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Machining tiny ’trodes can be a big challenge

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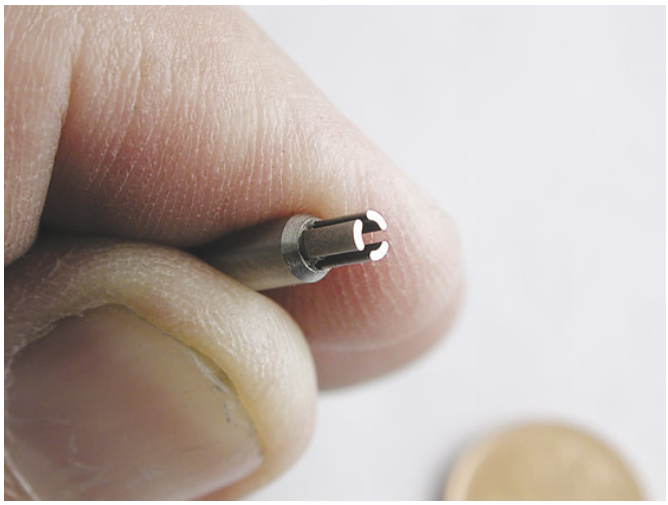
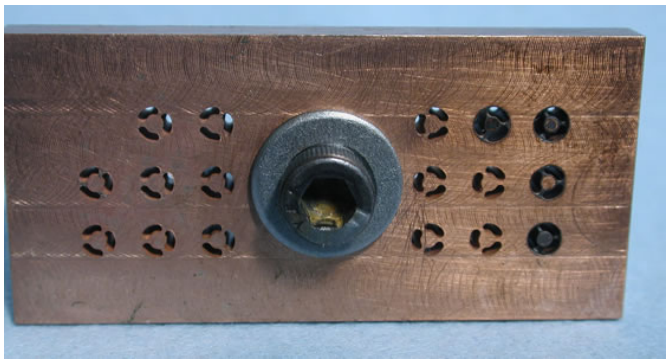
Figuring out micro-sinker-EDMing is no easy task. As electrodes shrink, challenges grow, including maintaining the proper spark gap, minimizing electrode wear and determining the correct power settings. Plus, experienced EDMers know that using graphite electrodes can turn your hands black.



This punch is an off-the-shelf blank with the profile burned into the end with a technique Implant-Mechanix Inc.’s Marcus Carius uses for small gears that can’t be wire-cut. The technique, often called “reverse burning,” consists of the electrode being made as a set of female cavities, the opposite of a typical sinker-EDM operation. All images courtesy Implant-Mechanix.

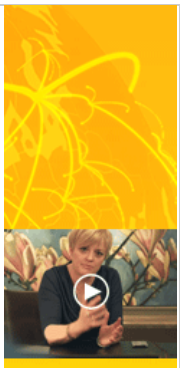


This wire EDMed electrode is for reverse burning the punch. For a burn like this, cavity spacing must be precise so that each burn can be made in succession without repositioning the workpiece. Running out of cavities before completing the final burn is a big problem, so too many cavities is better than too few.

But the challenges are worth it because micro-sinker-EDMing has a really big upside: “The whole point of sinker-EDMing is to machine parts you can’t get any other way—that means parts with features requiring crazy aspect ratios, steep-angled walls or sharp internal corners,” said Marcus Carius, proprietor of Implant-Mechanix Inc., Vancouver, British Columbia. “Any time that cutting the electrode would be far easier than machining the part itself, that’s the [deciding] factor for EDM.”

But, as Carius noted, burning parts with a sinker-EDM is often only half the battle. Just making a series of electrodes to produce a mold cavity or tooling component is an art. This is especially true when making electrodes for microparts.

Choosing the right electrode material—such as graphite, brass, copper or tungsten, among others—can mitigate some of those challenges, but the selection process itself can be a guessing game. While the guidelines for applying macroscale electrodes are well known, the rules for micro-EDM are a bit like predicting the next World Series winner.



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Even then, those with a solid understanding of EDMing might choose to ignore conventional wisdom.

Carius admits to doing some things unconventionally.

