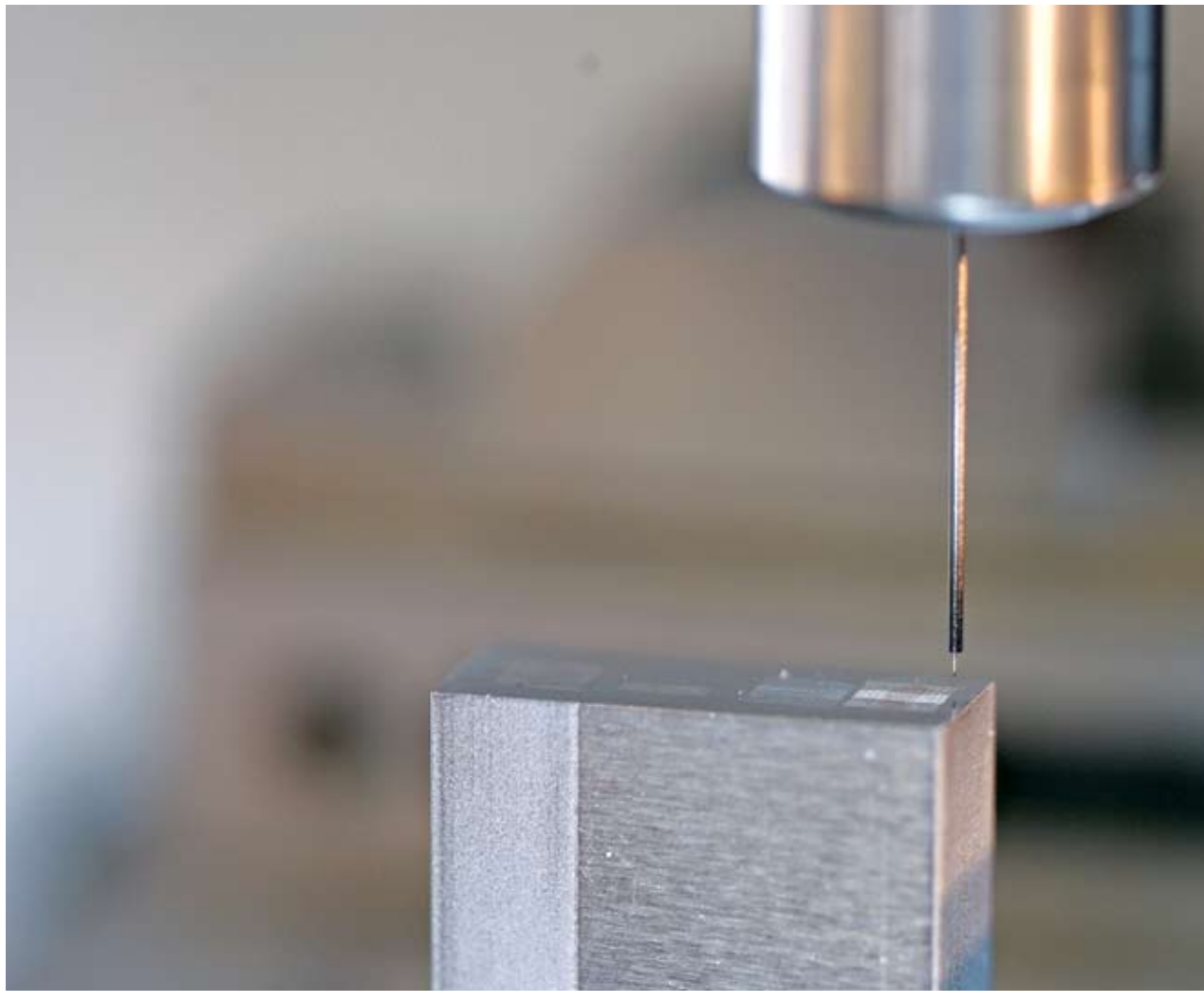


Dress for Success

By Alan Rooks,
Editorial Director

There are several ways EDM builders and machine shops can make micro electrodes for sinker EDMs. One popular way is discharge dressing.

