Solutions Flash

New Unique Tungsten Titanium Carbide (WTiC) Materials Offer Application Benefits Versus Traditional Tungsten Carbide Materials

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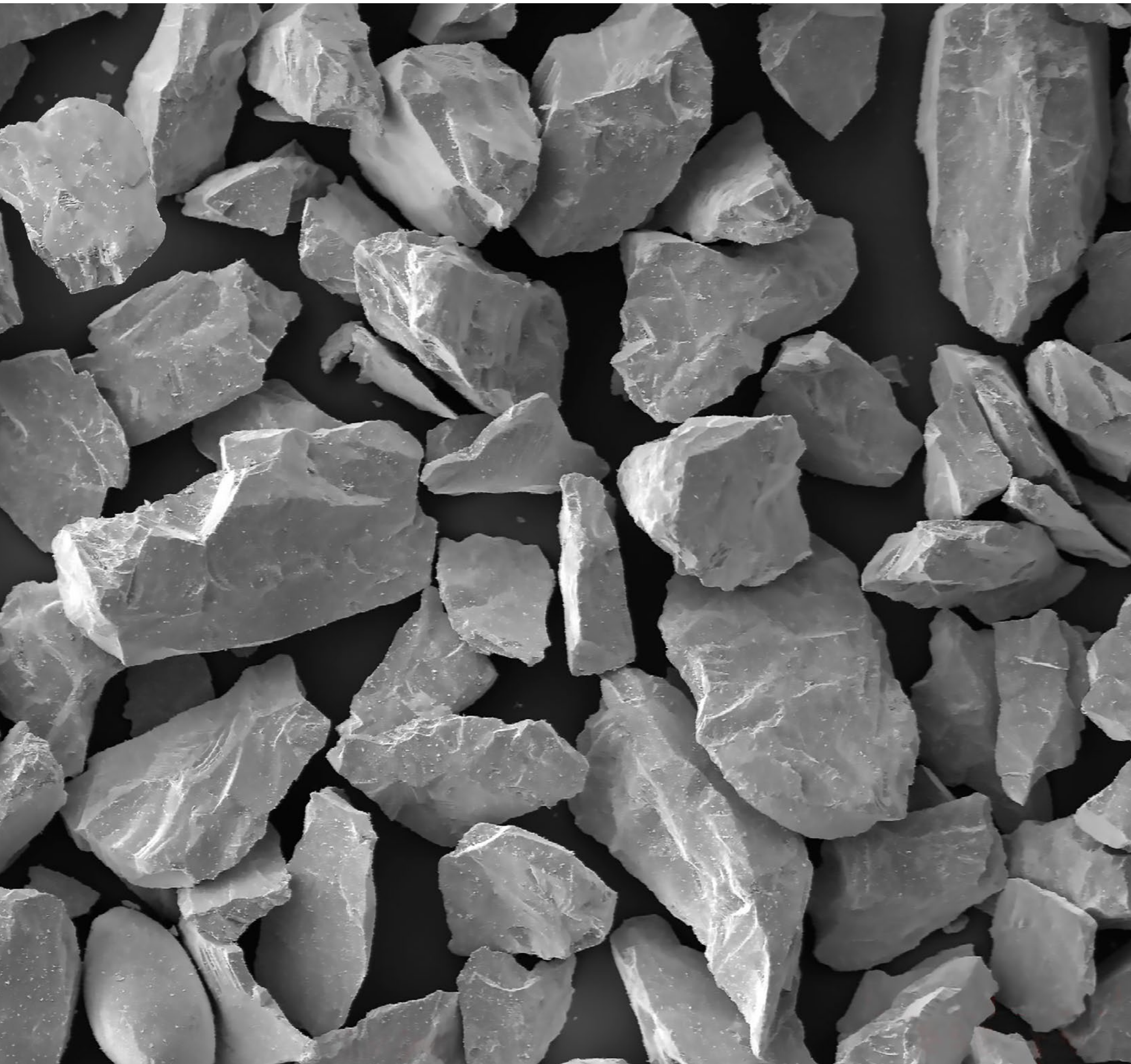


Today's Situation

Tungsten carbide is well known as a surface treatment to protect against wear of various forms. It can be successfully applied using a wide range of industrial processes, including thermal spray, various types of welded overlays, PTA (plasma transferred arc) as well as laser cladding. However, while tungsten carbide is very popular, it is not without its drawbacks.

