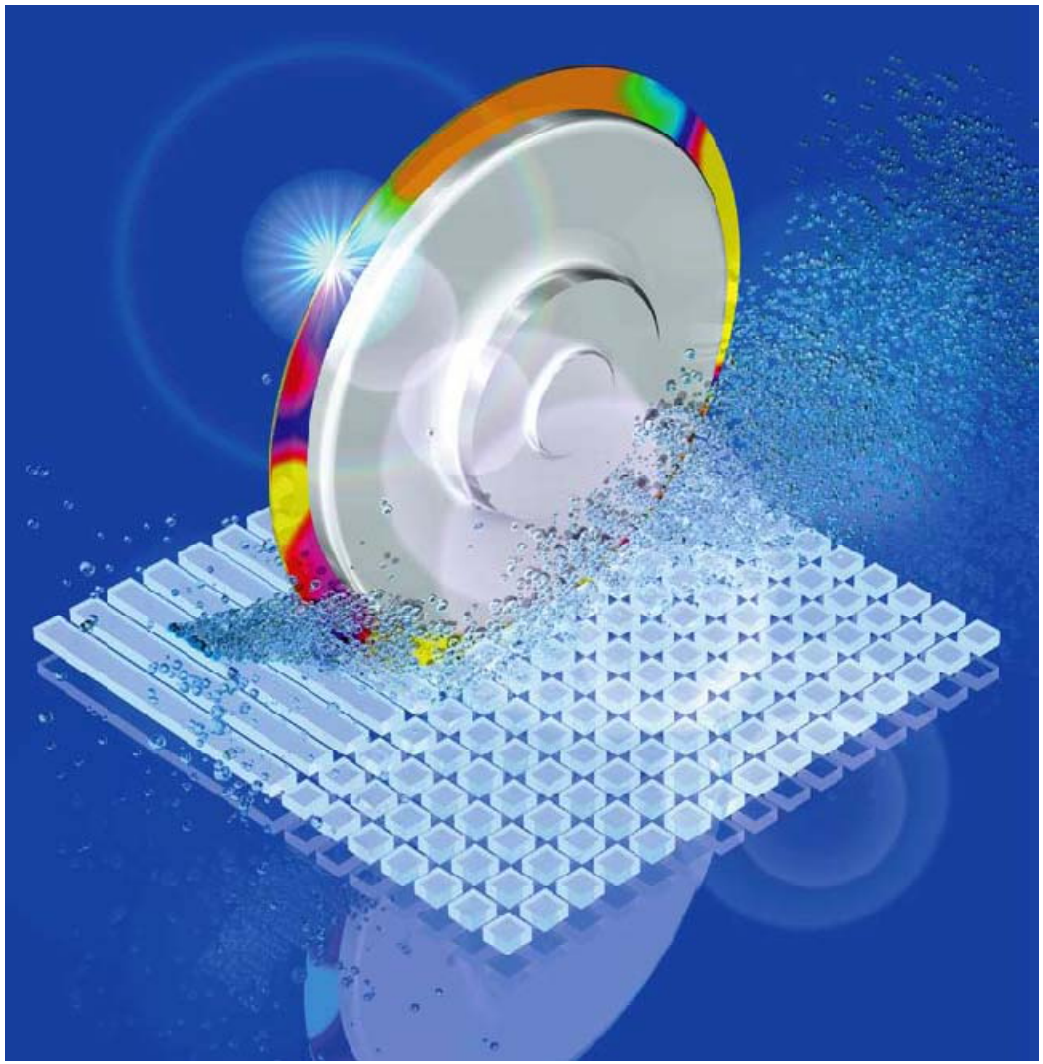
Ultrasonically Assisted Silicon Wafer Cutting Machine

