can see the dreaded dust bunnies that had managed to sneak into my camera during a two-week Utah sojourn. I counted 63 in the sky area alone, so I probably had 100 or so little imperfections waiting to mess up my shots. Of course, the healing brush in Photoshop makes fast work of these annoyances, but still, who wants to spend all their time post-processing photos?

Conversely, black dust spots don't show up very well on a picture of a lump of coal (unless you really overexpose the coal!).

2. You use a small physical aperture. At $f/1.8$, the multiple angles at which light is hitting the sensor filter and the shallow depth of field work in your favor. At $f/22$ any dust spot will be pretty much be resolved in your image.

The Test

Want to be appalled by how much dust is already on your sensor filter? Using a physically small aperture (e.g., a big number, such as $f/16$), take a picture of a plain white surface (wall, ceiling, sheet of paper, whatever), open the shot in Photoshop and apply Auto Levels. Bingo! Assuming that your plain white surface was really plain and white, all that gook you see

You can't send your camera back to Nikon, Fujifilm, or Kodak every time you get a dust speck on your sensor. If you did, you'd pile up quite a freight bill and be without your camera for significant periods of time. And these days, those companies usually charge for the service, as well.

While Nikon Capture (and Capture NX) now has the ability to use a "dust reference" shot to remove dust from NEFs, this doesn't help you much with most JPEG images (this changed with the D200, which does allow JPEG dust reference photos, but you still have to process the image with Capture or Capture NX to take advantage of that). The Capture Dust Off correction is done similar to cloning (i.e. copying neighboring data) but automatically. One problem is that this can sometimes obscure fine detail (cloud threads). Nor does the Capture dust reference photo idea work well in the kinds of environments I shoot in, where the dust accumulation on my CCD changes daily (I'd have to take several reference photos a day and then carefully track them, adding yet more complexity to my already complex workflow). Finally, Nikon Capture has an upper limit to the number of dust bunnies it can "erase," and I've encountered plenty of situations where I exceeded those limits. So the dust reference function in your Nikon DSLR isn't going to help you much.

Eventually you'll come around to the decision we all have: that you've got to learn how to clean the sensor yourself.

Oh, one last thing: you're not really cleaning the sensor, you're cleaning the anti-aliasing and IR block filter that sits just above the sensor (on the Kodak DSLRs, this was just an IR block filter).

First, don't be put off by Nikon's disclaimers (both Fujifilm and Kodak endorse user cleaning that touches the sensor if done properly). The Lithium Niobate filter over the original Nikon sensors is somewhat difficult to scratch if you use the right tools (on the MHOS Scale of Hardness table that ranges from talc at 0 to diamond at 10, Lithium Niobate is a 5, the same as Apatite, and a bit lower than Orthoclase and Quartz; Fujifilm and Kodak don't identify the material they use [nor does Nikon on the latest cameras], but it seems just as durable). While it's possible to scratch the filter surface, it's also not at all easy to do if

is stuff sitting on top of your sensor filter.

But don't get too upset, as this is a worst-case test. Some of what you're looking at won't show up in an image. Your goal in a cleaning is to substantially reduce the amount of detail you see in this test. In other words, because of the way Auto Levels works, any imperfection is going to show up, so unless you have an absolutely perfect surface to shoot, Auto Levels will find something to exaggerate.

Orientation: upside-down, but not reversed right to left. If you see a spot on the upper left corner of your test shot, the dust that caused it is in the lower left corner of the filter of the sensor as you face it from the back of the camera (that would be the right corner from the front of the camera).

Welded Dust

you're using the right tools.

Recently, Nikon began using filters that have a special additional coating on them (Indium Tin Oxide, or ITO for short). This coating is there to help the filter "shed" dust more easily (it essentially blocks some of the static charge that can build up and attract the dust). As with any coating, it is possible to damage it, and when you do so, the filter essentially needs to be replaced. Here's the list of cameras that do and don't have this coating:

- ITO coating: D40, D40x, D70s, D80, D300, D2xs, D3
- No coating: D1, D1h, D1x, D2h, D2hs, D2x, D50, D70*, D100, D200

*Photographic Solutions lists this model as having an ITO coating, but I've not been able to confirm that. If you want Photographic Solutions guarantee, you should use E2 solution on a D70, though.

