# Microlandscaped abrasive tools deliver perfect grinding results

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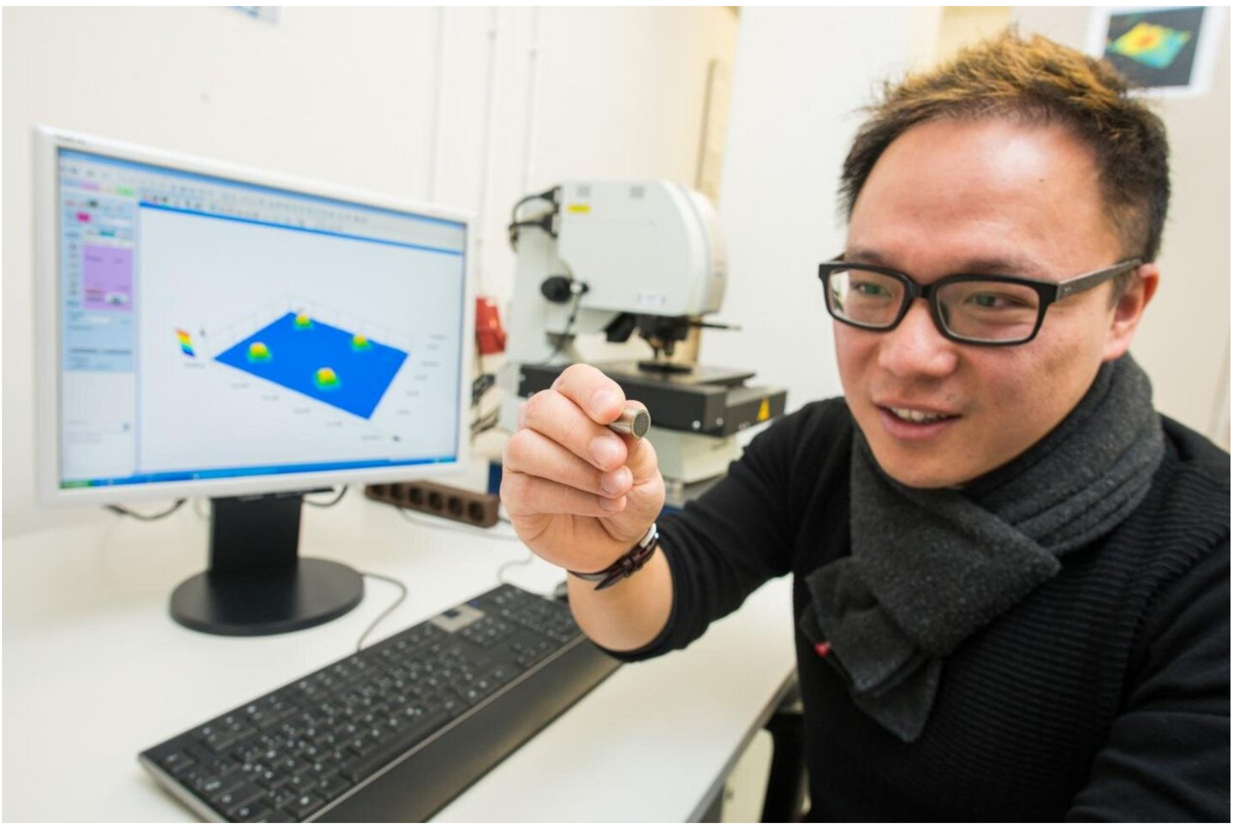

Dr. Shiqi Fang from Professor Dirk Bähre's research team at Saarland University with one of the tailor-made abrasive tools with its microstructured surface: in this case radial lines of minute raised dots. These microscopic structures whose size is similar to the width of a human hair, are enabling engineers to design novel grinding tools made from cemented carbides. Engineering professor Bähre and his team are using lasers to create carefully configured, micrometer-scale grinding surfaces. High-precision copies of these laser-generated surface patterns can then be produced in large numbers using electrochemical machining. Credit:

Oliver Dietze

Tiny pyramids and cubes precisely aligned in rows and columns or radial lines of minute raised dots—these microscopic structures whose size is similar to the width of a human hair, are enabling engineers to design novel grinding tools made from cemented carbides. Engineering professor Dirk Bähre and his team at Saarland University are using lasers to create carefully configured, micrometer-scale grinding surfaces. High-precision copies of these laser-generated surface patterns can then be produced cost-effectively and in large numbers using electrochemical machining.

