PCD MANT® wire drawing dies for drawing fine copper wire

Diamond-based materials for drawing copper wire are state of the art. Below are some points for the usage of tools using polycrystalline diamonds vs. tools with monocrystalline diamonds – i.e. natural diamond (ND) and synthetic monocrystals (also known as monodies).

Drawing 1 shows an exemplar wire drawing geometry in a monocrystalline diamond with crystal orientation of <111>.

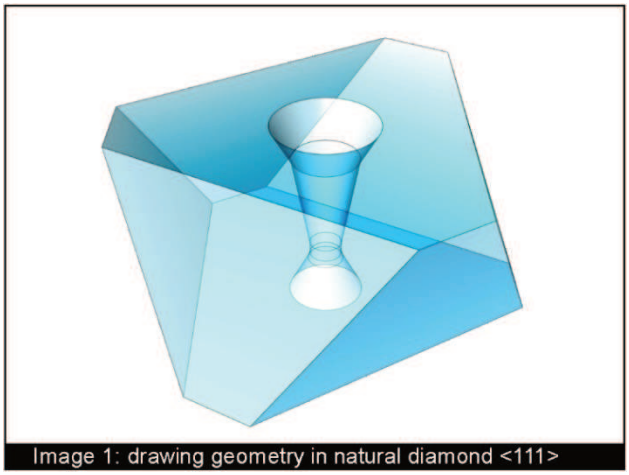

Image 1: drawing geometry in natural diamond <111>

Pictures, taken from perfectly polished ND-surfaces, using either optical microscopy or even scanning electron microscopy, are “optically empty”. There are no contrasting features on the atomic surface. Which is why we omit an actual picture.

Using optical microscopy to inspect a polished PCD yields also a perfectly smooth surface. However, depending on the grainsize of the PCD, the light appears a little more diffuse.

SEM-micrographs of even perfectly polished PCD-surfaces reveal the granular structure of the material (Image 2).

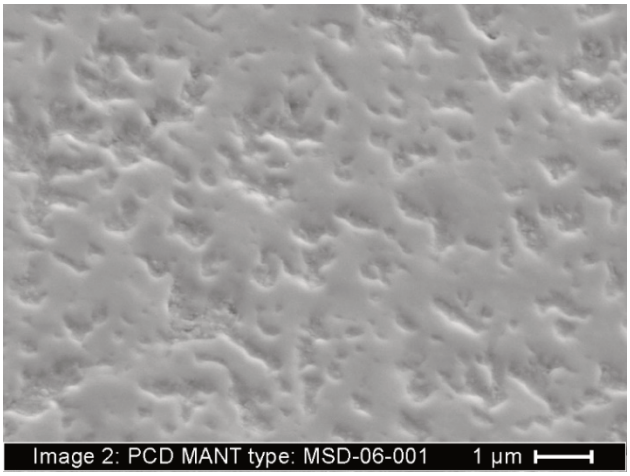

Image 2: PCD MANT type: MSD-06-001 1 µm

This is to be expected of course, as PCD is made from diamond powder – microscopically small monocrystalline grains of diamond (Image 3), which is sintered into a die in a high-pressure-high-temperature process involving a catalyst (e.g. cobalt), at temperatures around 1400 °C and pressures of 60 kbar. The result is a contiguous structure of interconnected monocrystalline diamond-grains, the PCD.

Diamond consists of cubically arranged carbon atoms, a material with directional physical properties (anisotropy). Directional differences of hardness in diamonds have been measured to have a ratio of 1:9.

Since hardness is the same as resistance to wear, ND wears preferably in certain directions. When drawing wire in tools using ND, carbon atom layers are stripped off the surface of the diamond, preferably in the “softer” directions. The cylindrical part of the drawing die geometry becomes oval while the atomic surface stays solid and smooth.

In contrast, the random orientation of diamond grains in a PCD die, suggest the material’s hardness to be isotropic. The paradox: wear of a PCD is higher by weight but its service life is longer.

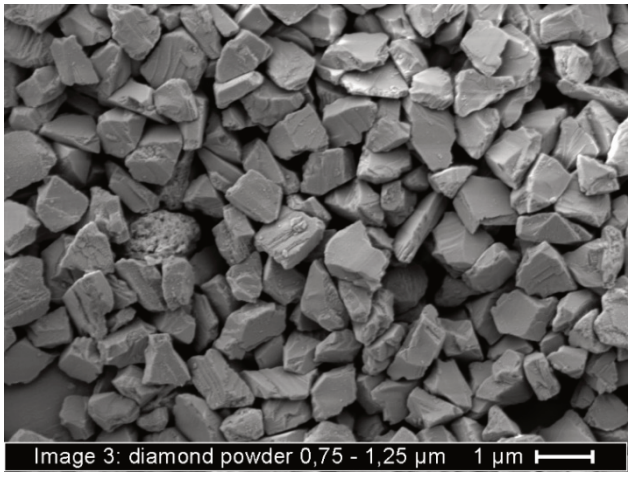

Image 3: diamond powder 0,75 - 1,25 µm 1 µm

Let’s trace back to image 2. We can see the polished surface of a PCD of type MANT® with a grainsize of 1 µm, the wavelength of infrared light. Because the mechanical polishing of diamond (e.g. supported with ultrasonic sound) can only be done using diamond powder, making this endeavour nothing but guided wear, the surface-diamond grains’ points are smoothed off, but the crystalline structure remains.

It’s yet to be settled whether these depressions on the surface – the softer flanks of the formerly single crystals – have a beneficial impact on the effect of the lubricant, perhaps like “lubrification pockets”.

As to the choice, which material (ND or PCD) would be better suited – apart from the price question – the following is as true as ever in practice:

Wire drawing dies with natural diamonds – best wire surface, higher proneness to non-circularity

Wire drawing dies with PCD – a rougher wire surface, longer tool life

Image 4: drawing die PCD MANT Ø 0,1820 mm

With the achievable smoothness of PCD wire drawing dies made with MANT® (see www.mant.com) with a grainsize of 1µm, it is nowadays possible and in practice to setup multi-die drawing machines without ND-wire drawing dies at all. The period of use of PCD MANT® wire drawing dies, e.g. for end-dies with 0.15 mm, is about 2-4 times higher than that of wire drawing dies with ND.

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