Shigeru Sato, ***Ultex*** Japan
Leo Klinstein, Dukane USA



3/23/2009

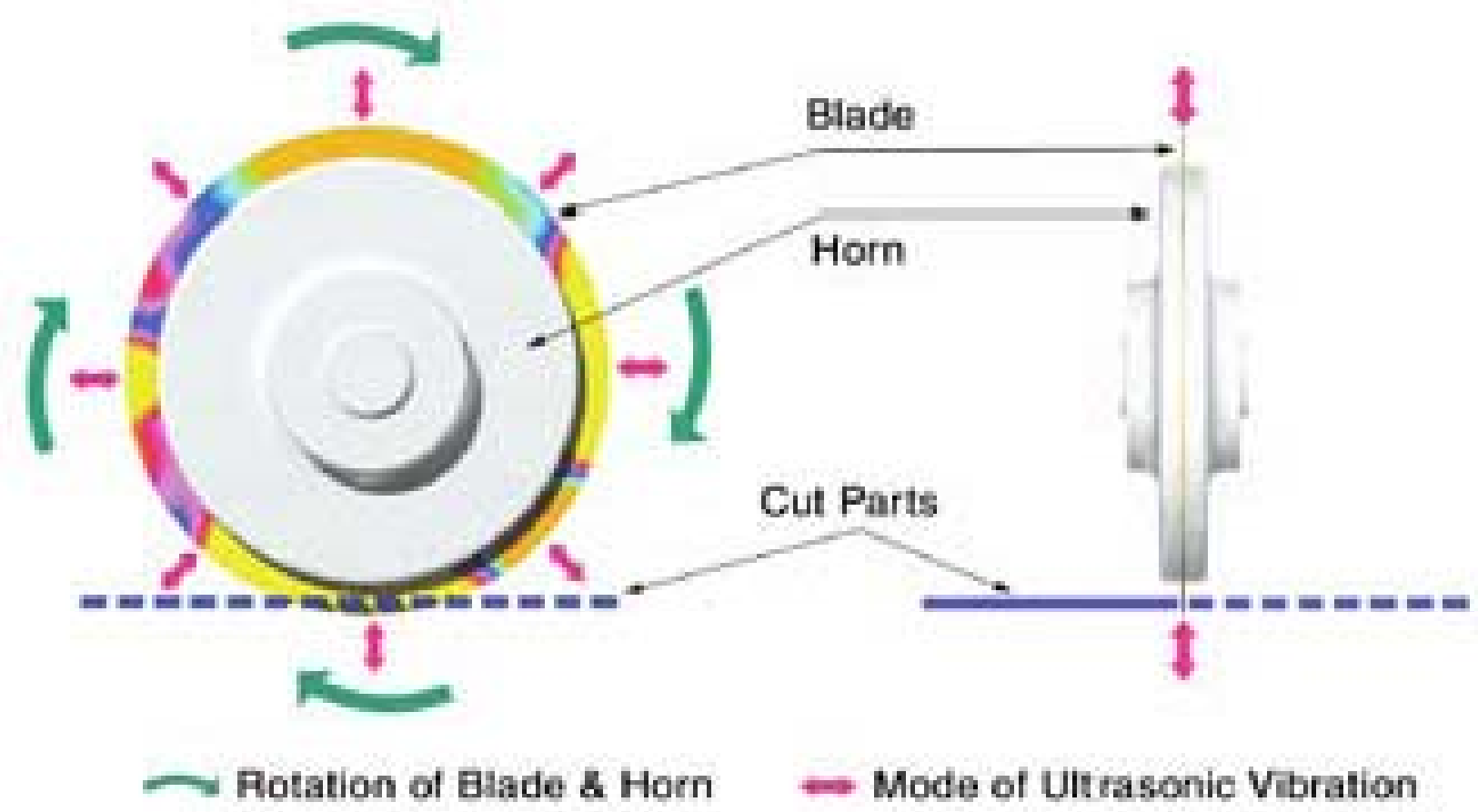
New Cutting Method using Ultrasonic Vibration (U.S. Patent # 6,098,514)

This system uses a new cutting method, in which the blade is installed directly onto the outer edge of the ultrasonic horn. It has a dual support system, the blade rotates while ultrasonic vibration is applied to it.

Because of this unique feature of the ultrasonic horn, it cuts a wide range of applications, ranging from soft to hard materials.