The geometry and topography of surfaces are critical features in determining whether the mechanical components in a machine are able to run smoothly or whether a cutting tool is still sharp and able to do its job. How rough or smooth a surface is often dictates whether a machine component or tool has the quality and properties needed to meet the needs of users in industry, in the skilled trades or in the home-improvement sector. Grinding is a material removal process that is typically accomplished using abrasive particles bonded to the surface of the grinding tool. "Normally, the distribution of abrasive particles on these tools is simply random and is not defined geometrically or arranged in a specific structure," explains Professor Dirk Bähre of Saarland University. This effectively limits the quality of the ground surface that can be achieved.

Bähre, a specialist in the field of precision machining and finishing, and his research team are looking at ways of overcoming these limitations. They are developing grinding tools with structured surfaces made from cemented carbides that enable workpieces to be ground extremely precisely. Laser texturing is used to create the required fine structure of the tool's abrasive surface. "In order to find out how these microstructured abrasive domains actually perform, we created isolated structures with different geometries on the tool cutting surfaces. This allowed us to analyze the results of the grinding tests without worrying that neighboring structures were influencing or falsifying the results," explains research fellow Shiqi Fang. Fang, a post-doctoral research engineer in Dirk Bähre's group, carries out research into special material surfaces funded in part by the German Research Foundation (DFG).

After conducting these initial tests, the research team then examined the grinding results that could be achieved when several of these laser-textured abrasive surfaces are used in combination. The researchers are applying the knowledge acquired from these studies to design grinding tools with precisely preconfigured geometrical arrangements of abrasive particles. The topographies of these surfaces often follow clear geometrical structures, such as lines of tiny raised hemispherical dots spreading out radially from a central point, truncated pyramids arranged in rank and file, or chessboard patterns of alternating raised and sunken cuboids. The lasers are used to etch the structures into the carbide. "The technique we use to create these microstructures on the surface of the carbide is known as laser surface texturing or "LST' for short. It enables us to achieve a remarkable degree of geometrical precision," explains Shiqi Fang. The engineers have been testing their new cemented carbide grinding tools in a range of operational tests. "We are now validating the performance of these grinding tools relative to conventional tools and materials by carrying out machining tests and tribological studies and by examining their mechanical properties," says Dr. Fang.

The textured surfaces of these high-performance cemented carbide grinding tools can also be precision replicated in large numbers using a technique known as electrochemical machining (ECM). "By employing electrochemical machining, we are able to generate highly complex geometrical structures on the surfaces of very hard materials," explains

Professor Bähre, who also carries out research designed to optimize ECM methods. In ECM, the workpieces are bathed in a flowing electrolyte solution and can be electrochemically machined to the required geometry working to tolerances of a few thousandths of a millimeter. All the engineers need is a source of electrical power. A high electric current flows between the cathode, which in this case is the laser microtextured tool, and the anode, which is the workpiece to be processed. Both electrodes (cathode and anode) are immersed in a conducting fluid (the electrolyte), which is simply an aqueous salt solution. The electrochemical machining process causes minute particles of metals to be removed from the surface of the workpiece. The metal atoms on the surface of the workpiece enter the solution as positively charged metal ions enabling the workpiece to acquire the required geometric form and turning it into a highly precise grinding tool.

Using this approach, the Saarbrücken engineers are able to produce high-quality precision grinding tools using cost-effective hard materials. "We are also able to reproduce the surface topographies of well-established, but expensive, tooling materials in the required dimensions," explains Professor Bähre.

Provided by Saarland University