If you have a camera that has the ITO coating, Photographic Solutions says that you need to use a different liquid in cleaning it. More on this in a bit.

While we're on the subject of coatings, I should mention that if you've had an IR or other filter swapped in place of the regular filter, your cleaning methods may need to vary. Those type of filters are made with different materials and coatings than the antialiasing filter that came with your camera. Thus, they may need different cleaning methods. I can't offer any specific advice here other than to consult the company that provided your filter to see what their cleaning recommendation is.

With that background information out of the way, it's time to look at the tools we use.

While I used to recommend what has become a much copied do-it-yourself approach to the tools for cleaning using Methanol solution with PecPads wrapped around a flexible but stiff improvised holder (my original was a filed down Wendy's knife, but I've used Rubbermaid spatulas and art supply tools from Michael's, as well), advances in available commercial products made the DIY approach no longer necessary. Today, I recommend three products (and you need them all): a common blower bulb, Sensor Swabs (with methanol), and the Sensor Brush. Let's look at these:

This type of spot usually shows up after you've moved in and out of different humidity. The best explanation I can come up with is that it is caused by evaporation directly over the dust spot, which "welds" the dust onto the top of the filter material. In other words, the dust is no longer held just by surface tension, but has actually bonded to the surface. Pollens can be like this, too, as they are slightly wet to start with and can dry on the filter material. The telltale signs of welded dust are two: (1) you can't get it off with a Sensor Brush pass; and (2) in pictures they look like a small black spot with a vague ring around it (I call them dust pimples or dust zits, because that's exactly what they look like: a small blackhead that's forming on your sensor filter!). I've never seen welded dust appear in totally dry environs (such as Southern Utah), but you can make it appear in such places by moving your camera in and

The most common blower bulb people use is the Giotto Rocket, though there are a wide variety of such blowers available. A good blower is your first line of cleaning, as most casual dust can be dislodged by a few quick puffs of air. A couple of pieces of advice: some blowers have a lubricating material in them that essentially turns into dust. Not good to be using that to blow on the sensor, as you just increase the amount of dust floating around to get attracted back to the sensor. Also, keep your blower bulb clean and well maintained. Throwing it into a dusty drawer and letting it get caked with other materials is going to come back to haunt you. Keep it in an air-free case and clean. I personally use a Giotto Rocket that has been modified (a patent has been filed on this by its inventor, one of my workshop students, so don't go trying to commercialize the idea) by adding a Nikon lens cap to hold its tip precisely and very close to the sensor (but not touching it). This makes the air stream very forceful at the filter due to the close distance to the filter.

Sensor Swabs: these are a simple blade-like swab that you wet with Eclipse or E2 solution before swiping them across the filter to clean it. The original Sensor Swabs had a fatal flaw--the support mechanism behind the cleaning cloth was not reliable and allowed the edge of the cleaning surface to "break" (bend and reduce pressure, making it not clean well). Moreover, the support mechanism was relatively thick, and if damaged, could produce little plastic pieces that you had to clean up. No more. Photographic Solutions produced a new version that has a full, thin, plastic "blade" behind the cleaning material. It's now possible to maintain even pressure across the edge without it collapsing, even when very wet. The blade itself is a very soft plastic and can't really be forced hard enough to damage a sensor or filter surface. While you can't quite put as much pressure on the edge as with homemade tools, that's a good thing in most ways. The one problem it may create is for some so-called "welded dust" particles (see right column). But this is easily solved by making the Sensor Swab wetter than usual--which might leave streaks that you have to clean up by using another swab). On the plus side versus the home-grown method is that the Sensor Swabs are still made in a clean-room environment and come in sealed packs. Thus, they're ready to go on demand but you won't be having to worry about keeping your cleaning materials clean as you try to wrap them around a home-grown support mechanism. Yes, they're on the pricey side (US\$48 for 12), but you won't be using a lot of them because of the other tools you'll be using. Basically, you only use a Sensor Swab when you have a persistent dust particle that isn't removed by brush, or you have welded dust. Nikon and Fujifilm users need Type 2 Sensor Swabs, except for the D3, which requires Type 3; Kodak Pro 14n, 14nx, and SLR/n users need Type 3 Sensor Swabs. *Note:*

