

Circuit Edit Tips and Tricks

Kimball Skinner, Circuit Edit Specialist

Circuit editing is a complicated process that requires precise skills and the confidence to use them without hesitation. You'll find that there isn't one single way to do anything in circuit edit.

This paper will cover the following six tips to help you become a more confident and successful circuit editor:

1. Prepare for the Edit
2. Use the Right Charge Control Method
3. Use Reference Marks
4. Control Metal Exposure
5. Try Defocusing
6. Be Consistent

To keep improving your skills and confidence, it's important to view each edit as a learning experience, and to practice whenever possible. Work on expanding your knowledge of your tool's functions and how they can help achieve various aims.

Prepare for the Edit

Preparing for an edit is important to improve flow and increase success. Good preparation prevents mistakes on complex edits, which require more attention to the sequence of activities, and allows you to move quickly through the system without constantly making minor tweaks that can cost frustration and time.

Figure 1 shows an example of a step-by-step edit flow strategy. Edits are typically received in the form of instructions for the various components or a schematic describing the designer's intent. Creating an edit flow strategy like the one pictured, or even just listing the edit locations in logical order, improves your throughput and efficiency. It prevents errors such as depositing a metal trace over a future cut by ensuring

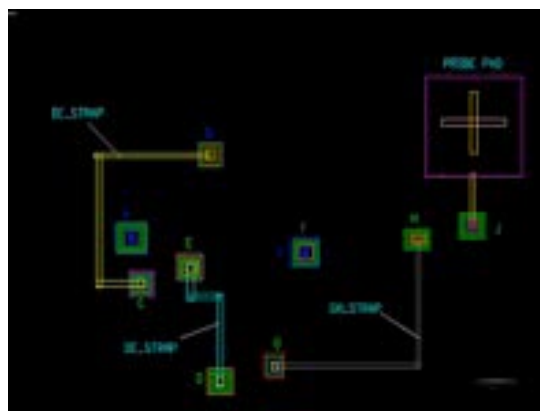


Figure 1 – An example of an edit flow strategy.

that all connections have enough space around them to avoid interference with adjacent or future edits.

Once your game plan is set, the next step in preparation is to make sure your system is tuned. Going from aperture to aperture should not require extensive focus and stigmating. Make sure your column is aligned, lens tables and offset calibrations are set, and gases are prepped and ready to go. Having the system perform as designed will aid in a better and more confident session.

Use the Right Charge Control Method

Today's shrinking geometries and more sensitive materials make charge control increasingly critical. More dangerous than the mere inconvenience they once were, charge control problems can ruin the device—and waste all the time you've invested working on it.

Three alternative methods for preventing charge problems are: use hardware, rely on chemistry, and bring in additional systems.

The first method involves using a charge neutralizer, also known as a flood gun. It is extremely efficient in removing the surface charge caused by positively charged gallium ions by flooding the area with electrons from a tungsten source.

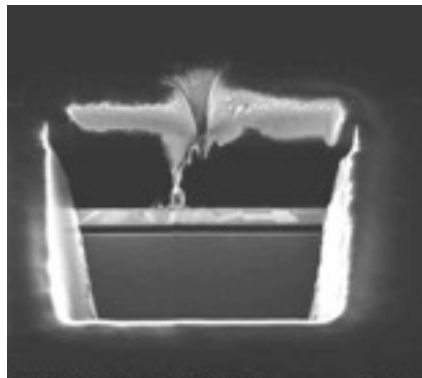


Figure 2 – Cross-section of an ESD event.

To use a charge neutralizer, you must have an imaging detector that can also detect secondary ions, because the additional flood of electrons will interfere with secondary electron detectors.

Another method is to deposit a thin film of focused ion beam (FIB) metal over the edit area. You must open a signal or use a nearby probe pad to provide a path to ground for the deposited film. This technique is effective, but as you progress you may have to reapply your film as it degrades from the edit processing. It's also important that you clean the area afterwards.