An EDMed microhole or a microfeature is only as good as the electrode that burns it. That simple statement is why EDM manufacturers and shops performing sinker microEDMing have developed several methods to make precise, high-quality miniature electrodes.

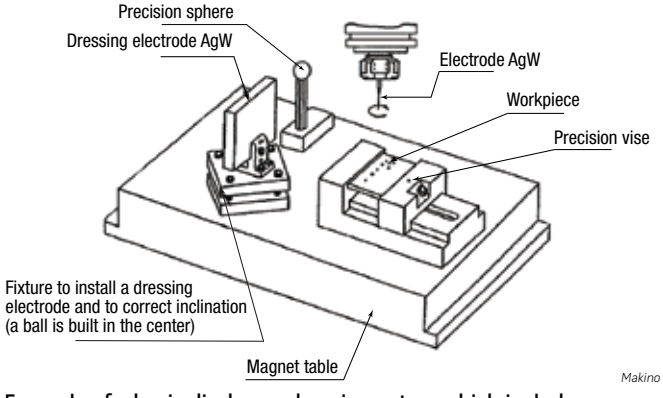
Electrodes for sinker EDMs are made of many different materials that are ground, milled, extruded or discharge dressed. The machining process depends on the electrode material and what the electrode will be used for.

Discharge Dressing

John Bradford, micromachining R&D manager, Makino Inc., Lacey, Wash., noted that when EDMing parts smaller than 1mm×1mm and part features smaller than 0.1mm×0.1mm, the challenge of electrode-shape preparation becomes quite significant. These difficulties revolve around the electrode materials and their resistance to traditional means of machining and shaping. These materials may include copper tungsten, copper, silver tungsten, tungsten carbide and graphite. Also, holding the materials during the machining process, where

A Sodick AE05 micro sinker EDM in use at Advanced Research Corp. The electrode, held in a collet, is machined and measured in situ on the machine.

ARC



Makino

Example of a basic discharge dressing setup, which includes spindle-mounted electrode (silver tungsten); table-mounted workpiece in precision vice; dressing block (silver tungsten); and precision sphere used for automatic measuring of the dressed electrode.

vibration and heat generation are ever present, can be difficult. Workholders can include V-blocks, vises, collets and specialized integrated tooling systems.

As a result, Bradford recommends discharge dressing to make micro electrodes for sinker EDMing. "To make electrodes for microEDMing 3-D features, the best approach is discharge dressing," he said. That involves machining a dressing block made of copper tungsten, silver tungsten or steel to create an electrode profile in it, and then using a sinker microEDM in CNC milling mode to create the mirror image of the dressing block in the workpiece (the process can also be used for making parts). The dressing block is typically produced by surface grinding, wire EDMing or milling.

Discharge dressing is accomplished by mounting the electrode in the sinker EDM and moving it in one direction next to the dressing block, allowing the discharge process to erode the desired shape in the electrode. Typically, the electrode is mounted in the C-axis, the dressing block is mounted on the machine table and the EDMing takes place along the X- or Y-axis.

There are several ways to accomplish discharge dressing, according to Bradford. "Essentially, you are preparing a reverse form of a near-final feature in the dressing block," he said. "The formed dressing block can be used, for example, to put a radius profile on the tip or the edge of the electrode. Then you can use the CNC sinker microEDM to discharge dress. We set our cutting parameters to take more material off the final electrode than off of the final dressing block." Ideal wear ratios are 50 percent or less, relative to the amount of material removed from the spindle-mounted tool, he said. For example, if 0.100mm is to be removed from the spindle-mounted device, then dressing block wear should not exceed 0.050mm.