First, the application of tungsten carbide can be quite technique dependent. To achieve the desired wear resistance, all carbide surfacing techniques rely on the carbide grains remaining undissolved in the matrix of the applied deposit. Carbide dissolution not only results in a loss of wear resistance, it also results in the formation of complex secondary phases that are brittle and highly prone to cracking.

Second, tungsten carbide overlays are of high density and heavy. This can limit their use in weight-sensitive and high inertia applications. Higher density also means higher cost per unit of weight of applied overlay.

Next, tungsten carbide is not known for its corrosion resistance, and its use in more corrosion resistant matrices is very limited as a result of its instability in presence of other carbide-forming elements such as chromium, molybdenum or niobium that are commonly used in corrosion resistant alloys.

Finally, as a result of its popularity, the raw materials to produce tungsten carbide powders are increasingly harder to obtain on the world market, and while Metco Joining & Cladding has stable sources of supply, supply chain pressure continues to increase.

Our Solution

Metco Joining & Cladding has developed wear-resistant tungsten titanium carbide (WTiC) materials that help to mitigate the shortcomings of tungsten carbide overlays.

WTiC is far less technique dependent in that these carbides are resistant to dissolution during processing, meaning that overlays are far more likely to consistently provide the wear resistance needed for the application and without fear of embrittlement and subsequent cracking.

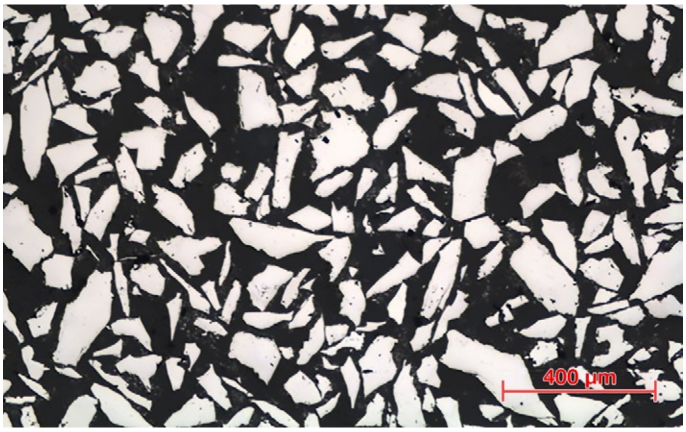
The density of WTiC is significantly lower than that of tungsten carbide allowing deposits of equal overlay thickness to be applied at reduced weight. Lower density = lower weight = less material required = lower costs. This can also be important for weight-restrictive and high inertia applications.

WTiC is more corrosion resistant than tungsten carbide and is compatible with more matrices — including nickel-based and iron-based materials. This further opens up wear solutions with better corrosion resistance, as in the case of nickel-based matrices, and economics and strength as in the case of iron-based matrices.

Finally, the reduced tungsten content helps to ease ever-growing pressures on the worldwide supply of tungsten carbide.

This material, offered to the market as Metco 50201A, can be applied using laser cladding, PTA and weld overlay methods such as GMAW (MIG) including "drop-in" GMAW when blended with matrix materials as specified in Section 8.1.

It should also be noted that while WTiC materials are not new to the market, Metco Joining & Cladding's ability to produce WTiC materials with coarser grain sizes is unique, further expanding the use of these materials to combat wear of various forms and in various applications.



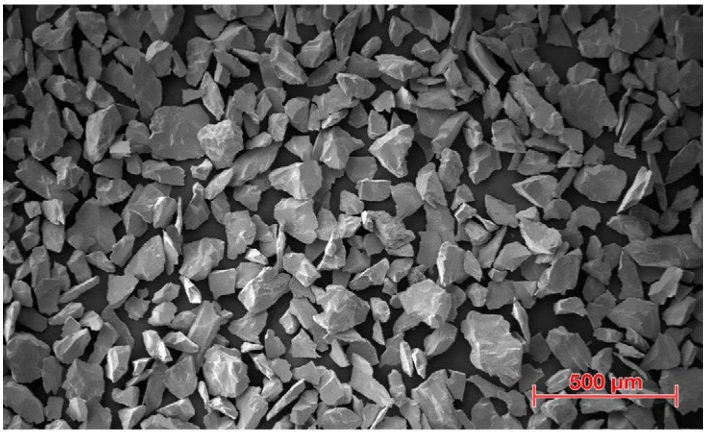


Figure 1. Inner morphology (left) and outer morphology (right) of Metco Joining & Cladding's WTiC powder available as Metco 50201A.

