INTRODUCTION
Micro mechanical components and tooling are required to support advances in many fields including electronics, medical and optics industries. Makino has long been a leader in manufacturing high precision machine tools. We are putting our accumulated knowledge of many years to the test with several new machines that are designed to achieve ultimate accuracy in both Wire EDM and Ram EDM. We would like to introduce some of Makino’s advanced technologies, which have been proven in the field.

Ultra Precision Wire EDM “UPN-01”
Wire EDM for micro mechanical components requires the use of a very fine wire to achieve the minimum kerf and smallest corner radius. The Makino UPN-01 is unique having the wire travel horizontally through a submerged oil bath. This machine is capable of automatically threading fine wire of 20um (0.0008 in) through a 30um (0.0012 in) start hole with close pitch dimension to adjacent holes. The minimum kerf possible is 16.9um using a 15um (0.0006 in) tungsten wire.

Photo 1. An automatic threading nozzle which carries a wire electrode and a suction nozzle are brought close to both sides of the work-piece.

Photo 2. Minimum kerf with 15um tungsten wire. Carbide 1.5mm, Surface finish 0.5umRz, 1 cut

Minimum feed increment of 0.1um or less is achieved by aerostatic pressure guide-ways. The machine is also designed to use no lubrication to achieve minimum impact on the environment.

Constant temperature technology for controlling the ambient air temperature is used to minimize thermal drift during cutting. Tightly sealed machine covers and a high-performance air conditioner control the temperature variation in different parts of the machine to within +/- 0.5 C. Maintaining the internal-machine temperature constant also helps to reduce the cost of air conditioning the entire shop.

Figure 1. Static accuracy for XY axes
Roundness 0.6um, Diameter 5mm
SPG machining circuit (Makino-designed machining circuit which provides micro pulses under the certain condition) provides the best surface finish of 0.14umRz in carbide materials. Brass wire which has a copper / zinc ratio in the range of 65/35 to 63/37 is by far the most widely used wire type and is also used for the sample in Fig3. Incidentally we usually recommend using brass wire due to cost performance.

All begins with through temperature control
The UPN-01 has been assembled in a special facility called UP-Room. The UP-Room has no cranes that could cause vibration and is divided into several booths where temperature of each machine can be rigorously controlled. Separated booths make it possible to assemble and inspect individual machine under temperature conditions identical to the customer’s shop floors.
Ultra Precision RAM EDM “EDAC1”
As digital cameras and mobile phones become more compact and lightweight, the size of electronic components and connectors that are incorporated into these devices, also must be reduced. This requires smaller corner radius for die/mold tooling of these products. RAM EDM is utilized for blind features and precision small holes where Wire EDM cannot reach. Developed for these applications is the EDAC1.

The EDAC1 is able to achieve minimum corner radius of 5um in steel. The best surface finish capability is 0.45umRz in carbide using a copper tungsten electrode and an interface level difference within +/- 1um in the X and Y plane. Z height differences of +/- 1um are achieved between several EDMed surfaces. These high accuracies are achieved using an advanced Z-axis stabilizer. In high-accuracy machining, even the slightest amount of heat generation cannot be tolerated. The Z-axis ball screw is constantly cooled by oil, which reduces the sharp rise in temperature caused by repeated jump motions. For all axes, full travel perpendicularity and straightness are hold to within +/- 2um.

Figure 4. Best surface finish in carbide.
Electrodes made of copper tungsten are produced by Makino’s vertical Machining Center V33i.
Surface finish: 0.45umRz with SPG circuit.
Measured by KOSAKA SURFCORDER SE3500.

Work-piece: Steel (SKD11, JIS)
Electrode: Copper
Surface finish: 0.6umRz with SPG circuit

Photo 4. Ability to execute tiny corner radius is in increasing demand for precision die/mold, electronic connectors and other micro components.

Figure 5. Interface level difference between ground and EDMed surface improves in +/- 1um.

Work-piece: Steel (SKD11, JIS)
Electrode: Copper
Surface finish: 0.8umRz with SPG circuit
Measured by non-contact 3D measuring device, WYKO NT series NT8000

<table>
<thead>
<tr>
<th>R</th>
<th>Ra</th>
<th>Ry</th>
<th>Rz</th>
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<tr>
<td>0.12</td>
<td>0.100um</td>
<td>0.630um</td>
<td>0.450um</td>
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Ground surface
EDMed surface

R=5um

Photo: 100um

Ra   0.100um
Ry   0.630um
Rz   0.450um
Figure 6. The Z-axis stabilizer reliably removes heat produced by repeated high jump motions.

Fine Hole EDMing
In order to produce fine holes precisely, it is very important to improve rotational deviation of spindle head. The MA head which is limited the rotational deviation within 2um makes perfect positioning possible.

Photo 5. Finest holes with dressed electrodes of 6um.

Figure 7. Heat sources of Z-axis (Motor, Ball screw). These are constantly cooled by refrigerant oil.

It is possible to choose a suitable solution from 2 kinds of available spindle heads. One is an MA head which is mainly used for fine hole machining with dressed or hollow pipe electrodes, and the other is an Mi head fitted with a rotary encoder to guarantee indexing accuracy of +/- 2sec. Both heads help to automate the micromachining process.

CONCLUSION
Companies all over the world are facing financial crisis and the influence of the expanding economic recession. In response to demand for new innovations from our customers Makino is committed to providing new ideas for micro EDM. It is our aim to foster innovation that will lead to engineering of new high value products that previously could not be made without our technology.

REFERENCES