out of air conditioned places. I've had the toughest problem with welded dust in Hawaii, especially when going from high up on the volcanoes (dry) to a coastal area (wet). Condensation is also a factor in this case, so you can help by sealing your equipment in air-free containers before making the move.

Some History

When I first put this page up in 2001, it had much different advice on it, including my infamous Wendy's knife trick, which has now been morphed by others into Rubbermaid and Michael's variants, and was copied by at least one commercial outfit without giving due credit. My original Wendy's knife suggestion was mostly tongue in cheek ("eat at Wendy's, clean your CCD"): I was trying to poke fun at Nikon's reluctance in having users even *look* at their sensor, let alone clean it. But it was also a practical

many Sensor Swab imitations have appeared. Essentially they're all plastic support mechanisms with a lint-free cloth of some sort wrapped over it. While most of those others appear to work okay, I've simply never had a problem with Sensor Swabs, so continue to recommend them.

Sensor Brush: essentially a brush with extremely fine and soft bristles and no coatings. You use compressed air (or CO2, or a very strong foot pump) to charge and clean the bristles. You **must** clean the edge of the brush with air after every pass across the sensor. Light dust (in dry climates) is held onto the sensor by surface tension and static buildup, and what you're trying to do is break that bond and transfer the dust to another surface (the brush). Used correctly, the Sensor Brush works very well on most dust. Indeed, in a dusty, dry environment, it's usually the only cleaning tool I usually need. The biggest issue you face with this product is keeping your brush clean (the original Sensor Brushes come in a protective case; I'm not sure about the latest). The second biggest issue is that it can't remove dust which is welded; but that's why you bought Sensor Swabs, too. Unfortunately, Visible Dust seems to want to push their Arctic Butterfly (see below) these days and has stepped away from selling Sensor Brushes. You can still get an 8mm version for US\$42, but because it is narrow that means you'll need to do multiple passes on your sensor. Your other alternative is to get the Arctic Butterfly SD800 Pro Kit for US\$180, which includes the Arctic Butterfly and a DX and FX sensor sized Sensor Brush. Yes, that's pricey, but it pretty much has all the brushes you'd ever want or need.

What about the Arctic Butterfly? The Sensor Brush folk make several variants that have an electric motor in them to spin the brush to charge and clean the bristles (that way you don't have to travel with or have access to compressed air). The original version had two flaws, the newer version has one. The fatal flaw in both is that the brush blade tends to widen as you use the spin cycle to clean it. This makes it more likely that the brush touches the *sides* of the chamber around the sensor filter, and most cameras have a greasy compound in those areas that you absolutely don't want to transfer to the brush. If you choose to use a Butterfly, be very careful about what the brush comes into contact with, or else you'll have an even more difficult cleaning chore to deal with some day. Personally, I like the original solution better, but I realize that you can't travel with canned air, which led Visible Dust to the motorized solution.

suggestion, as my original descriptions showed you how to make a tool that fixed the original Sensor Swab's shortcomings. My unique ideas on this page were copied many times over (and almost never credited) by others who decided that my Wendy's knife suggestion could be improved upon.

Personally, when new commercial tools appear that allow me to retire my impromptu DIY solutions, I go with the commercial tools. In the case of Sensor Swab, that includes a guarantee against sensor damage. So I've taken all my DIY suggestions out of this article and now recommend the commercially available products instead.