Makino recommends using silver tungsten or copper tungsten for electrodes produced through discharge dressing. Conventional machining techniques, such as grinding or milling, may leave edge burrs or impart rough surface finishes, said Bradford. "Discharge dressing eliminates issues related to setup, tool runout and tool positioning error because the electrode is produced using the spindle of the machine that the electrode will be used in," he said.

Bradford noted that Makino sinker EDMs have a wire EDM option that can use a feeding wire that runs horizontal or parallel to the machine worktable to either machine a workpiece mounted to the spindle or to discharge dress the electrode. A CNC guide arm holds the tip of the electrode or part in place while the machinist dresses against the wire or a dressing block.

Bradford noted that two customers are currently employing this option to make parts by using guide arms in Makino sinker microEDMs to hold a workpiece in the spindle. "If they are EDMing a long core pin, ejector pin or some other small-diameter pin that might need a very small detail on the end of it, they will actually invert that pin from the spindle, run it through the guiding device, move it to the traveling wire and use the wire attachment to machine the part," he said. "They can also use the C-axis to rotate the part to go to a new angle or location on that pin, all in an automated fashion." The process serves as a replacement for traditional manual grinding processes—particularly for materials such as tungsten carbide, which is difficult to grind, said Bradford.

Gisbert Ledvon, business development manager for GF AgieCharmilles LLC, Lincolnshire, Ill., agreed that discharge dressing is the preferred way of making electrodes for sinker microEDMs. "Even if you can make the electrode by other means, it's always difficult to clamp it," he said. "If you turn or

spin the electrode on the die sinker and it is not perfectly concentric, it will not be easy to properly align the electrode."

The discharge process, however, creates a perfectly concentric electrode, he said. "You can make electrodes down to 0.03" in diameter and they come out perfectly aligned."

The discharge dressing process can be automated, an essential feature for high-productivity EDMing. "If you have a toolchanger, you can mount multiple electrode rods in the toolchanger and leave the carbide dressing block on the table so that you can redress the electrodes at any given time," said Ledvon. "You can write a program to call up the carbide technology on the CNC and run the electrode along that carbide to dress the electrode, cut the parts, bring the worn electrode back into the toolchanger, pick up the next electrode, dress it and so on. You can run this completely unattended." GF Agie Charmilles' discharge dressing option uses tungsten-to-carbide technology with reverse polarity to create more wear on the electrode.

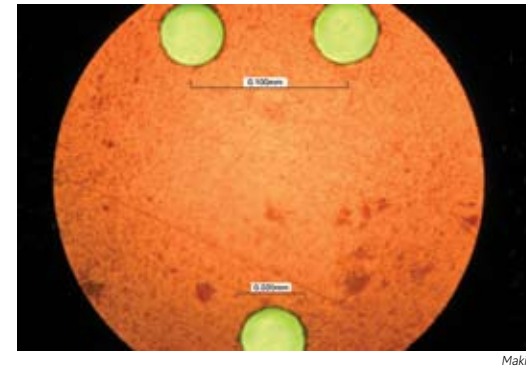
Dressing During Operations

In addition to using automated dressing to create electrodes for sinker microEDMs, the ability to automatically dress electrodes during EDMing operations is also critical, according to Graham Ruck, sales and application manager for Leer Technologies Inc., Hudson, N.Y. Leer is the Northeast U.S. representative for Switzerland-based Sarix SA, which builds microEDMs. For sinker microEDM dressing applications, Leer recommends using pure tungsten or tungsten-carbide electrodes. "Pure tungsten is a solid rod and tungsten carbide is available either as a tube or a rod," he said. "You can typically produce a tube electrode down to about 85 microns OD, but below that you have to go to a solid rod."

In holemaking, dressed electrodes are typically about half the size of the holes they are designed to make, according to Ruck. For example, an electrode would need to be dressed down to about 5µm in diameter to generate an approximately 10µm hole. Sarix sinker microEDMs have an automated wire EDM dressing feature for rotating electrodes. This eliminates the problems of handling and mounting a small electrode on the machine, according to Ruck. "You end up with a perfectly concentric electrode after you've dressed it," he said. In Sarix sinker microEDMs, tube or rod material is typically applied in 6" to 12" straight lengths. The dressing process is applied to a ¼" tip of the electrode.

