Micro-abrasive Applications in Micromachining.

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Micro-abrasive blasting is a well established technology with over 40 years of applications in industries ranging from precision metalworking, aerospace and electronics to the medical and semiconductor industries. In recent years the number of specialist applications in micro-machining have been increasing steadily as the requirements for de-burring, surface finishing, surface preparation of small parts and drilling of fine holes have increased.

Micro-abrasive blasting utilises a stream of fine abrasive particles in clean dry compressed air or nitrogen delivered by a fine blast nozzle (from 0.38 mm diameter or 0.2mm x 0.5 mm slot) to effect surface modification. A range of abrasive media are available ranging from very soft (walnut shell or plastic media) to very hard (silicon carbide). (see table 1)

The blast unit allows control of both air pressure and the air/media mix to optimise the process for the specific application, by varying the distance of the nozzle from the workpiece and the incident angle of the blast the effect can be further adjusted to achieve the desired effect. Comco's micro-abrasive blaster range uses a unique pressure modulation system for powder feed that eliminates the many moving parts needed for a 'pepper pot' system and offers more control than a venturi feed. Their latest blaster, the Accuflo offers improved powder flow consistency and uses Powdergate™ technology to eliminate the hose wear associated with using a pinch valve on the blast hose to turn the abrasive flow on and off. The final process depends on volumes and the required accuracy of the blast and can lead to either a manual process in a blast cabinet, a fixed nozzle process with the parts jigged and/or masked or a more automated solution.

Table 1 Common Abrasives and their applications

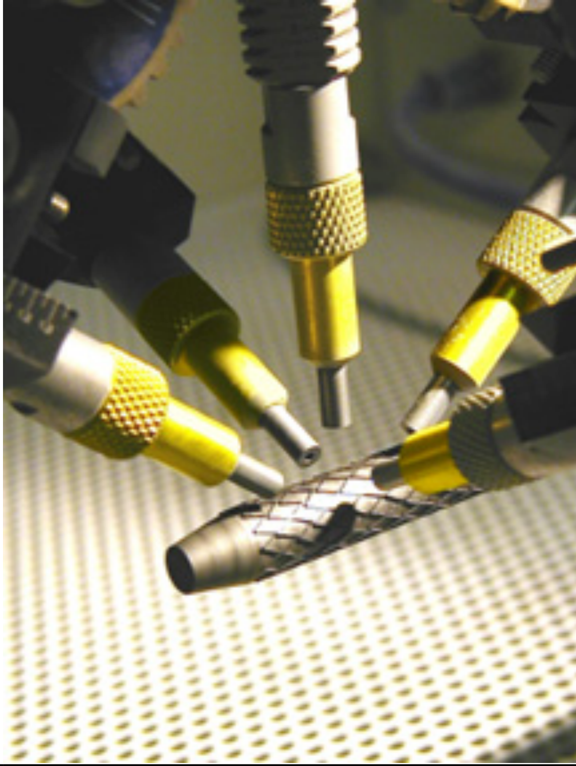
Abrasive Material	**Particle Size**			**Description/Characteristics**
	Average Particle Size		**Range (Microns)**	
	Micron	**Inch**		
Aluminum Oxide	10	0.0004	5 - 25	The most common abrasive used. A very hard abrasive that cuts well through almost any material, particularly brittle ones. Normally leaves a matte finish, with the surface roughness being dependent upon the abrasive size and the blast pressure. Somewhat sensitive to moisture.
Aluminum Oxide	17.5	0.0007	10-25	
Aluminum Oxide	25	0.001	15 - 35	
Aluminum Oxide	50	0.002	30 - 80	
Aluminum Oxide	150	0.006	75 - 200	

Glass Beads	50	0.002	40 – 80	Good for light deburring and satin finishing of some metals but not good for cutting. Can be used to remove loose surface particles such as oxides. Sensitive to moisture.
	30	0.001	20-50	
Silicon Carbide	20	0.0008	10 - 40	The fastest cutting of the standard abrasives. The best abrasive to deburr stainless steel and titanium parts. Does not absorb moisture. Dark gray or black in color.
Silicon Carbide	50	0.002	30 - 80	
Sodium Bicarbonate	50	0.002	20 - 150	A very gentle abrasive, good for very light cutting of soft materials. Can be used to remove conformal coating from PCBs. Water soluble and easily removed from delicate parts. Susceptible to moisture and cannot be heated to above +150ºF.
Walnut Shell	250	0.010	80 - 300	Gentle abrasive that can clean metal or ceramic surfaces without changing the surface finish. Absorbs moisture easily.
Plastic	200	0.008	150 - 300	Good for stripping soft materials, such as paint or conformal coating, from harder substrates.
Crushed Glass	80	0.003	40 - 90	For light cutting of soft to medium materials.