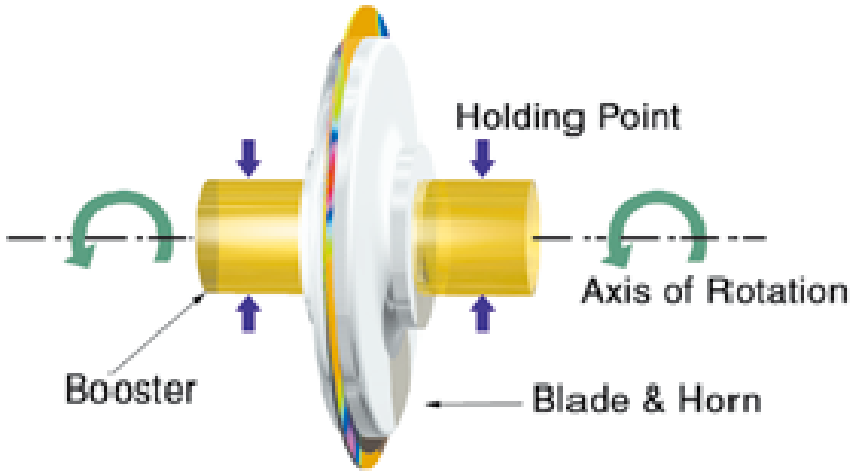
This cutting machine is especially effective for compound materials, which consist of more than two materials, and materials that crack easily when applying conventional blades.

New Cutting Method using Ultrasonic Vibration (U.S. Patent # 6,098,514)



Rigid DSSR
Dual Support System Rotation
(U.S. Patent # 5,883,460)

This machine has Ultex's patented Dual Support System Rotation. Unlike the traditional single support cutting rotor spindle, the actuator grips on both left and right boosters at the flange and rotates.The DSSR structured rotor spindle allows for the cutting impact and transmits ultrasonic energy and vibration to work without energy loss.

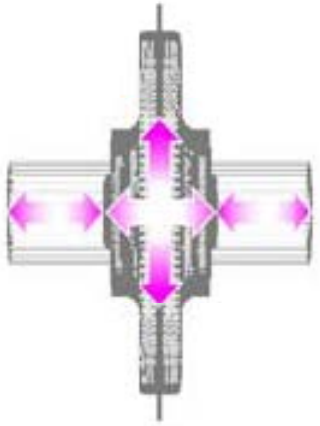


Spindle Assembly

Blade horn (U.S. Patent # 6,098,514)

This "Ultrasonic blade horn" is made of diamond dust, molded into a donut shape with electroforming process. The ultrasonic wave hits the center of the horn and then is transmitted in a cross-shape within the horn. Therefore, ultrasonic energy is applied vertically to the part (refer to diagram).

Diamond blade is well known as the hardest cutting blade, however, by using ultrasonic vibration its potential applications have been greatly expanded allowing to cut the materials that could not previously be cut and also giving longer life to the blade.



Blade horn (U.S. Patent # 6,098,514)

Simultaneous Cutting and Polishing

In addition to using rotary cutting motion found in conventional machines, the ***PolishCut*** System transmits ultrasonic waves to the cutting blade, which causes the blade to vibrate radially. These vibrations produce a polishing effect, which occurs simultaneously with the cut.

The combination of cutting and polishing also eliminates residual stress within the part.

Accurate rotation and energy concentration

When cutting, energy must be concentrated at the cutting section. The ultrasonic cutting system with the DSSR structure and rotor spindle allows for accurate rotation.

Because the structure is held at both ends (DSSR) and the new ultrasonic rotary system minimizes deflection to below 10μm, the misalignment of the rotation axis and the blade plane is below ± 2μm, resulting in a smooth cutting surface and a precise cut.

Ultrasonic wave helps keep the blade from clogging

Ultrasonic vibration helps prevent blade clogging typically observed in conventional cutting. Materials coated with aluminum, solder, or resin can be cut without experiencing clogging problems.

Silicon wafer (thickness 0.6 mm) + aluminum coating on surface (thickness 2μm)
Rear 0.5 × 0.5 mm; Front 0.5 × 1.0 mm

Magnified image (× 100) of the tip of the diamond blade
No material clogging found between teeth after cutting

Cutting and dressing simultaneously

Ultrasonic waves activate the blade with diamond particles, which polish the edges of the part being cut simultaneously with the cutting process, eliminating dressing process which was previously necessary.

In addition, blades life and sharpness are maintained for longer periods.

PolishCut - Summary

The effect of the ultrasonic vibration in preventing clogging of the diamond blade and accelerated kinetic energy expands the range of use.

In addition, due to ultrasonic vibration in this cutting machine, and its improved accuracy and rigidity, simultaneous cutting and polishing has been achieved.
We call it "***PolishCut***".