Solution Description and Validation

1. What is WTiC?

Metco 50201A is a fully alloyed tungsten in a titanium carbide cubic lattice. It can be interchangeably represented as WTiC, TiWC or $(Ti,W)C_{1-X}$.

It combines advantages of both tungsten carbide and titanium carbide while reducing their less favorable characteristics.

Tungsten carbide has good ductility and wear resistance but it is also unstable in many molten alloys. Its density is also very high that leads to its segregation when combined with lower density alloys.

Titanium carbide is very hard and stable but it is also brittle and has low density.

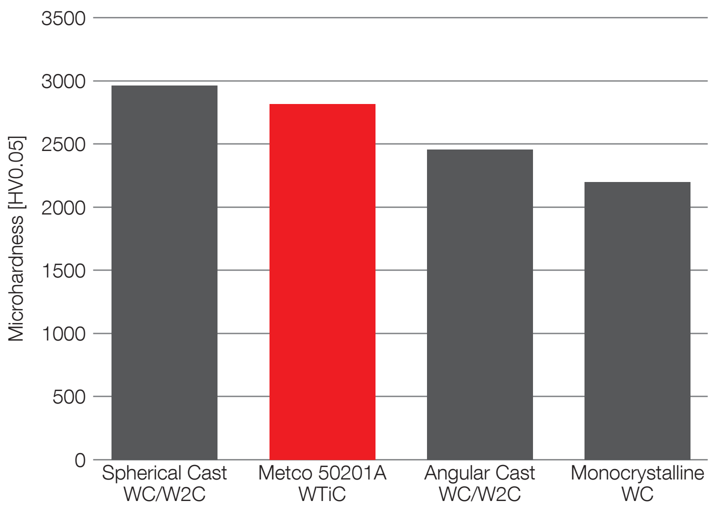
By combining characteristics of both tungsten carbide and titanium carbide, WTiC is able to provide high stability in highly alloyed matrices, good ductility, wear resistance and density more similar to metal alloys.

While WTiC is known and used in many applications it is only known as a fine powder or a coarser agglomerated and sintered powder with lots of internal porosity and low cohesive strength. Metco Joining & Cladding uses a proprietary fusing technology to make very coarse and dense particles of WTiC and is currently the only producer of such a powder in the world. The high particle density transfers into high mechanical properties and its chemistry has been designed to increase ductility and impact resistance. The powder has angular morphology but can also be produced as a spherical powder.

2. Carbide Grain Hardness

WTiC exhibits excellent hardness when compared to that of tungsten carbide manufactured by various processes. It even comes very close to that of very hard spherical cast tungsten carbide.

Carbide Type	Microhardness [HV0.05]
Spherical Cast Tungsten Carbide	2965
Tungsten Titanium Carbide - Metco 50201A	**2818**
Angular Tungsten Carbide	2457
Mono Tungsten Carbide	2200



3. Low Dissolution

Unlike tungsten carbide, WTiC is very resistant to dissolution. Therefore, it can be far less technique dependent to apply. Once parameters are established, customers should find they obtain reliable, repeatable deposits more readily than with tungsten carbide deposits.