Lastly, with the support of a carbon sputter tool and a plasma etcher, you can sputter a coating of carbon on the entire device to provide a path to ground. After the modification is complete, you'll need to protect the edit areas and use a plasma etcher to remove the deposited carbon.

Use Reference Marks

No matter what your navigational accuracy, a good operator always double-checks for accurate pattern placement. Every time you switch apertures or insert and retract a nozzle, you are introducing an external interference to your detector that causes the image to shift. The trick is finding a way to do this without having to repeat the timely alignment process over again.

By planning ahead, you can etch or deposit a feature, such as a box or X, which you then can use to quickly and confidently reposition your edit pattern to the correct location.

This is critical, for example, with complex multi-layer edits. As shown in Figure 3, an etched mark can help you align each layer after switching apertures or changing gas chemistries during deprocessing. The key is to maintain the relationship between the reference marks and the edit pattern. That way, as you move from top to bottom, you can be confident that you are aligned correctly without having to redo your alignment for every changing condition.

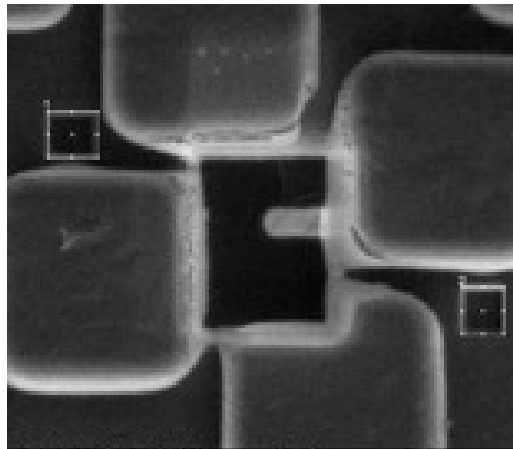


Figure 3 – Example of reference marks.

It's also a good practice to save your pattern relationships using the export or save function—just in case you accidentally change that relationship.

Control Metal Exposure

With the edit now planned and located with a reference mark, it's time to switch to the beam current appropriate to the metal exposure. The tendency is to intensify the contrast in order to see the metal line, but the best way to get a clear metal exposure is to control the contrast level.

The amount of secondary electrons actually increases before you reach the metal, due to the interaction depth of the beam. It is important to know this and to reduce your contrast level as you approach the metal line. Often you will see the overlying nitride or Ta-nitride melt away after reducing your contrast.

For hard-to-see features, you can use a secondary electron endpoint graph. It will show a rise and short decline before rising again when the actual metal line is exposed. This can help prevent the kind of misfortune shown in Figure

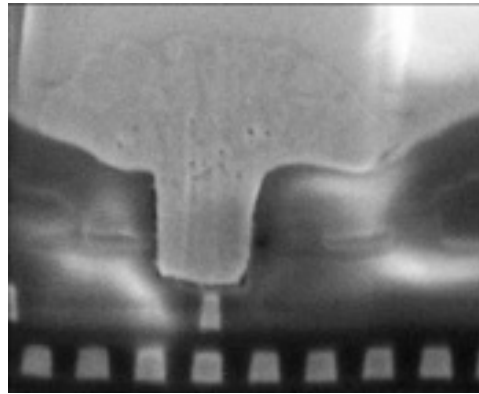
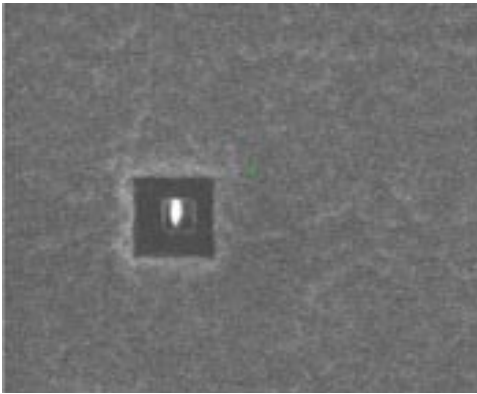


Figure 4a and 4b – Metal exposed with contrast too high. 4b shows the cross-section of underexposed metal.