I strongly suggest that you retire your Wendy's knives, Rubbermaid utensils, and wood concoctions. I have.

What About

So here's the full cleaning regimen:

1. If you've got a D300, regularly use the built-in dust cleaning mechanism. About once every shooting session and after any long period of disuse should be fine. Remember to hold the camera normally (sensor perpendicular to the ground) so that the dust falls to the adhesive strip at the bottom of the sensor chamber designed to catch the dust.
2. (For non-D300 users) On a regular basis, use your blower bulb to try to dislodge casual dust from the filter surface (camera should be facing down so that dust dislodged falls out of the camera through the lens mount). Do this in a clean environment and regularly, and you generally will get most of the dust dislodged this way without having to touch the filter.
3. Use a Sensor Brush whenever you need to remove casual dust the automated cleaning or blower bulb can't dislodge. Follow their procedures exactly; don't take shortcuts. Most of the time, this is enough cleaning to remove the offending dust.
4. If a Sensor Brush session doesn't remove stubborn dust, use a Sensor Swab wet with Eclipse (non-ITO cameras) or E2 (ITO cameras). Again, follow the manufacturer's procedures exactly. If you can't get Eclipse, water-free methanol will work on non-ITO cameras. On ITO cameras you need to get E2 or use another cleaner that isn't as strong as methanol.
5. If you still have a persistent dust bunny, you'll probably have to really wet a Sensor Swab (being careful not to wet it so much that the cleaning material breaks) and go over that spot again, perhaps with a gentle scrubbing action. This will likely leave streaks. If it does, let the sensor dry and then do another regular Sensor Swab of the sensor. Sometimes you have to do this sequence several times (wet pollens are no fun to remove).

If the above still leaves a stubborn spot, I think I'd let Nikon handle it. Their method of "scrubbing" uses a cleaning tissue wrapped several times around a small wooden stick (and wet with methanol), which allows them to put more pressure on the area being cleaned. But an amateur cleaner isn't likely to be very effective using this technique without putting his or her sensor filter at risk. Given that replacing a sensor filter can be very costly, since it requires dismantling the camera, that's just not something I'd even begin to recommend. So if steps 1 through 5 don't do it for you, send your camera in for a professional for

Automatic Sensor Cleaning?

A number of DSLRs now have so-called automatic sensor cleaning, including the D300. This first appeared on an Olympus DSLR, but now both Sony and Canon have their own variants. Does it work? Sort of.

If we're talking about the casual dust that I suggest using a Sensor Brush to remove, the Olympus system seems to work fairly well. The Nikon, Sony, and Canon systems don't seem to fare as well (I haven't tested the one in the 1DIII yet, though).

But if you get pollens, welded dust due to humidity, water drops on the sensor while changing lenses, or a few other types of things that require wet cleaning, the automatic cleaning methods don't work at all. In other words, if your sensor needed a wet cleaning, the current built-

cleaning.



A frame from the video that comes with Nikon's cleaning kit. Essentially, the wrap lens cleaning paper around a narrow wood stick. Nikon wets the tip of this "brush" and then uses the same technique on the CCD that they use cleaning a lens: a circular brush motion outward from the center of the item being cleaned.

In Japan, Nikon actually sells a cleaning kit (for camera body, lenses, *and* sensor). The kit contains training videos (see still image from one, above) as well as cleaning material. This US\$80+ kit (!) apparently is only sold in Japan, but it does provide guidance in cleaning a sensor using Nikon-approved methods (and the ones they use in their repair stations).

By the way, it'll probably take you a few tries with the Sensor Swabs to get it right. The usual mistakes I see from first-timers are:

- Too much liquid is used, and a streak is left behind. One or two drops is all that is needed most of the time.
- You don't start beyond one edge of the sensor's imaging area and swipe past the other edge, leaving dust at both edges.
- Swiping too gingerly, which tends to leave behind a few stubborn spots (and may even make them more stubborn as they've now been wet and start to act more like welded dust [see sidebar at right]).

in sensor cleaning systems are not an adequate substitute; you'll still need to do a wet cleaning.