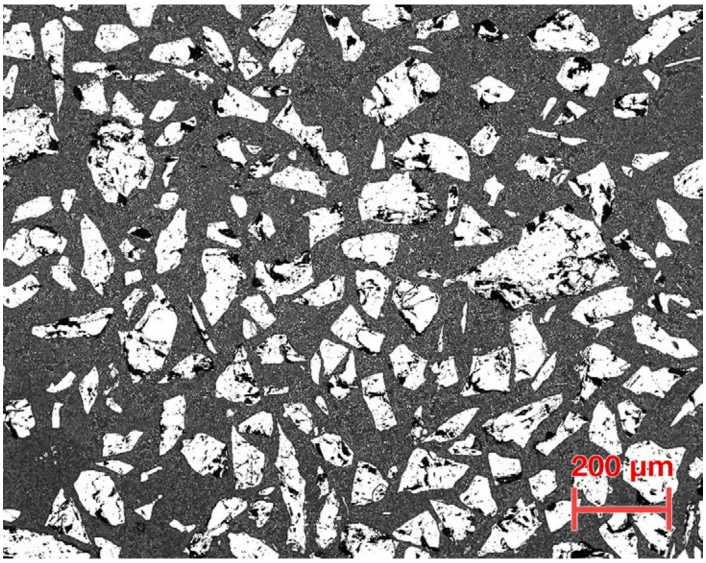
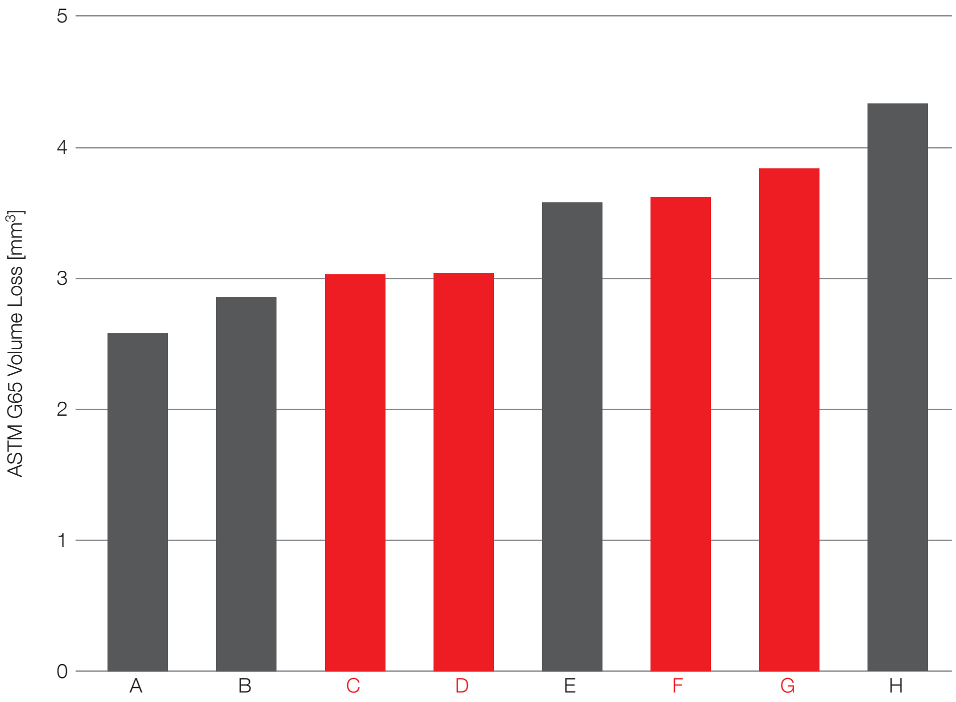


Figure 2. SEM photomicrograph of a PTA deposit of Metco 50201A (WTiC) in a matrix of Metco 1030A (iron-based alloy) demonstrating the low dissolution of the WTiC (white regions).