Following are a few micro-machining applications of the micro-abrasive process.

1. Stent processing.

The laser cutting of stents (pic 1) and other fine tubes causes oxidation of the cut surfaces and produces a sharp edged cut which can be undesirable. In many cases an electro-polish process is applied to the parts after laser cutting to remove the oxide, round the edges and give the fine polished finish that is required. This can be a slow process as the oxide is hard to remove by this means.



Pic 1. Stent OD processing

It is possible to remove the oxide layer and radius the edges of the cuts by micro-blasting the parts inside and out with a fine alumina media. This reduces the time required for the electro-polish process and it has been reported by a number of end users that the key provided by the roughening of the surface gives improved electro-polishing performance. The micro-acrasive process thus offers faster processing and improved surface finish.

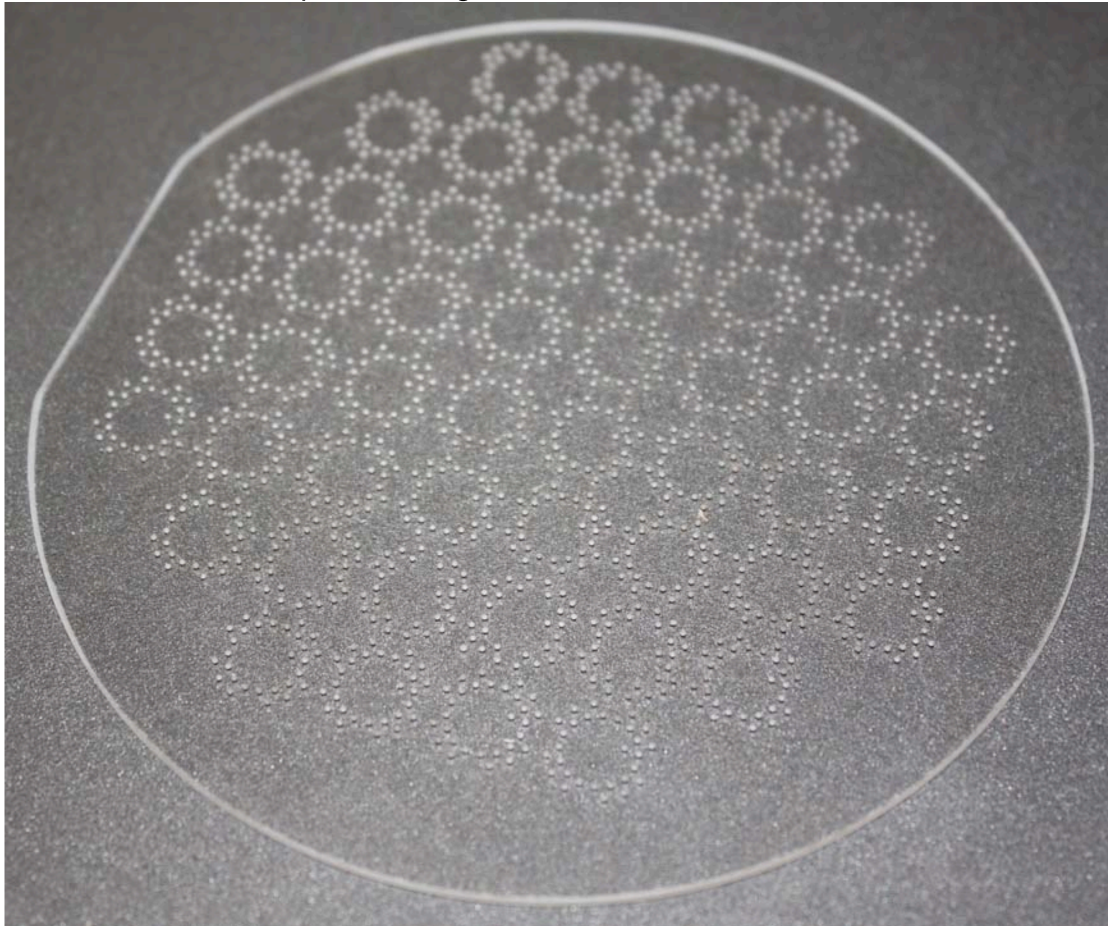
Comco have developed a micro-abrading lathe to automate the blast process. This system uses a spindle and mandrel to hold and rotate the parts and a programmmable multi-nozzle head which can be moved in the X axis to blast the whole of the part automatically. A clam-shell holder and 90 degree nozzle head is used to hold and blast the inside of the parts.

