DOI: 10.1017/S1431927603444048
Microsc Microanal 9(Suppl 2), 2003

Patterned Wheels for Faster Dimpling and Improved Specimen Preparation

D. M. Follstaedt, M. P. Moran and A. K. Norman

Physical and Chemical Sciences, Sandia National Laboratories, Albuquerque, NM 87185-1056

Dimple-thinning of hard materials proceeds slowly, and some materials like sapphire are prone to fracture if aggressive methods are used. To improve thinning rates, we have developed patterned wheels that remove material much faster. These wheels also require less operator attention, and patterning makes a previously unusable wheel material effective, leading to reduced fracturing.

A key problem with conventional (smooth) dimple wheels is seen in Fig. 1. With the unpatterned wheel, the contact surface is wiped clean of diamond polishing compound (whitish-green color) within about two minutes; few diamonds are present at the contact to polish the specimen. However, the wheel patterned with 36 slots retains diamonds on the contact surface. We suggest diamonds are carried in the slots and released to the surface during dimpling. Whereas the operator must apply the compound to the surface of smooth wheels often, patterned wheels need only intermittent attention.

We have developed 3 types of wheels seen in Fig. 2. At left, smooth brass or stainless steel wheels are patterned with slots across the edge; we slotted others at 45°. The center wheel is machined from a porous metal made of sintered bronze particles (4-500 μm), and dimples hard materials fastest. At right is a plastic Delrin wheel with holes in the surface and grooves across it. We find smooth Delrin wheels almost useless, but as detailed by Moran *et al.* in these proceedings, patterned wheels can be used to thin even sapphire and are more gentle for thinning fragile material to $\leq$ 5 μm thicknesses.

Dimpling rates into sapphire with smooth and patterned wheels are compared in Fig. 3. For dimpling each side of a specimen to a depth of ~50 μm, the difference between patterned and unpatterned wheels would be only ~10 min. However, if all thinning is from one side to 80 μm depth, over 30 min. more would be needed. The slotted wheels are more than twice as fast as the unpatterned one, whereas the porous bronze wheel is 3 times faster. We obtained similar results with two dimpling units from different manufacturers. Figure 4 shows that the patterned wheels also remove SiC about 1.5 times faster. Results were more variable for Si. The patterned Delrin wheel removed material at a rate 2-3 times that for unpatterned Delrin and ~70% that for unpatterned stainless steel wheels.

Notably, the patterned wheels produce surface finishes comparable to or better than those with unpatterned wheels. Figure 5 shows optical images of the center of dimples in Si made with smooth and patterned wheels. The surfaces produced by slotted and porous bronze wheels show more uniform, fine polishing grooves whereas the smooth wheel produced a varied pattern with some deeper grooves. We think the fine grooves reflect more uniform polishing by diamonds on the patterned surfaces instead of irregular polishing and scratching occurring with the smooth wheel. The patterned Delrin wheel also produced a smoother polish on Si than an unpatterned Delrin wheel.

We conclude that patterned wheels polish more effectively, and allow less aggressive treatments, (finer abrasives & lighter loads) throughout the dimpling process. This is especially important in the final stages ($\leq$20μm thickness) when the specimen is weakest. Reduced dimpling times may lessen chances for fracture. The deformable nature of Delrin wheels likely also reduces fracturing.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-95AL85000.

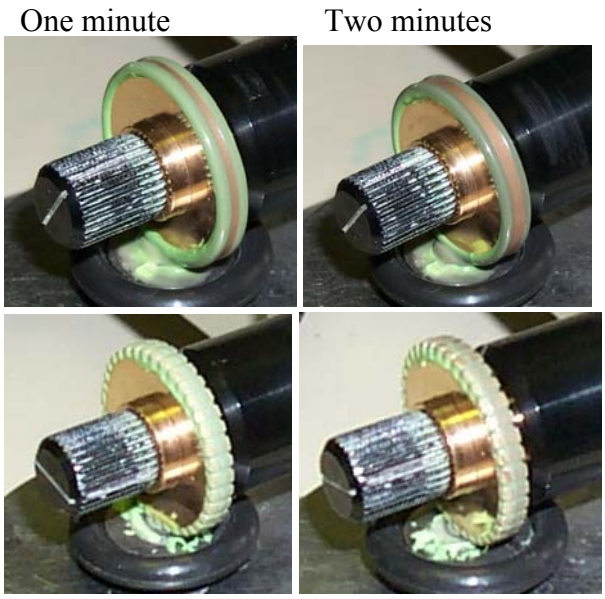


Figure 1. Wheels dimpling sapphire. Top: as-received, unpatterned brass. Bottom: brass with 36 slots. Dimpling with Gatan model 656 using 1 μm diamond compound & 40 g weight.