4. Abrasion Resistance

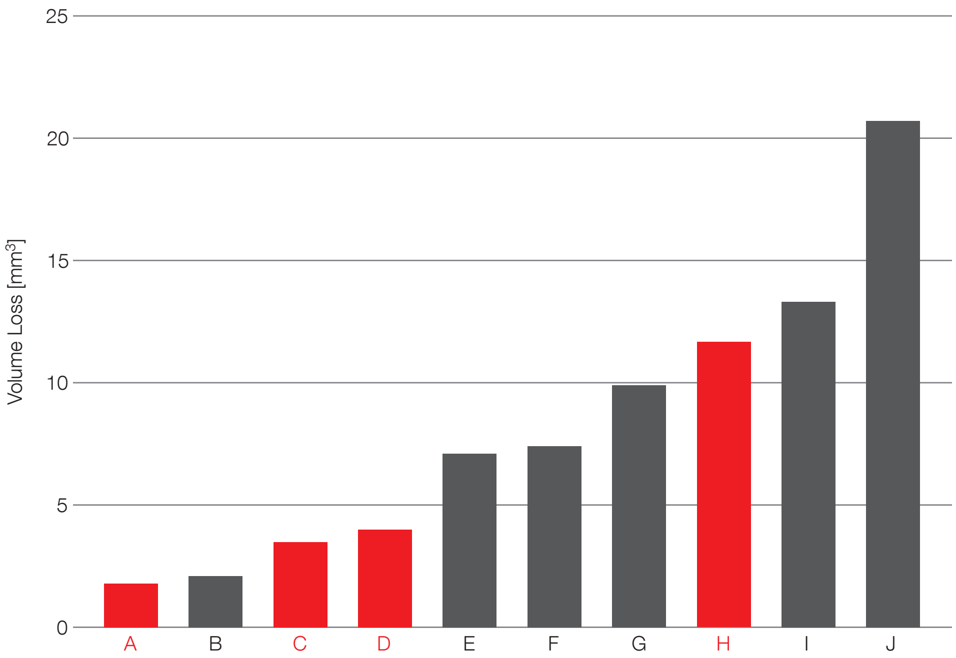
WTiC demonstrates excellent abrasion resistance compared to a variety of tungsten carbide materials. All overlays applied using PTA. Lower values represent better abrasion resistance.



A. PlasmaDur 51322 (monocrystalline tungsten carbide)
B. PlasmaDur 51937 (spherical cast tungsten carbide)
C. Metco 50201A + 40% Metco 1040A
D. Metco 50201A + 40% Metco 1030A
E. PlasmaDur 51202 (cast tungsten carbide)
F. Metco 50201A + 40% MetcoClad 316L-Si
G. Metco 50201A + 40% Metco 1625B
H. PlasmaDur 51027 (cast tungsten carbide)

5. Impact Resistance

WTiC also provides excellent impact resistance in service. Overlays applied using PTA. Lower values represent better impact resistance.



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E. PlasmaDur 51202 (cast tungsten carbide)
F. PlasmaDur 51027 (cast tungsten carbide)
G. PlasmaDur 51322 (monocrystalline tungsten carbide)
H. Metco 50201A + 40% Metco 1040A
I. PlasmaDur 51302 (monocrystalline tungsten carbide)
J. PlasmaDur 51122 (monocrystalline tungsten carbide)

Impact Test Setup:

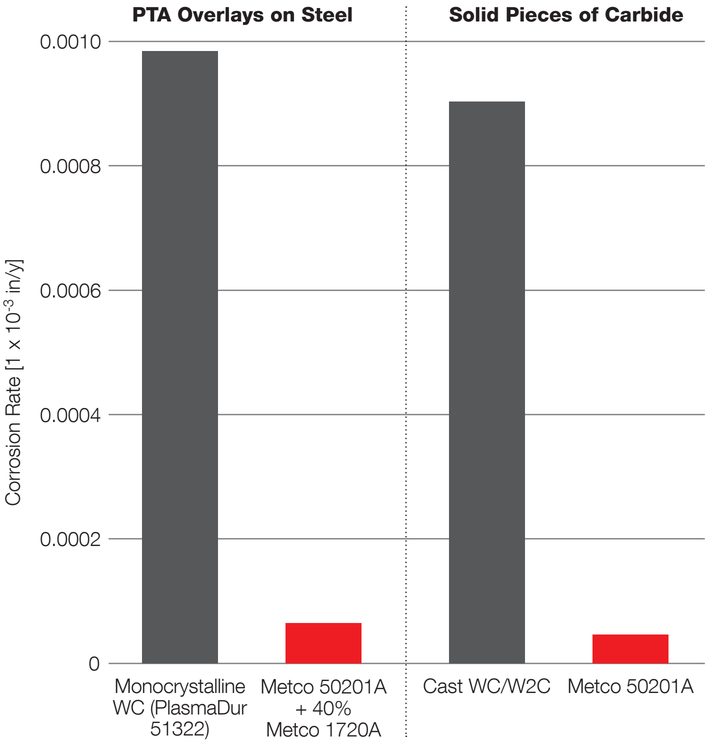
Principle:	A single arm with a ball bearing impacts a stationary sample
No. of Samples:	3
Duration:	24 min in 4 min increments
Arm RPM:	150 ± 5 rpm
Impact Energy:	≈ 8 J
Weight Loss:	Average of 3 samples
Volume Loss:	Calculated from weight loss and density