Cut surface of quartz
thickness 0.8 mm

Cut surface of tantalite acid lithium
thickness 0.4 mm

Manual type Ultrasonic *PolishCut* System

This full-scale ultrasonically assisted rotary cutting machine features the minimum necessary functions to effectively cut various materials, and it works well even for small production lots.
Operator enters the number of cuts, cut pitch, starting point in X-Y position, depth of the cut and blade's height, then the machine cuts the part automatically.
The maximum rotational speed of the spindle is 12,000rpm, moving speed is 0.01-200mm/sec, and the maximum diameter of the part is up to 300mm.

Manual type Ultrasonic *PolishCut* System

Model LAB-CS50 Specifications

Ultrasonic System - Dukane DPC5015L4+

- Frequency - 50 kHz
- Amplitude - 1.5 um to 8.0 um
- Power - 150 W

Spindle

- Dual Support System Rotation (DSSR)
- Drive – 400 W electric motor; 12,000 rpm max

Tool

- Ultrasonic Horn – Cross Mode Type
- Blade material – Electroformed Diamond Grain
- Blade Diameter – 3.0”, Blade Thickness – 50 um- 200 um;
- Blade height – 1.0 – 3.0 mm

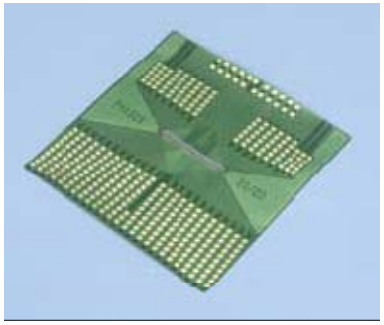
Electroforming of Diamond Coatings

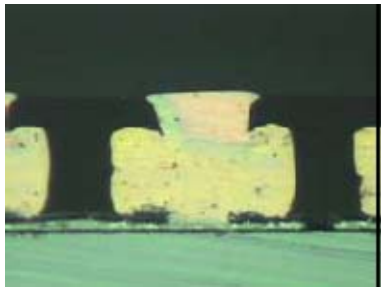
T. Semba[a] and H. Sato[b]

A high-speed electroforming technique that can produce an electroformed tool efficiently is developed to overcome a disadvantage of the conventional sediment codeposition technique that an extremely long time is required for the production of thick composite coatings. Aggregated diamond grain particles sedimented on a tool surface are agitated at a low speed with a rubber blade to increase the electric conductivity and to disperse the grain particles uniformly on the tool body. The time required to produce a thick nickel-diamond coating of 1 mm thickness is successfully reduced to 2.5 hours from the minimum of 81 hours required by the conventional sediment codeposition technique.

[a]Department of Intelligent Mechanical Engineering, Faculty of Engineering, Fukuoka Institute of Technology, Fukuoka, Japan
[b]Department of Precision Mechanics, Faculty of Science and Engineering, Chuo University, Tokyo, Japan