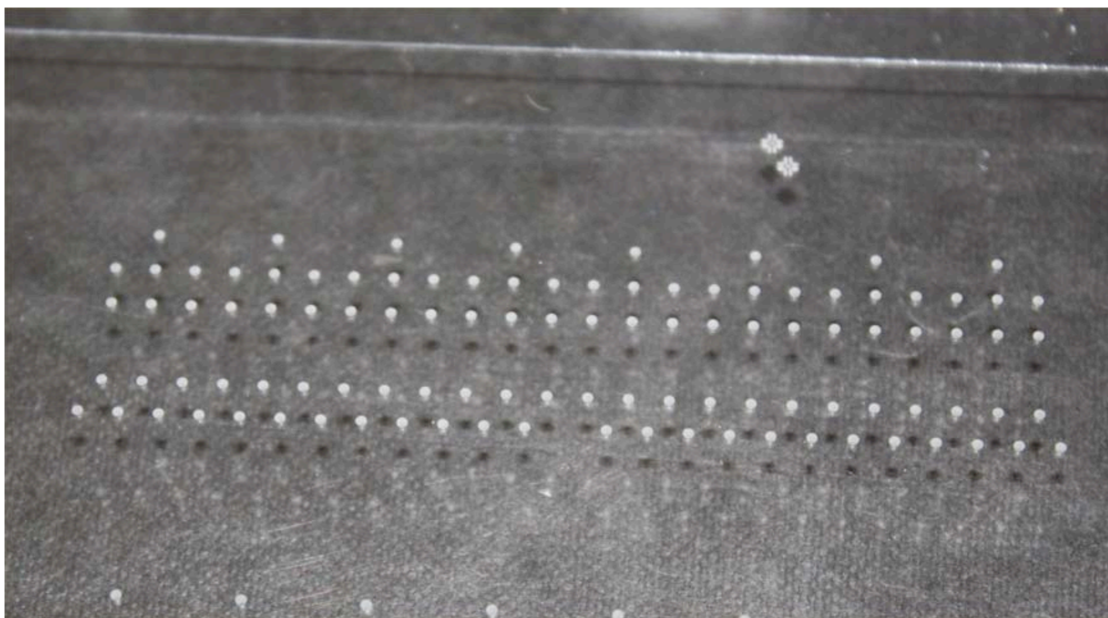
2. Wafer drilling and machining

The micro-machining of fine structures and holes in glass and other materials can be effected using drills, laser cutting EDM and etching by various methods. But when the requirement is for deep holes or features these processes can be relatively slow.

The micro-abrasive blasting can be used in conjunction with an abrasive resist mask that is patterned by photo-lithography to effect deep etch of glass wafers much more quickly. It is possible to blast multiple small (200 micron min.) holes in a 2 mm thick thick wafer in a single process (pic 2). The sand-blast mask materials are similar in chemistry to PCB resist masks and require only a simple NaOH spray development and can be stripped after the process