6. Corrosion Resistance

The corrosion resistance of WTiC is truly superior to that of tungsten carbide and should be strongly considered for applications involving both wear and corrosion.

Electrochemical corrosion testing shows that Metco 50201A has significantly lower corrosion rates and more electropositive potential compared to tungsten carbide.

Linear polarization resistance pr ASTM G59



Corrosion Test Conditions:

NaCl Content:	3.5 %
pH:	8.3 (adjusted by NaOH)
Aeration:	None
Temperature:	Room temperature
Potentiometer:	Gamry

- Samples allowed to stabilize for 16 h before proceeding with corrosion rate measurement
- Linear polarization resistance per ASTM G59
- Tafel polarization used to determine Tafel slopes
- Data collected is used to estimate corrosion rates by applying Faraday's law
- Generalized corrosion rate calculated in 0.001 in per year
- 0.001 in = 25.4 µm

7. Density Comparison

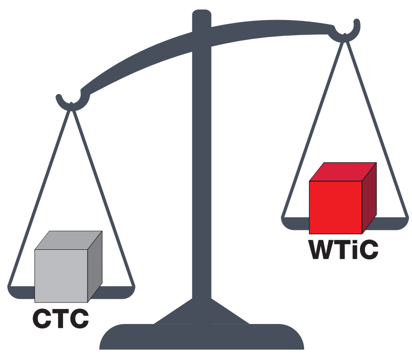
The density of WTiC (Metco 50201A) is considerably lower than that of tungsten carbide. This is important for several reasons:

- WTiC may be a better choice for weight-sensitive and high inertia applications
- When comparing deposit thickness, the same thickness of WTiC can be applied as that of tungsten carbide at a lower weight, which should be considered in cost calculations; or
- A thicker deposit of WTiC can be applied at the same weight as a thinner deposit of tungsten carbide, which should be considered for overall service life.

Note: Volume and thickness differences must also take into account blend ratios and matrix density.

Carbide Type	Carbide Density [g/cm³]	Carbide Volume of 1 kg [cm³]
Cast WC/W2C	16.5	60.6
Monocrystalline WC	15.6	64.0
WTiC (Metco 50201A)	**10.0**	**100**

The same weight → more overlay of Metco 50201A



The same overlay thickness → lower weight

8. Matrix Compatibility

Unlike tungsten carbide, WTiC is not compatible with standard self-fluxing alloy matrices as this can result in overlay porosity.

However, this doesn't limit the choices for possible matrices to use with WTiC. For corrosion resistance, nickel-based superalloys can be used. For additional hardness and strength, iron-based and steel matrices are recommended.

Tungsten carbide blends usually require 60 wt. % carbide + 40 wt. % matrix. To achieve the same deposit volume, Metco 50201A requires approximately 36 to 39 wt. % although to achieve the best results, most applications will require 50 to 60 wt. % of Metco 50201A blended with 40 to 50 wt. % of matrix material.

8.1 Recommended Matrix Materials for Use With Metco 50201A:

Product	Type
Metco 1625D	Nickel-based superalloy
Metco 1030A	Iron-based alloy
Metco 1040A	Iron-based alloy
Metco 1051A	Iron-based alloy
MetcoClad 316L-Si	Stainless steel (Type 316)
Metco 1720A	Nickel-based alloy
Metco 1020A	Iron-based alloy

Please note that many other matrix material are available. For specific recommendations, please contact your Metco Joining & Cladding Account Manager.

8.2 Matrix Selection

As with any application, the selection of matrix material will make a difference in the service properties of the deposit. Metco Joining & Cladding can assist in selecting an appropriate matrix material for your application.