- Not holding the support nearly perpendicular to the filter (I use a very slight tilt towards the side I'm moving towards), or lifting one side and leaving dust on the filter on that side.
- Trying to "rub" the filter clean (you tend to just move the dust around--once it is on the lint-free cloth, it can migrate back to the sensor filter if you use improper technique, such as not enough fluid, or rubbing motions; moreover, if you "rub" a really hard particle across the filter you can scratch it).
- Doing the cleaning in an environment where there is lots of dust in the air!

Here's a couple of added tips for cleaning:

- *Get a headlamp.* The Petzl LED headlamps work great, though you look like a geek using one to clean your camera. Using a headlamp lets you put light right where you need it, and even makes it easier to see the largest dust bunnies.
- *Minimize the time.* I try to keep the amount of time my sensor is exposed to light, especially bright light, to a minimum. That's not to scare you into thinking that if you leave your sensor exposed for five minutes that it'll produce poor color next time you use it; just that light accumulation to Bayer layer really should be minimized if you can. If you clean in a darkish environment using an LED headlamp and don't take more than a few minutes, don't worry about it. But don't leave the camera's shutter open while you walk around the house or office looking for your cleaning supplies, decide to have lunch, watch a football game, and then come back and clean your camera! (Besides, the longer you leave the shutter mechanism open, the more dust gets into the box that you'll eventually have to clean out.)
- *Don't worry if you can't see it.* A photosite on most DSLR bodies is between 36 and 64 square microns. You could fit several hundred photosites onto this hyphen: -. Thus, a dirt particle that covers a photosite or two can be very small--essentially invisible to the naked eye. That's just one reason why I discourage use of the Speckgrabber to clean sensors--you can only see the really big stuff.

Recently, we've had two so-called "sensor microscopes" introduced that you place in your lens mount with the camera set to the sensor clean mode. These LED-lighted devices have modest power magnification that allows you to closely examine the sensor surface. The Delkin version is less clear than the Visible Dust version, but neither are exactly great at picking out small dust. They are, however, reasonably good for checking for streaks after

cleaning, or for some exotic larger problems (like wet pollens adhering to the sensor surface). Personally, I don't find them worth purchasing: just do a regular, thorough cleaning and don't get anal about examining it! Besides, the longer you leave that shutter open, the more that dust in the air--and there will be dust in your air--will wind its way into the sensor area, and eventually onto the sensor.

There is one unique product that has made it to the market: Dust-Aid. This product is a sticky wicket (literally). You press it gently against the sensor and it pulls off the dust with its slightly sticky compound (supposedly tested to insure it won't leave any residue behind). As such, it's a substitute for the brush type cleaning you normally do.

Finally, the question that sometimes comes up: what do you do if you actually damage your camera during cleaning? First, make sure you've actually damaged it. I've had a number of people show me cameras they thought had damaged filters from cleaning that simply turned out to be either very persistent particles (in one case, a very sticky pollen), or simply had residue left behind due to a botched cleaning. If you live nearby a Nikon repair center, you can ask them to clean the sensor (more often than not these days, they'll charge for that). But if they hand you back the camera and say that you do have a damaged filter, then your choices are these:

- *Go topless.* Have someone remove the filter. You'll actually get sharper images this way, but on many Nikon bodies, you'll need to shoot with a hot mirror filter to avoid near IR pollution in colors.
- *Head up-spectrum.* Ever wanted an near-IR capable camera? Well, in the process of converting those cameras, they remove the regular filter and replace it with a near-IR filter. Thus, your problem filter is no longer a problem.
- *Replace and learn.* You haven't actually damaged your sensor, which is usually the most expensive part in your camera. The bad news is that disassembling the camera to replace the filter is not a 10-minute job, and requires someone who knows what they're doing. That means NikonUSA, [LifePixel](#), or [LDP](#) here in the US.

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