Scientists have found a way to 3D print one of the world's strongest engineering materials.

New research combining 3D printing and hot-wire lasers helps produce ultra-hard WC-Co carbide while reducing waste of expensive materials like tungsten and cobalt.

A new manufacturing method is opening up a new path for creating one of the hardest materials the industry has ever used.

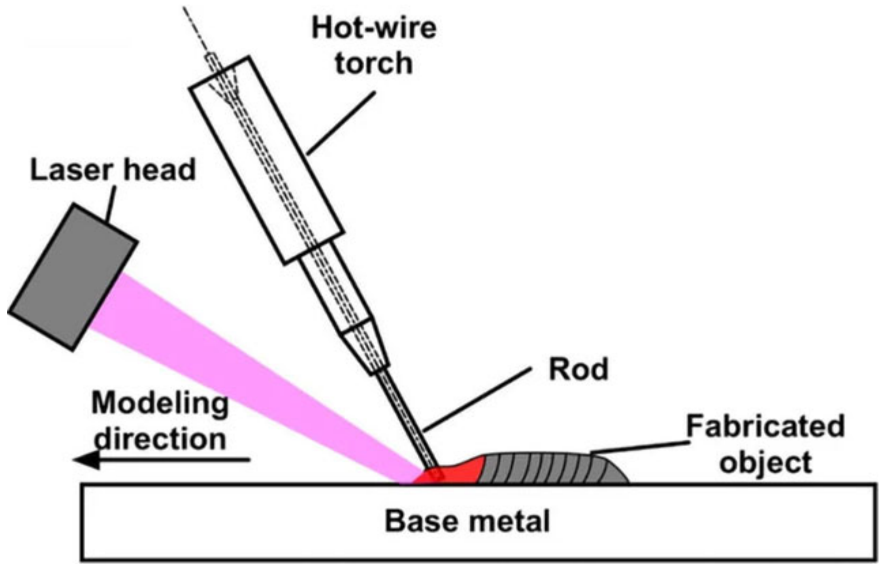
Tungsten-cobalt carbide (WC-Co) alloys are the foundational material for many ultra-durable cutting blades capable of cutting through metal, concrete, and stone. However, this exceptional hardness presents the biggest challenge in manufacturing. Once formed, the material is almost unyielding, making processing slow, expensive, and wasteful, while the final yield of satisfactory products is low.

This is particularly important because WC-Co cemented carbide is widely used in environments with high friction and heavy loads – where conventional metals quickly wear down. Currently, manufacturers mainly use powder metallurgy technology: WC and Co powders are pressed together, then sintered under high pressure and temperature to form solid parts.

The drawback lies in efficiency. While this method produces products with very high hardness and durability, it often consumes more expensive materials than are actually needed for the final part, reducing the recovery rate. New research is experimenting with a different approach, combining additive manufacturing (AM, also known as 3D printing) with hot-wire laser irradiation. The goal is to 'deposit' cemented carbide only where needed, maintaining performance while reducing waste and costs.

3D printing using hot wire laser

Instead of treating cemented carbide as a solid block that needs to be cut and shaped, the research team investigated whether it was possible to 'build' the material in a more selective way using 3D printing. Their main tool was hot-wire laser technology, which combines a laser beam with a preheated additive metal wire.



Preheating the additive wire accelerates deposition speed and improves efficiency, as the laser doesn't need to supply as much energy during the deposition process.

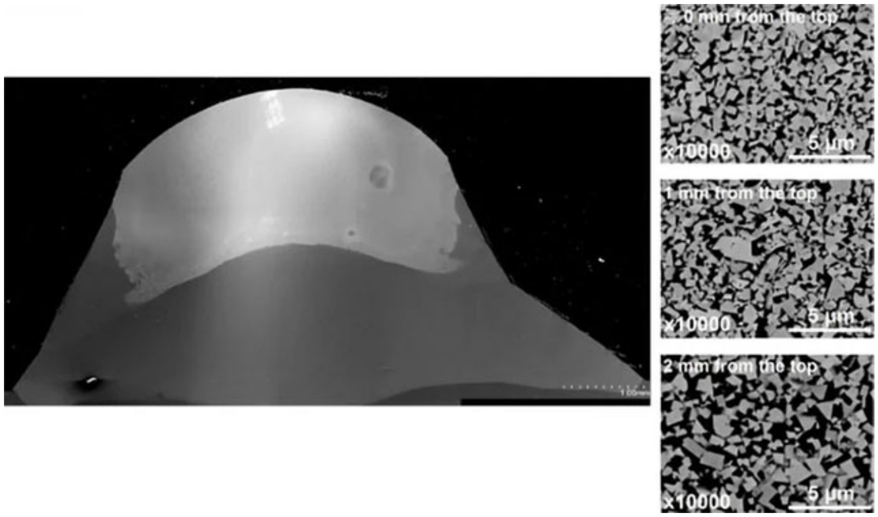
The team tested two implementation methods. In the first, the cemented carbide rod was brought forward during the layering process, with the laser beam directed at the top of the rod. In the second, the laser preceded and shone on the area between the bottom of the carbide rod and the substrate (iron). In both cases, the goal was to soften the metal rather than completely melt it. This approach aimed to shape the cemented carbide under less extreme thermal conditions, limiting the risk of cracking – a common occurrence with hard and brittle materials.

According to Associate Professor Keita Marumoto from Hiroshima University, materials like tungsten and cobalt are very expensive, so reducing consumption is crucial. 3D printing allows for material deposition only where needed, rather than machining a large block and then removing the excess.

Achieves industrial hardness without defects.

The results showed that this method could maintain hardness and mechanical integrity equivalent to traditionally produced WC-Co carbide. The matrix material achieved a hardness of over 1400 HV (HV unit), without defects or structural degradation.

At this level of hardness, the material is among the hardest materials used in industry, second only to superhard substances like sapphire or diamond. Creating defect-free cemented carbide molds – the main goal of the research – has been shown to be feasible, although some results remain variable.



For example, the 'bar-first' method tends to cause WC degradation at the top of the structure, leading to defects in the final product. The 'laser-first' method also struggles to maintain the necessary stiffness. To overcome this, the research team added an intermediate layer based on a nickel alloy, while also tightly controlling the temperature: higher than the melting point of cobalt but lower than the threshold that causes the material particles to overgrow. As a result, the 3D-printed cemented carbide maintained the desired stiffness.

The current positive results are seen as a stepping stone for further research. The team wants to continue improving the design to reduce the risk of fractures and create more complex shapes.

According to Marumoto, the approach of softening the metal instead of melting it completely is a novel idea with potential applications not only to cemented carbide, but also to many other types of materials.

In the future, the research team aims to directly manufacture cutting tools, experiment with new materials, and find ways to improve the long-term durability of the product.

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