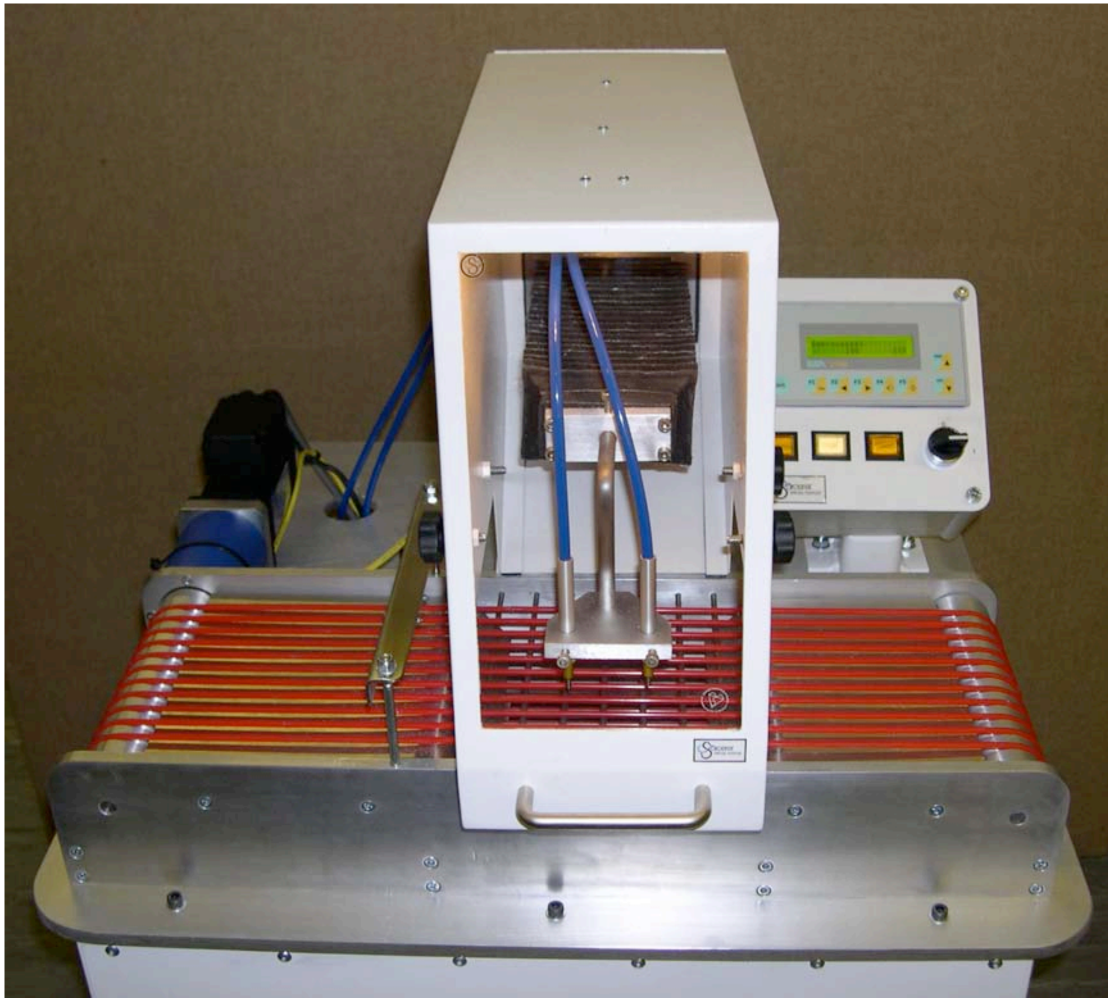
with a caustic soda. A 100 mm square boro-silicate glass wafer can have holes cut over the whole area in less than 20 minutes. The wall angle on small holes will be limited to about 60 –65 degrees but in may applications this is acceptable as long as the volume of the hole is consistent. For larger features and holes much steeper wall angles can be achieved.





Epak have developed the Surface Abraders, SA150 (pic 3) and SA3000 that offer automatic processing of wafers up to 300 mm wide. A stepping belt

moves the wafer under a multi-nozzle head that blasts across the belt, the belt the indexes a small distance and the head blasts across the wafer surface again. This process is repeated across the whole surface of the wafer to give even abrasion. Ths system can be programmed for step length, head traverse speed and width and can be programmed to make multiple passes of the wafer through the machine. This can be required for deep etching as some sand-blast resist materials need to 'relax' between blast cycles to allow them to survive the process. The distance of the head from the part is adjustable as is the blast pressure and abrasive flow to allow us to optimise the micro-abrasive process.