4a and 4b, which show an over-contrasted exposure and the resulting cross-section performed after testing proved the edit unsuccessful. Being aware of your contrast level gives you more confidence for future activities.

Try Defocusing

Tangential to metal exposure is to use defocusing as a technique to aid your editing. As shown in Figures 5a and 5b, shadowing is a common image defect for single-source gas delivery systems.

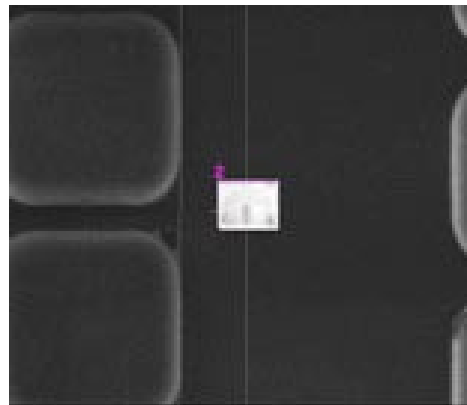
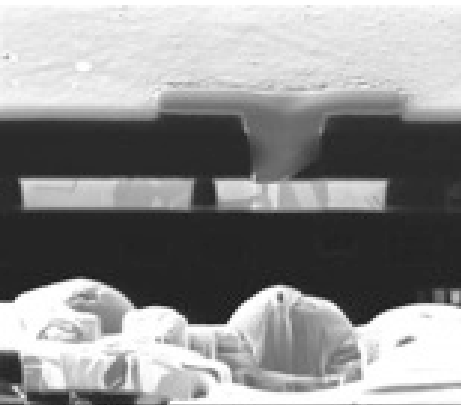


Figure 5a and 5b – Examples of gas shadowing artifacts. Figure 5a shows a cross-section of a metal exposure, and Figure 5b is the live patterning of shadowing artifacts.

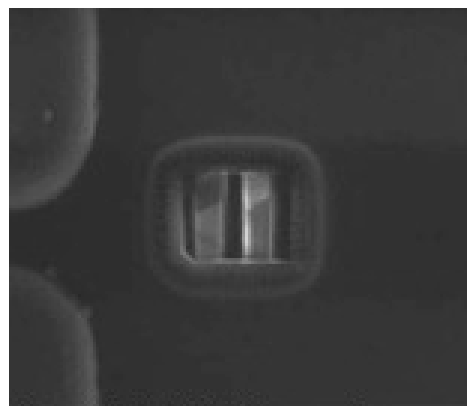
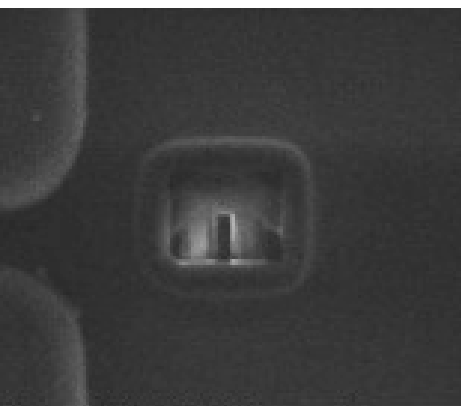


Figure 6a and 6b – Contrast adjusted metal exposure showing gas shadow artifact. Figure 6b shows metal fully exposed using defocus to prevent metal damage.

With the contrast turned down, as in Figure 6a, you can see that the metal is not fully exposed. To continue would actually begin to etch the metal already exposed while trying to clear the remaining dielectric.

Turning down the focus slightly effectively reduces the beam's current density. This results in less direct sputtering and more gas enhancement. As you can see in Figure 6b, the metal that was initially exposed remained relatively undamaged while the remaining area was exposed. This was due to defocusing, which uses the XeF₂'s selectivity over the dielectric to reduce the sputtering of the metal.

Defocusing also works well to expose larger areas and increase the metal deposition rate. If you use metal film deposition for charge control, try increasing the beam size, defocusing, and increasing your throughput. Defocusing lowers the sputter yield with a lower beam density and enables you to deposit the charge-dissipating film faster.