Ultrasonic *PolishCut* Applications
LCD Driver IC



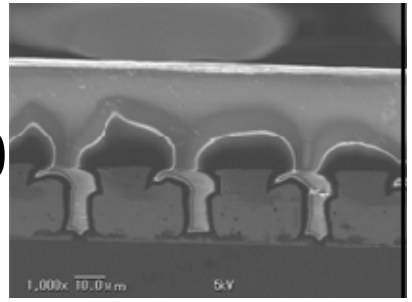


x4600

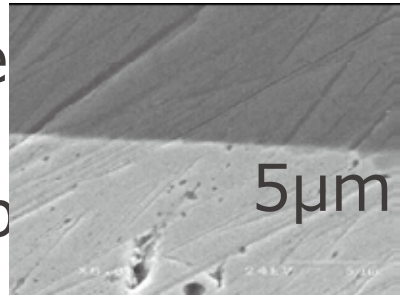
LCD driver IC on film substrate

Ultrasonically bonded

SEM x1000

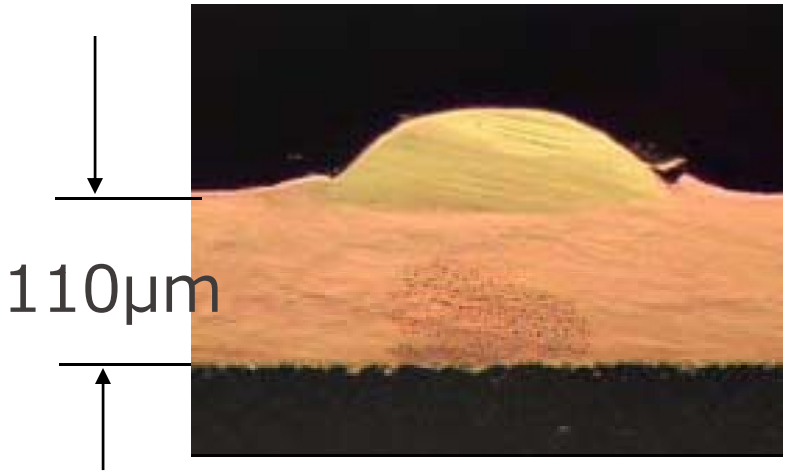


Blade - Electroformed Diamond grain diame
#6000(0.5~3.0μm) 150 um thick
Speed - 0.1mm/sec Amplitude - 3.9μm p



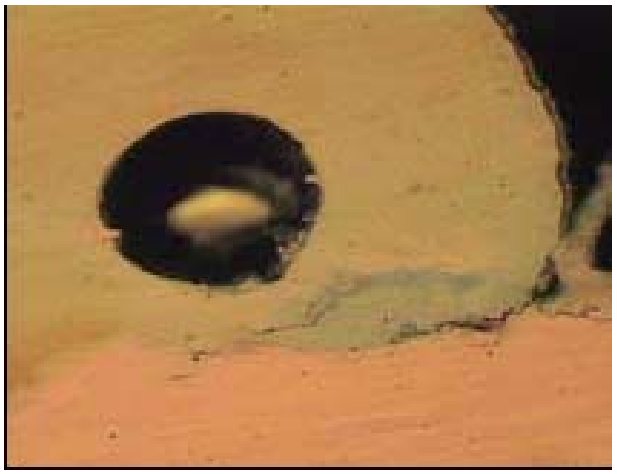
SEM Expansion

Ultrasonic *PolishCut* Applications
Samples of *PolishCut*



Cu + Brass x460

laser welded section

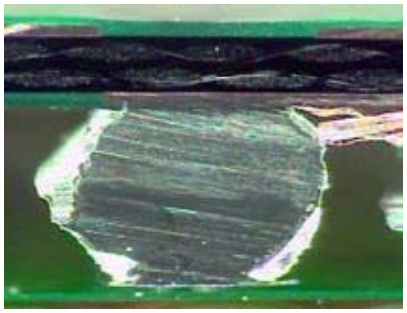


Cu + Brass x1800

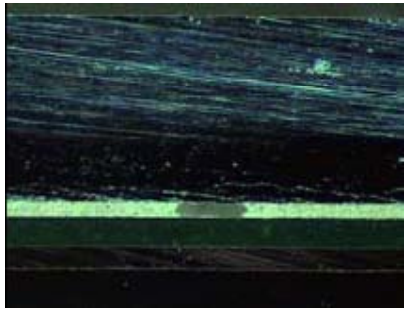
Pore of laser welded section

Speed 0.1mm/sec;
Amplitude 3.9um p-p
12000 r.p.m
Blade Thickness 134um

Ultrasonic *PolishCut* Applications
Samples of *PolishCut*

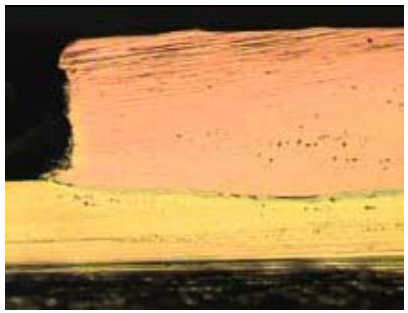


BGA solder ball φ0.8mm



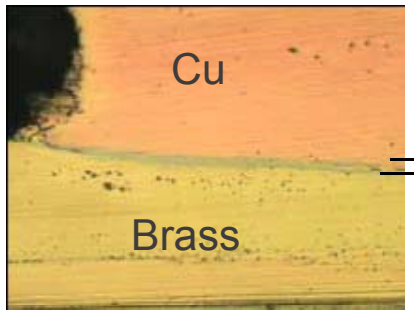
Speed 0.1mm/sec
Amp. 3.9um
12000 r.p.m
Blade Thickness 82um