While Sarix machines can use tube electrodes down to the 85µm OD limit previously noted, "We wouldn't necessarily choose to use the very small end of the tube range unless we really had to because they become exponentially more expensive as the size goes down," said Ruck. "Also, the smaller you go, the more handling and feed problems you have. If your hole's depth-to-diameter ratio is not that high, it will be a lot easier to use a solid electrode—they are much cheaper and easier to handle."

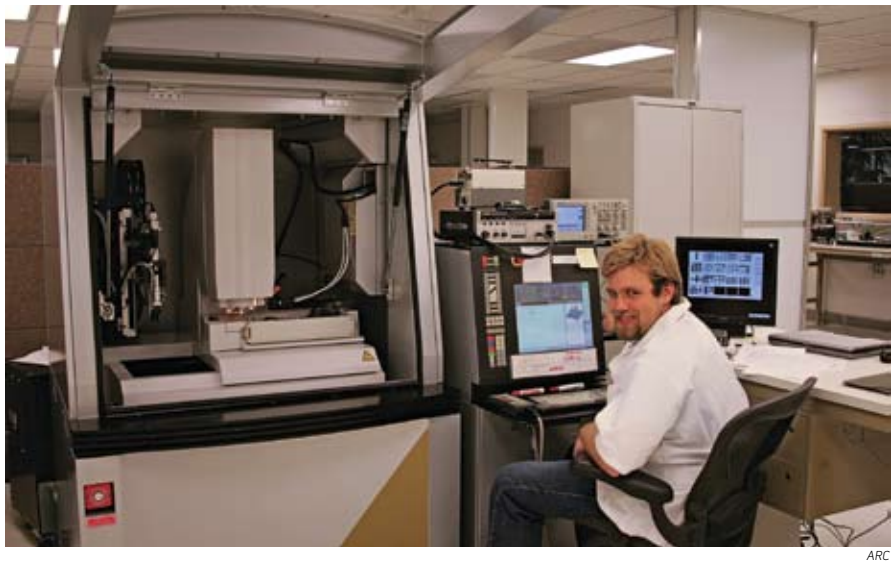
Still, tube electrodes do offer significant advantages when EDMing because the operator can flush dielectric down the center of the tube and into the spark gap, which allows for faster machining at a higher depth-to-diameter ratio. "You get flushing directly at the cutting point, which tends to drive the electrode into the hole instead of just relying on gravity," said Ruck.



Makino

An electrode prepared by the EDM discharge dressing method was used to produce 0.035mm-dia. holes in 0.100mm-thick tungsten carbide. Cycle time was approximately 3 minutes; hole roundness and location was less than 1µm.

While Sarix has not yet used the wire dressing function on tube electrodes, it may be possible provided that the tube has a sufficient amount of wall section. "If you had to make an other-than-round-shaped hole, such as a triangle, to some depth, you could perhaps use



ARC

Machinist Dave Swanson operating the Sodick AE05 sinker microEDM at ARC. The machine is in a clean-room environment that also includes three ARC electronic microscopes. ARC makes its own electrodes for the AE05.

the dressing unit in conjunction with a positioning rotating spindle, which would make the electrode into the shape that you need and you would still have the center hole there for flushing," said Ruck. "Obviously, you would need to carefully consider the geometry because you're not talking about a very big tube. If you dress three sides, you would have to be very careful that you don't break into the tube bore."