Be Consistent

Another key to success is to execute each activity the same way every time. Consistency prevents surprises and gives you the confidence to operate without second-guessing your actions. For example, use the same brightness level and field of view for each same type of activity. This provides you with a baseline of what to expect when performing similar tasks on different samples.

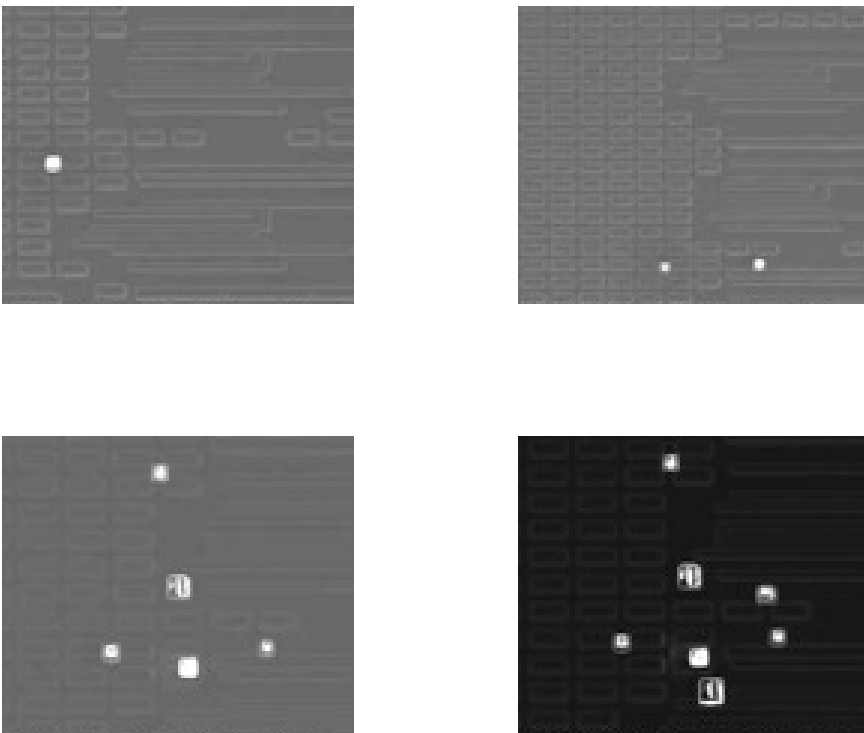


Figure 7a-d – Example of an edit becoming more and more complex and higher in perceived value as a result of time invested.

As illustrated by the images in Figure 7, a circuit modification becomes more complex over the course of the edit simply because there are more locations to modify. It's another example of why it's key to be methodical and process-driven, because by the time you get to Figure 7d, making a mistake would be unfortunate.

Even for simple edits, samples and prep time are valuable, and you don't want to lose them by taking shortcuts or experimenting with new techniques. You want to get all the practice you can—but on a live edit, consistency is key. Stick what you know best, and do it the same way every time.

Conclusion

It's been said that circuit edit can be three hours of boredom followed by three minutes of sheer terror. It's how you act during those three minutes that defines you as an operator.

Good circuit edit operators have a certain confidence that is sometimes misconstrued as arrogance. This confidence comes from being diligent, paying attention to detail, and really studying the tools at your disposal.

Each time you have to pause in a pattern because you aren't sure what you're seeing, you risk compromising your activity, wasting valuable time, and lowering your confidence and that of those around you.

Following the tips in this document and expanding your knowledge will help increase your confidence, along with your skills as a circuit edit operator.

© 05/2008

03WP-FI0211

FEI Company

World Headquarters and
North American Sales
5350 NE Dawson Creek Drive
Hillsboro, OR 97124-5793 USA
Tel: +1 503 726 7500
Fax: +1 503 726 2615

fei.com/sales

European Sales
Tel: +31 40 23 56110
Fax: +31 40 23 56634

Asia-Pacific Sales
Tel: +86 21 6122 5988
Fax: +86 21 6122 5999

Japan Sales
Tel: +81 3 3740 0970
Fax: +81 3 3740 0975