Pore of die bonded BGA x150



Ni plated Cu + Brass x460

Ultrasonic bonded section

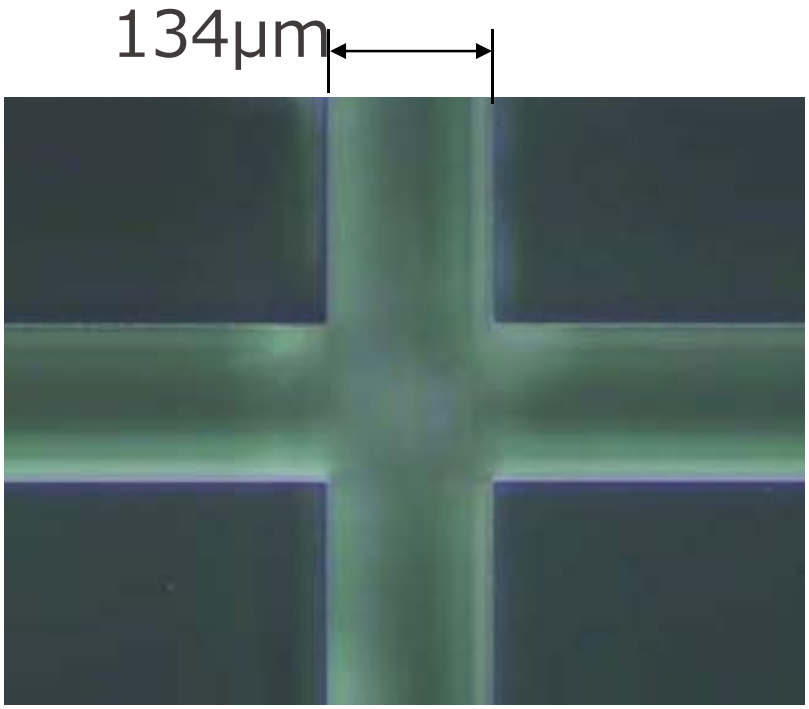


X4600

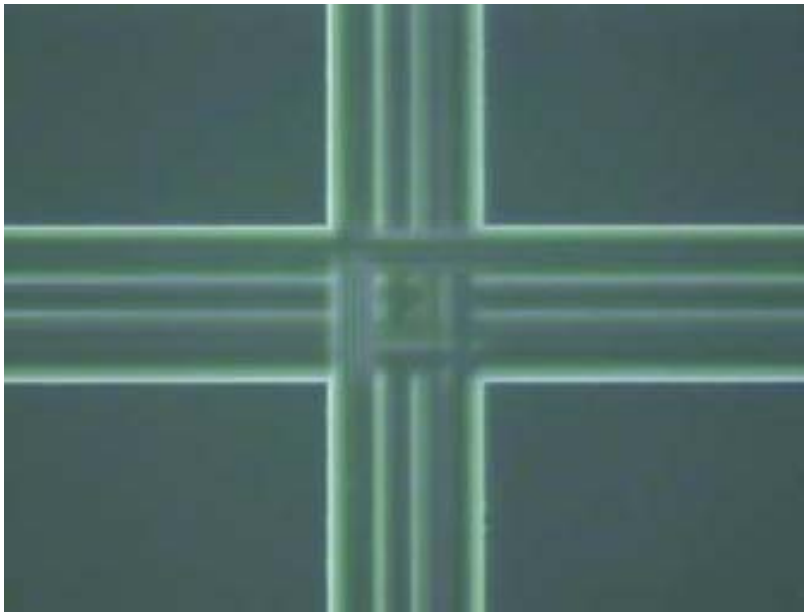
Speed 0.1mm/sec; Amp. 3.9um p-p
12000 r.p.m
Blade Thickness 104um