One of them is to not machine small electrodes from graphite. He opts for copper instead. "Graphite smells really bad when cut, and it gets into everything. If you don't set up properly for it [including covering machine ways and evacuating graphite particles], you come home with nasty, black powder up your nose. That's why I made a business policy to avoid graphite except for work ½" square or larger, where the amperage is high and when you need to remove a lot of material."

If you're questioning his judgment, Carius defends his choice of material for small electrodes. "If I make a small part with a 0.02"×0.05" burn, for example, copper works well enough to accept its limitations."

Machining copper won't blacken your nose hairs, but it does present other problems. "You cut an electrode in copper and it's lousy with burrs," Carius said. "This means running the toolpath several times to remove the burrs. Then I may still have to spend time deburring under the microscope. It can be very time-consuming."

Carius uses tellurium copper (telco) almost exclusively. It's easy to machine and holds up well in most micro-EDMing applications.

But he admits that, below a certain size, telco fails. Carius said: "If you're burning a 0.01" rib and hope to hit a 20µin. Ra finish, telco wears out quickly. It can't handle very low (or very high) amperage without excessive wear. Because of this limitation, your choices are limited to either ultrafine-grain graphite or a tungsten alloy on very small burns like this."

Right recipe

Someone who knows which electrode material works best for micro-EDMing is Mark Raleigh, CEO at EDM Department Inc., Bartlett, Ill. But good luck getting specifics out of him.

"Micro-EDM is about 50 percent of what we do, and our processes are proprietary," he said. "I will tell you this: The biggest problem we see is that neither the workpiece material nor the electrode hold up well when micro-EDMing."

As a result, EDM Department uses a handful of different graphite materials and at least a dozen alloys for its micro-electrodes. "We don't use just one type on a job," Raleigh said. "That's something many shops overlook. Different materials work better at certain stages of the process." This means a low-density graphite electrode would be used for roughing and a micrograin graphite or copper electrode for finishing.

This fragile telco electrode was made on a rotary-axis wire EDM because the process is burr- and stress-free.

Raleigh said his shop analyzes several parameters when planning a job, including workpiece material and part quantity, geometry and tolerance. "You also have to consider the electrode machining time compared to the total burn time," he said. "Historically, the electrode cost comes in at around 50 percent of the total job, but with micro-EDMing, the ratio can be as high as 70 percent, primarily because you're burning less material."

For that reason, designing an effective micro-electrode strategy is crucial. Where electrode performance is sensitive to part shape and material at the macroscale, it's hypersensitive at the micro level. Raleigh said: "The world's consumer products are evolving. Because of that, we're burning things we didn't think possible before: pillars 10µm across and pockets [down to] 20µm. At that size, the [material's makeup]—not only of the electrode but also the workpiece itself—make a big difference. Sometimes it's a challenge getting things to behave in the micro world."

Mind the machine

Another area where behavior is important is the machine tool. Even the perfect micro-electrode

will fail if the wrong power settings are used or if the spark gap is too large.

Viteris Technologies LLC, Salt Lake City, designs and builds small specialty machines, including wire and sinker micro-EDMs. One micro-EDMing process the company's president, Eberhard Baumberg, has a lot of experience with is small holemaking. Using a centerless-ground tungsten rod for an electrode, his machines can form holes down to 12µm in diameter and with aspect ratios upwards of 30:1.

"I really like tungsten," he said. "It has good mechanical strength, fantastic melting temperatures and the erosion rate is relatively low—a good combination for making really small stuff."

Power control is key to micro-EDMing. "Our peak current is a couple amps, which is much less than that of a production EDM," Baumberg said. "With a large commodity machine on high power, you would literally blast a micro-electrode away."

Baumberg explained that a micro-EDM uses a much lower power setting. Low power means the electrode is much closer to the work material during the burn than when the power is high, so maintaining the correct spark gap can be challenging since it requires extremely fine motion and accurately determining the distance the electrode is from the workpiece.

Sinker-EDMing, once a crude process to remove broken taps, is now precise and well-accepted. Typically, any shape imaginable can be burned, provided you can mill, turn, grind, EDM or otherwise machine that shape's mirror image into an electrode. But however you make your 'trodes, beware: The smaller they are, the more challenging the burn will be once the sparks fly. µ

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