Other Processes

Other methods, such as extruding, traditional grinding and wire EDMing, are also capable of manufacturing micro electrodes. For example, National Jet Co., LaVale, Md., a contract shop and microtool manufacturer specializing in microholemaking, has developed a proprietary process for making electrodes. "We use, in many cases, pure silver. It is not cheap, but it is a very good conductor," said Ben Odom, general manager of National Jet. "It's malleable enough to make into the different shapes that we need." The electrodes are made by extruding silver through a small die to make the desired shape in 12" lengths. No additional machining is necessary. The electrode is mounted in a stainless steel cartridge and pushed out of the tube automatically as the electrode wears during holemaking.

Another material National Jet uses to make electrodes is tungsten carbide, including C-2 micrograin carbide. "We use a lot of C-2—it offers good conductivity characteristics and it is a very stiff material, so we can burn a little bit deeper hole with it," said Odom. He said that a hole with a normal length-to-diameter ratio is about 7:1, with deeper holes having a ratio of 10:1.

"Since C-2 is rigid, it doesn't bounce around as much as softer materials. You get a rounder hole with a better shape and finish," said Odom. He added that it is relatively easy to grind round electrodes from C-2, which can also be ground into rectangular, square and triangular electrodes. The nonround operations are more challenging because the electrode has to be positioned a number of times. Also, the different shapes create new edges to contend with in terms of radii, sharpness of edge and tolerances on the angles and flats created by these different shapes. "On a round electrode, the attributes are just how round and how long—there are none of the other things to worry about," said Odom.

National Jet does two to four mechanical rotations of the electrode to generate the shapes. The shop is limited to making square electrodes larger than 0.001" due to the pressure from the grinding wheel.

Making electrodes doesn't always have to be a challenge, however. "We produce mostly round holes, and if that hole is of a certain size we can use an off-the-shelf straightened tungsten or tungsten-carbide round wire that can be fed automatically," said Odom. He noted that

off-the-shelf electrodes are usually no smaller than 0.0035" in diameter, which normally yields a hole of about 0.005" in diameter.

"A single electrode can sometimes burn as many as 1,000 holes if the depth of the hole is 0.020" or less, he said. "The longer the hole, the smaller the number of holes it will do. Each time we burn a hole, we change the polarity of the wire and dress it to get rid of the irregular, worn end so we can get consistency from hole to hole. When we burn a hole, we are normally on negative polarity, and when we dress the electrode we are normally on positive."

While automated dressing is a key feature for productive microholemaking, not all of these processes run unattended, said Odom. "With some jobs, even though they are running on a CNC, you still have to constantly observe it. If we're working on a $25,000 blank, we can't take a chance that the machine will improperly feed the electrode or improperly dress it, so the operator has to be there to intervene immediately. In cases like these, the operator is observing the spark and the hole under a 50x microscope at all times."

When it needs to create its own carbide electrodes, National Jet uses custom processes to grind the workpiece, typically from a 0.040"-dia. shank. It also grinds 3/32"- or 1/8"-dia. shanks. "We can grind any round diameter if the length-to-diameter ratio does not exceed 15:1," said Odom. "If it gets longer than that, the thin electrode will want to deflect away from the pressure of the grinding wheel, and if the workpiece is carbide it usually just snaps off."

Designing and making electrodes for sinker microEDMs is indeed critical to the success of EDM operations, according to Marlow Roberts, vice president of Advanced Research Corp. (ARC), which is in part a contract micromachining shop in White Bear Lake, Minn. About 18 months ago, ARC purchased two Sodick EDM machines: an 8-axis AP200L wire EDM and an AE05 sinker microEDM. ARC uses wires for the AE05 ranging from 2µm to 6mm in diameter. The shop makes electrodes for the sinker EDM using the wire EDM and conventional machining processes. It primarily uses tungsten electrodes, but has employed other materials as well.

"You have to start out with a blank piece of paper and design your own electrodes," said Roberts. "That is the key to getting things right with [sinker] microEDMing." CTE

Editor's Note: Related articles on microEDMing are available in the Fall 2008 issue of MICROmanufacturing, which is available online at www.micromanufacturing.com.

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