Ultrasonic *PolishCut* Applications
Samples of *PolishCut*

Half cross cutting of Alkali-free Glass



Depth - 350μm



Depth - 50μm

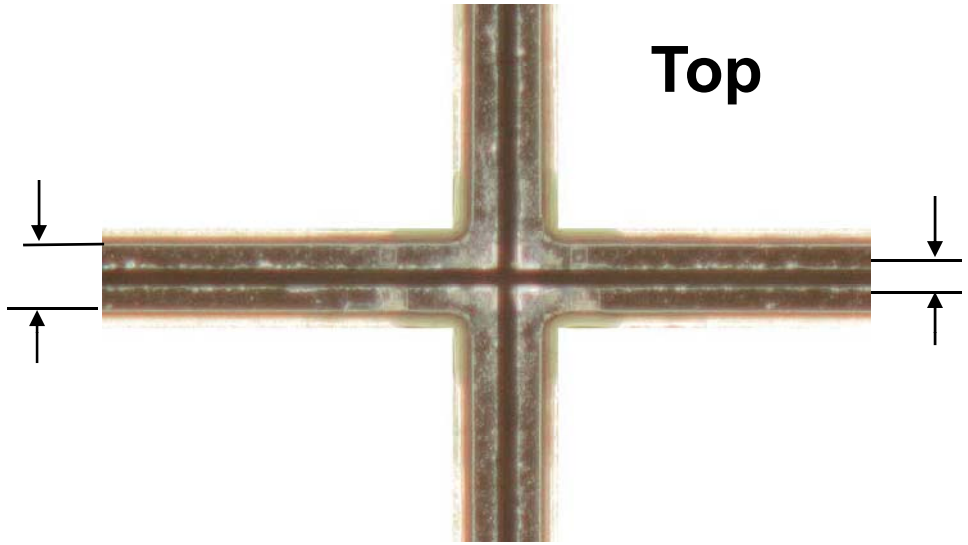
Blade - Electroformed Diamond grain diameter #6000(0.5~3.0μm)
Speed - 0.1mm/sec
Amplitude - 3.9μm p-p

Ultrasonic *PolishCut* Applications
Samples of *PolishCut*
Full cutting of Multi-layer Alkali-free Glass

Blade 82 um thick - Electroformed Diamond grain diameter (4.0~6.0μm)
Speed - 0.1mm/sec Amplitude - 3.9μm p-p

Ultrasonic *PolishCut* Applications
Samples of *PolishCut*
IC wafer cracks easily, cut with 25µm width blade

