Electrical Discharge Machining

Electrical discharge machining (EDM) is a non-contact process capable of removing material at very small length scales without creating mechanical stresses. The material is removed through highly localized melting and evaporation as a result of electrical discharges from an electrode to the material. The discharges, which form tiny plasma channels with temperatures up to 10,000 °C, locally melt very small amounts of material. As the plasma collapses when the current flow is shut off, the resulting vacuum pulls out the molten material into the surrounding dielectric medium. For discharges to occur, the material needs to have sufficient electrical conductivity whereas material hardness is of no consequence. As such, any metal as well as many semiconductors are candidates for this process. Micro-EDM is a specialized form of EDM whereby the workpieces have features as little as 10 microns (0.0004 inches). These small features are achieved with electrodes that are also very small in size. For EDM sinker and EDM milling, the typical features are internal geometries such as holes, slots, etc. Therefore, the electrodes are typically a tiny bit smaller than the features to be machined. For wire-EDM (micro-WEDM), where most features are external, this restriction is not necessarily the case.

Micro-EDM Examples - 0.1 mm (0.004 in) brass wire

0.4 mm (0.016 in) pitch microelectrode array, 5x5mm (0.2 x 0.2 in) with 144 electrodes of 5 mm height (0.2 in). Material: doped silicon
0.4 mm (0.016 in) pitch microelectrode array, 5x5mm (0.2 x 0.2 in) with 144 electrodes of 5 mm height (0.2 in). Cross section of electrodes is wavy to increase flexibility. Material: doped silicon

Micro-EDM Examples - 0.05 mm (0.002 in) steel wire
For wire diameters smaller than 0.1 mm, inexpensive brass wire is replaced by higher-strength alternatives that include silver- or gold-coated steel wires, molybdenum, or tungsten.

0.15 mm (0.006 in) pitch microelectrode array, 3x3mm (0.12 x 0.12 in) with 1156 electrodes of 1.0 mm height (0.04 in). Cross section of electrode is curved to increase flexibility. Material: brass

Turbine vane test windows with very small corner radius of 0.03 mm (0.0011 in) and matched curvature as well as very tight tolerance relative to a non-conductive out layer. Material: nickel-superalloy. Courtesy of Prof. Kevin Hemker and Binwei Zhang, Johns Hopkins University.
Micro-EDM Examples - 0.02 mm (0.0008 in) tungsten wire

0.05 mm pitch (0.002) microelectrode array, 1.5x3mm (0.06 x 0.12 in) with 3000 electrodes of 0.2 mm height (0.008 in). Material: brass

Micro-EDM Examples - 0.012 mm (0.00047 in) tungsten wire

0.04 mm pitch (0.0016) microelectrode array, 0.3x0.3mm (0.012 x 0.012 in) with 9 electrodes of 0.4 mm height (0.016 in) - before cleaning. Electrodes have a reverse bend slanted to increase electrode flexibility. Material: copper beryllium

Micro-EDM Examples - rotational features

1.0 mm pitch (0.04 in) helical microswimmer machined with rotary axis. Material: 1mm diameter nitinol tubing. Courtesy of Prof Jake Abbott, University of Utah

0.3 mm pitch (0.012 in) helix support for artificial muscles. Material: 1mm diameter nitinol tubing. Courtesy of Prof Stephen Mascaro, University of Utah