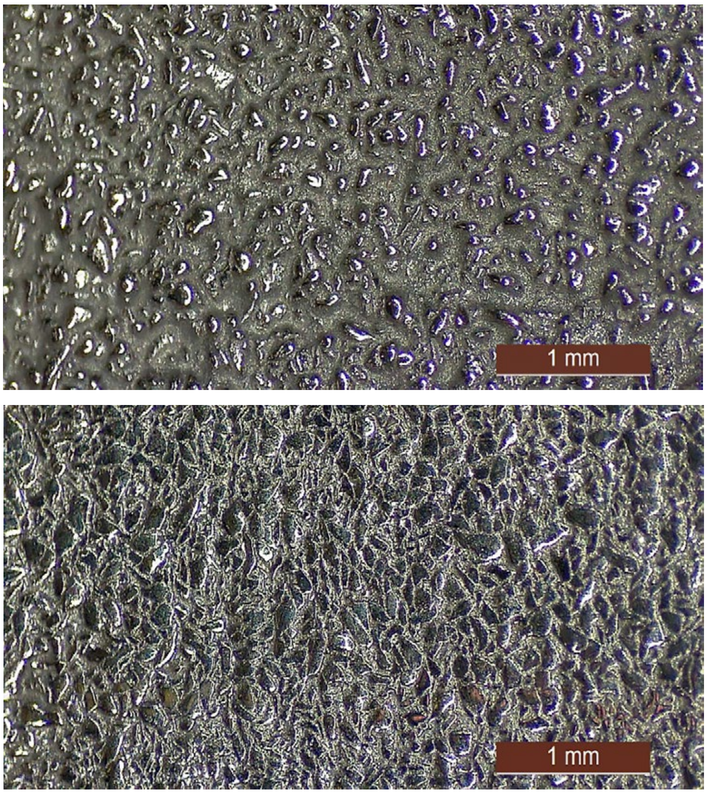


Figure 3. Wear scars of deposits of Metco 50201A in different matrices. Top: Metco 50201A + 40 % Metco 1625D (similar to Inconel 625). Bottom: Metco 50201A + 40 % Metco 1720A (proprietary nickel-based alloy). Note the difference in wear behavior using different matrices. The carbides in the top photo appear more washed out, worn and rounded. In the bottom photo, the carbides remain sharper and more densely packed.

9. Summary

The following table compares and summarizes WTiC versus various types of tungsten carbide. For numeric values, 1 is best.

	Cost		Resistance / Hardness					Matrix Compatibility			Process Compatibility			
	Cost per weight	Cost per volume	Impact resistance	Low stress abrasion resistance	Corrosion resistance	Dissolution resistance	Microhardness	Iron-based alloy matrix	Nickel-based superalloy matrix	Nickel-based self-fluxing alloy matrix	PTA	Laser cladding	GMAW (MIG)	Spray & Fuse
WTiC (tungsten titanium carbide)	4	1	1	3	Yes	1	2	Yes	Yes	No	Yes	Yes	Yes	No
Cast tungsten carbide	2	3	2	3	No	3	3	No	No	Yes	Yes	Yes	Yes	Yes
Spherical cast tungsten carbide	3	4	1	1	No	3	1	No	No	Yes	Yes	Yes	Yes	Yes
Monocrystalline tungsten carbide	1	2	3	2	No	2	4	No	No	Yes	Yes	Yes	Yes	Yes

Customer Benefits

Effective

- Deposits exhibit excellent wear and impact resistance
- Offers corrosion resistance not provided by standard tungsten carbide
- Resists dilution resulting in highly repeatable deposits
- Highly recommended for wear applications where corrosion is a factor
- Lower density factors into weight-sensitive and high inertia application

Economical

- Lower density means same deposit volume using less material by weight
- Thicker coatings using the same weight of material as tungsten carbide can result in longer component service life

Efficient

- Can be applied using standard processes such as PTA, laser cladding and GMAW
- Low dilution results in deposits that are less technique dependent than tungsten carbide for reliable, repeatable results
- Compatible with more corrosion resistant nickel-based matrix materials and higher strength iron-based materials

Environmental

- Reduced tungsten content results in more secure supply chain management

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