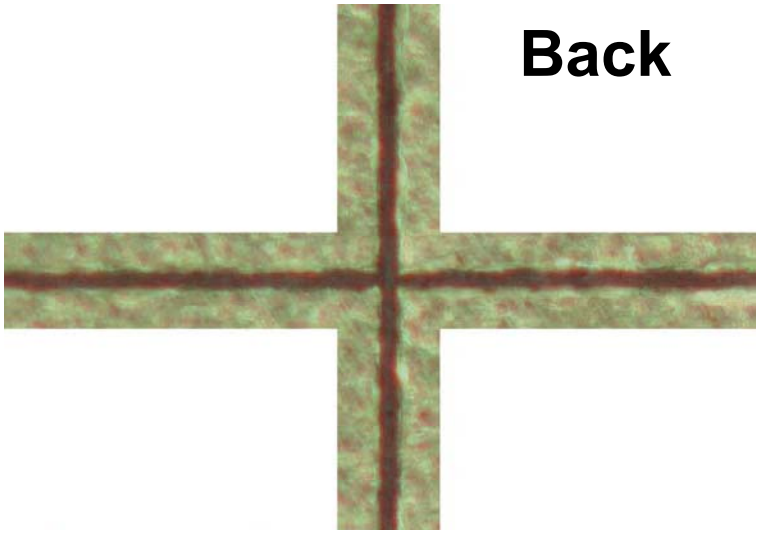
Top



Track width about 90µm

Cut width about 30µm

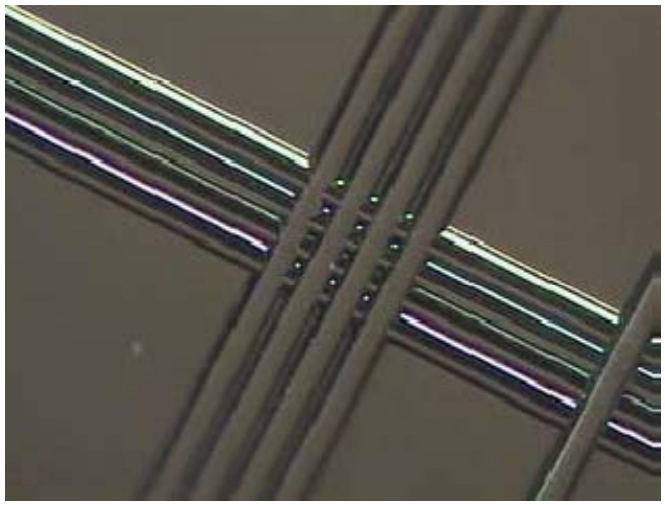
Back

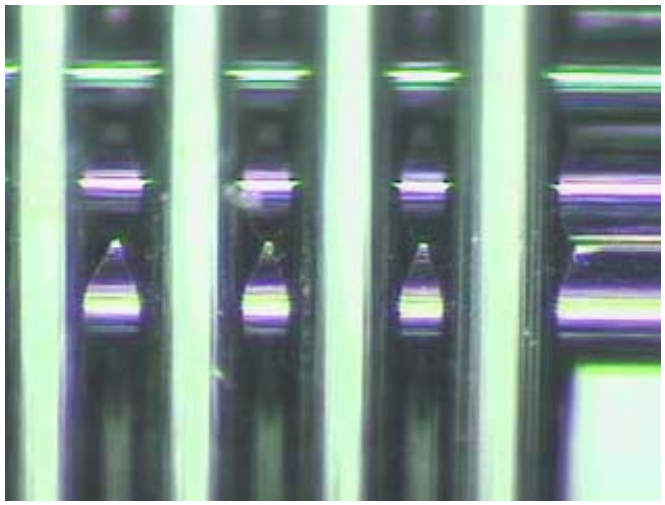


Linear Speed 30 mm/sec
Amplitude 2.0 um p-p

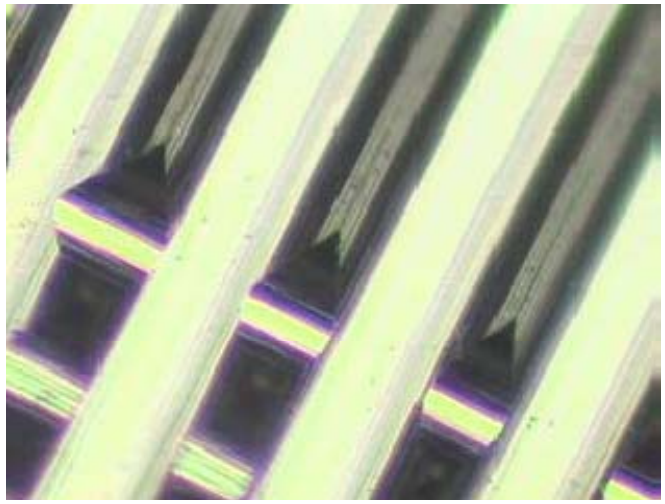
Ultrasonic *PolishCut* Applications
Samples of *PolishCut*

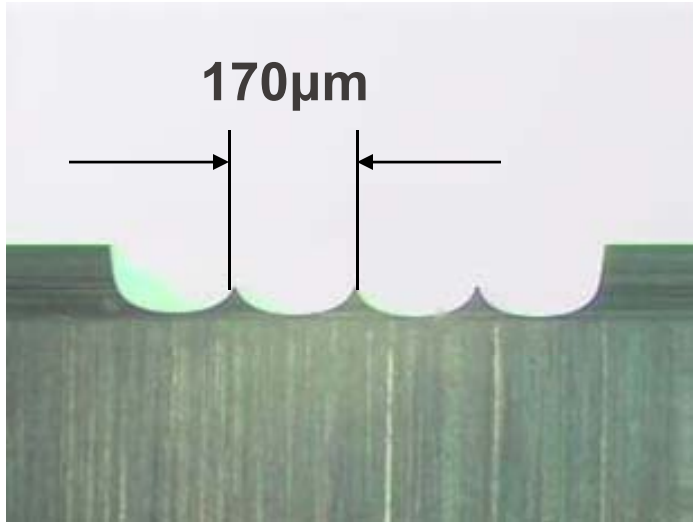
Half cross cutting of Tungsten Carbide (WC)





0.1 mm/sec
3.9 um p-p





ACKNOWLEDGEMENTS

Most of the work related to the Ultrasonic Cutting Machine was performed by the ***Ultex*** Ultrasonic Laboratory of Fukuoka, Japan.
Mr. Shigeru Sato is the Founder and President of ***Ultex*** and its Principal researcher and innovator. He has authored numerous patents.
Ultex is a recognized leader in precision Ultrasonic Metal Welding, Ultrasonic Soldering and related High-Tech applications. Please visit www.ultex.co.jp

Ultex and Dukane have been working together for almost 18 years. Dukane has supplied a customized 50 kHz 150 W Ultrasonic generator and transducer for this machine.

QUESTIONS?