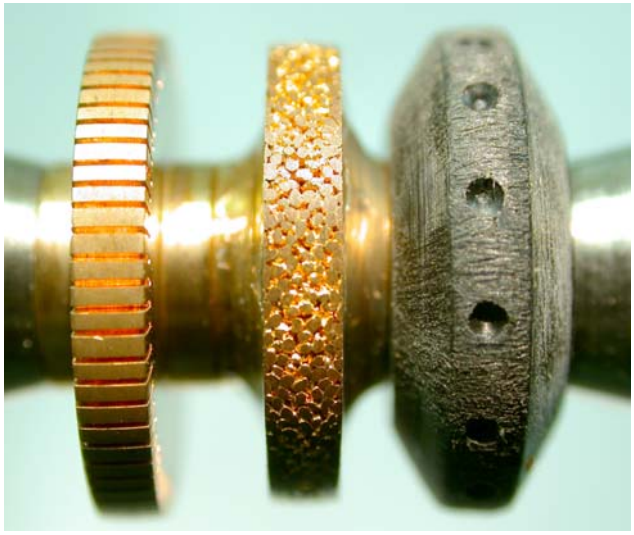


Figure 2. Surfaces of (left) brass wheel with 72 slots, (center) porous bronze wheel, and (right) patterned Delrin wheel.

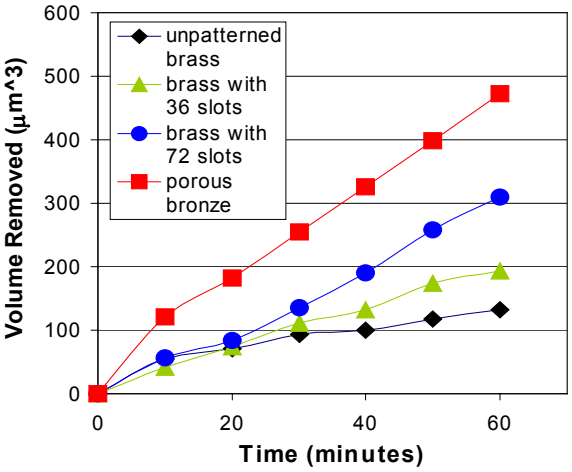


Figure 3. Dimple rates into sapphire for unpatterned brass, brass with 36 slots, 72 slots, and porous bronze wheels. Obtained with Gatan model 656 using 3 μm diamonds & 40 g weight.

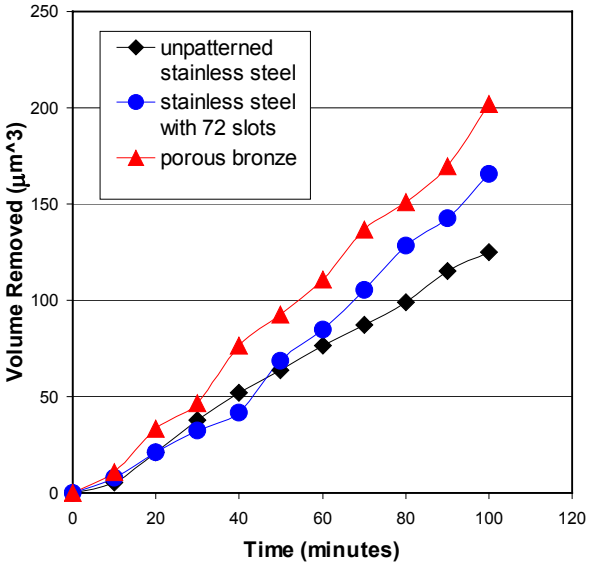
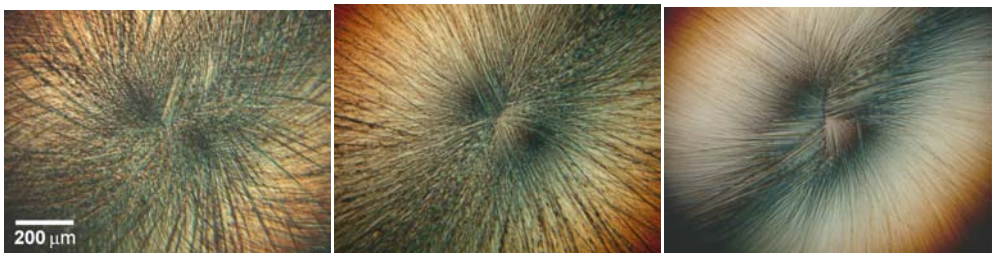


Figure 4. Dimple rates into SiC with unpatterned (as-purchased) stainless steel, slotted, and porous bronze wheels. Obtained with Fischione model 2000 using 1 μm diamonds and 40 g weight.

Figure 5. Images of Si polished with (left) unpatterned stainless steel, (center) with 72 slots, and (right) porous bronze dimpling wheels.



https://doi.org/10.1017/S1431927603444048 Published online by Cambridge University Press