Pic 3. SA150 Surface Abrader

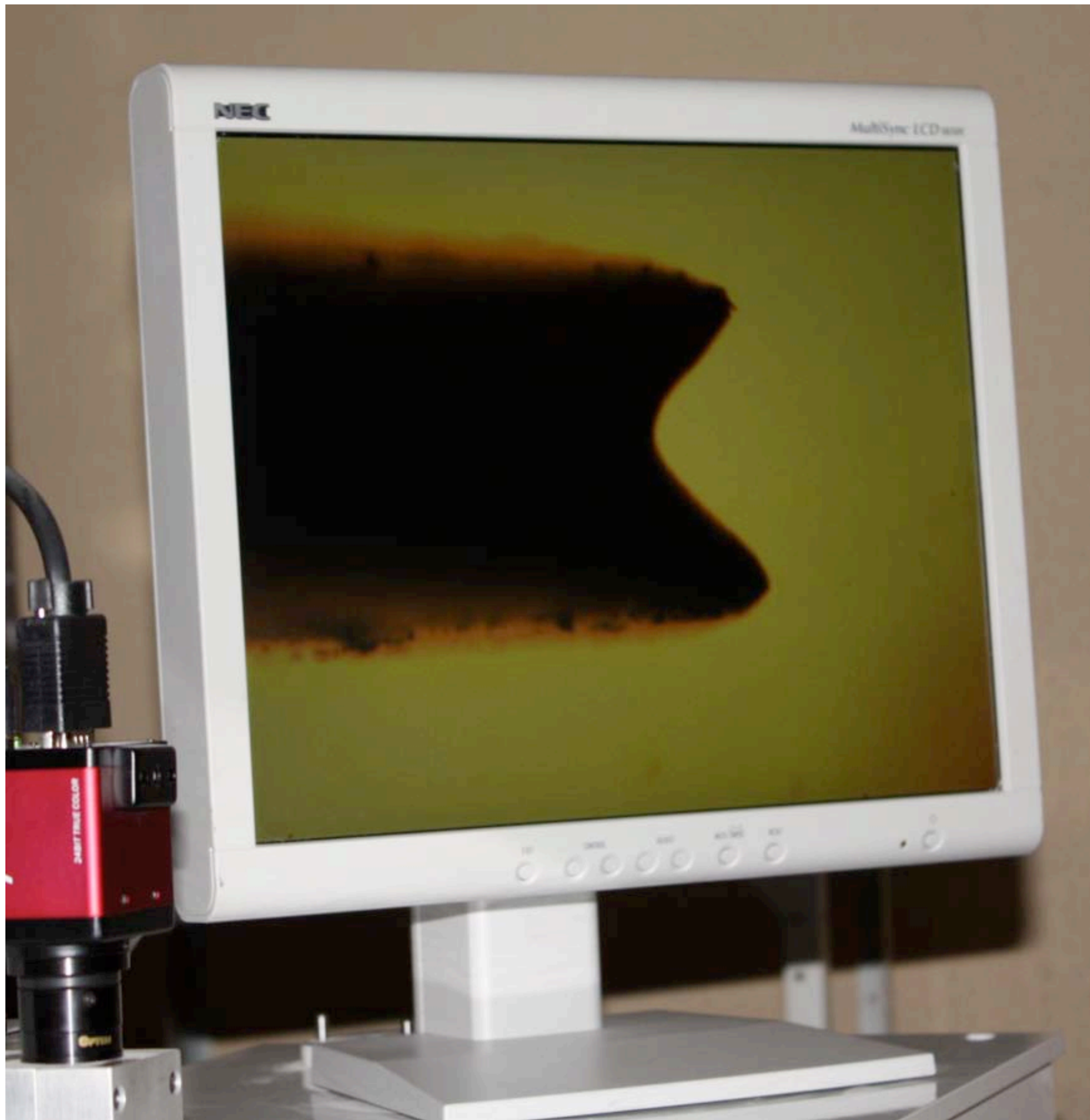
3. Coating removal and surface preparation for bonding.

There are an increasing number of applications where it is required to remove an oxide from a wire or tube, to roughen a surface to improve adhesion or to strip a coating to allow bonding to the underlying substrate. Micro-abrasive blasting processes both manual and automated have been utilised successfully in a number of industries for this very purpose. Some examples include stripping PTFE from Nitinol wire before welding, stripping coatings

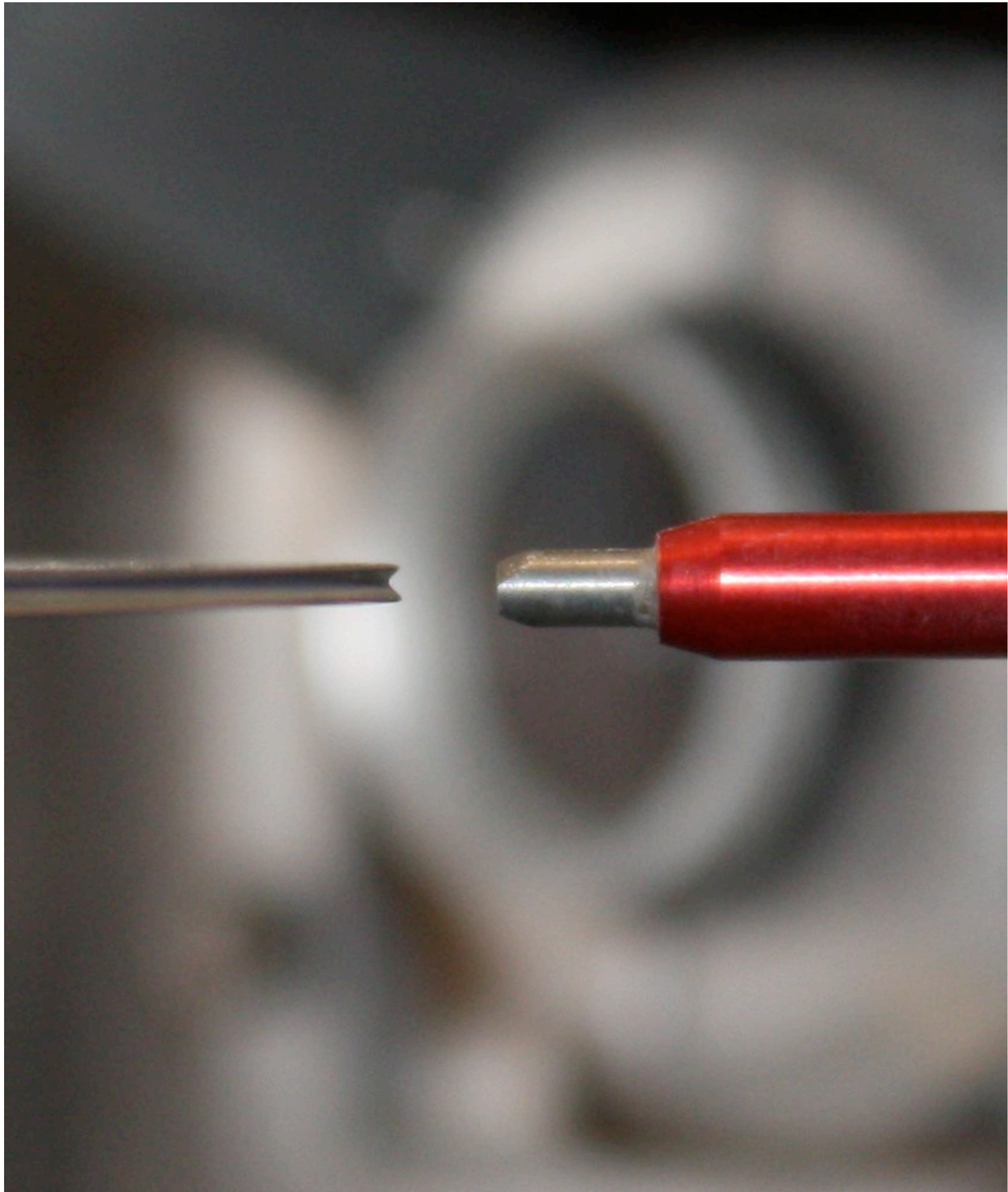
from fine tubes to either mark distance or allow bonding of components and the preparation of plastic and metal parts by surface roughening to increase the bond area and improve the adhesion process. The process is also used to remove the coating of oxide and drawing compounds formed due to the heat generated by friction during the drawing of fine wires. For 360 degree blasting of tubes and wires multi-nozzle blasting from a single blast unit provides even blasting around the part. In one specific case, the tip of a PTFE coated catheter was stripped with sodium bicarbonate media to improve the welding process and then polished using glass bead to give a bright cosmetic finish to the completed weld.

4. Wafer bevelling

The manufacture of silicon rectifiers includes a bevelling process that improves the current carrying capabilty of the components. Processes include both positive and negative edge bevels, surface slots and pulley wheel edge bevels. Micro-abrasive blasting technology is used to form these features on silicon wafers in volume production. The process involves rotating the wafers on a vacuum chuck whilst an acccurately positioned nozzle or nozzles delivers the abrasive blast to etch the required profile. The micro-abrasive process is cold, does not require direct contact and does not produce any surface slag. For a pulley wheel bevel (pic 4) the wafer edge is first cut to 90 degrees then a fine slot nozzle is used to etch a v-groove in this edge. Wafers as thin as 500 micron can be processed in this way, the wafer in the photograph (pic 4.) is about 600 micron thick.



Pic 4.



In conclusion, there are many applications for micro-abrasive blasting in micro-machining and we have only had space here to illustrate a few. But, whether your requirement is for general area abrasion, precise blasting in a small area or precision cutting or etching, it is possible to develop either manual or automated processes to meet these needs.