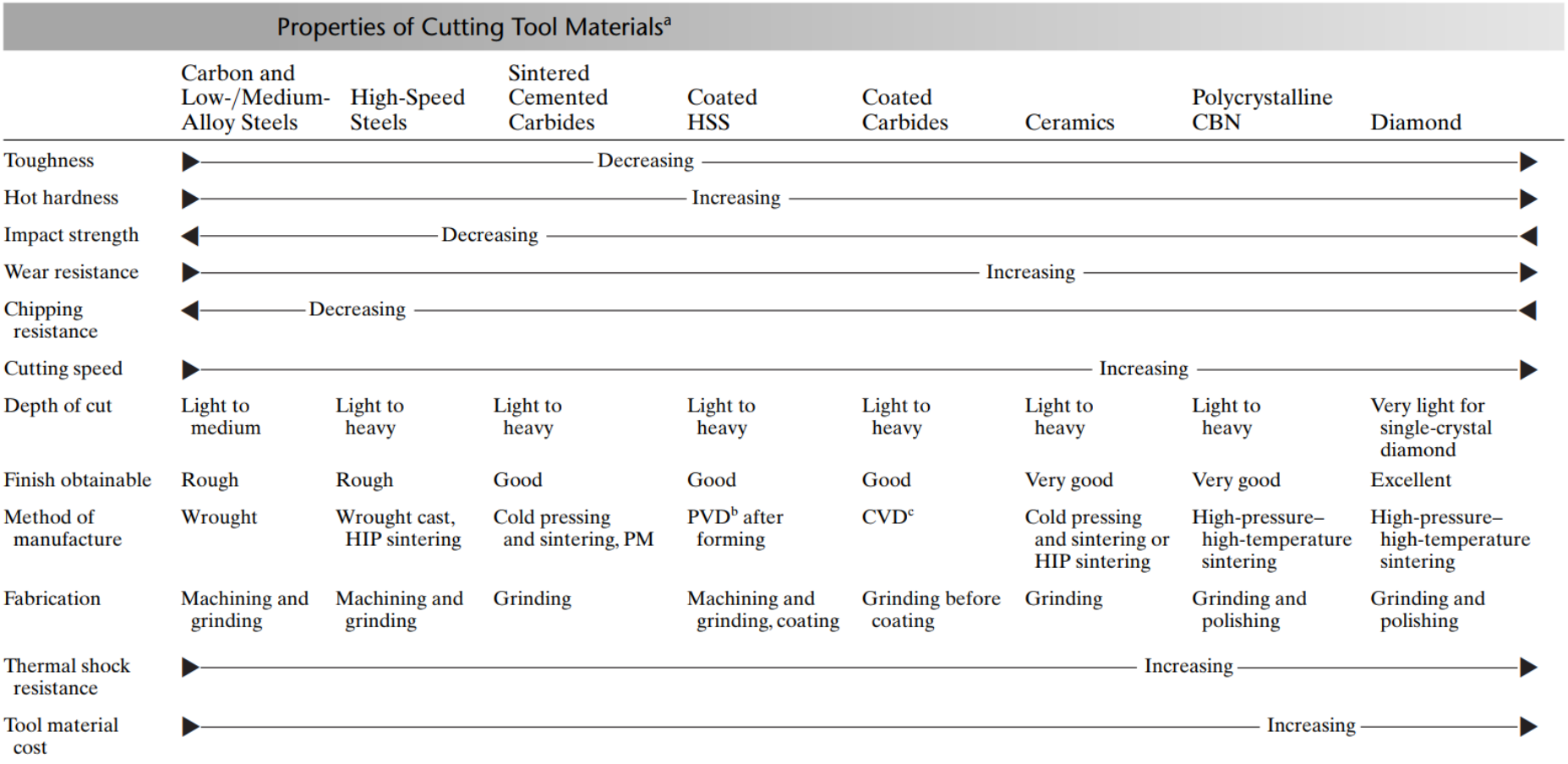
# Cutting Tools

# Salient Properties of Cutting Tool Materials



Properties of Cutting Tool Materials[a]

| | Carbon and Low-/Medium-Alloy Steels | High-Speed Steels | Sintered Cemented Carbides | Coated HSS | Coated Carbides | Ceramics | Polycrystalline CBN | Diamond |
|---|---|---|---|---|---|---|---|---|
| Toughness | ▶ Decreasing ▶ | | | | | | | |
| Hot hardness | ▶ Increasing ▶ | | | | | | | |
| Impact strength | ◀ Decreasing ◀ | | | | | | | |
| Wear resistance | ▶ Increasing ▶ | | | | | | | |
| Chipping resistance | ◀ Decreasing ◀ | | | | | | | |
| Cutting speed | ▶ Increasing ▶ | | | | | | | |
| Depth of cut | Light to medium | Light to heavy | Light to heavy | Light to heavy | Light to heavy | Light to heavy | Light to heavy | Very light for single-crystal diamond |
| Finish obtainable | Rough | Rough | Good | Good | Good | Very good | Very good | Excellent |
| Method of manufacture | Wrought | Wrought cast, HIP sintering | Cold pressing and sintering, PM | PVD[b] after forming | CVD[c] | Cold pressing and sintering or HIP sintering | High-pressure–high-temperature sintering | High-pressure–high-temperature sintering |
| Fabrication | Machining and grinding | Machining and grinding | Grinding | Machining and grinding, coating | Grinding before coating | Grinding | Grinding and polishing | Grinding and polishing |
| Thermal shock resistance | ▶ Increasing ▶ | | | | | | | |
| Tool material cost | ▶ Increasing ▶ | | | | | | | |

[a] Overlapping characteristics exist in many cases. Exceptions to the rule are very common. In many classes of tool materials, a wide range of compositions and properties are obtainable.
[b] Physical vapor deposition.
[c] Chemical vapor deposition.

# TOOL MATERIALS

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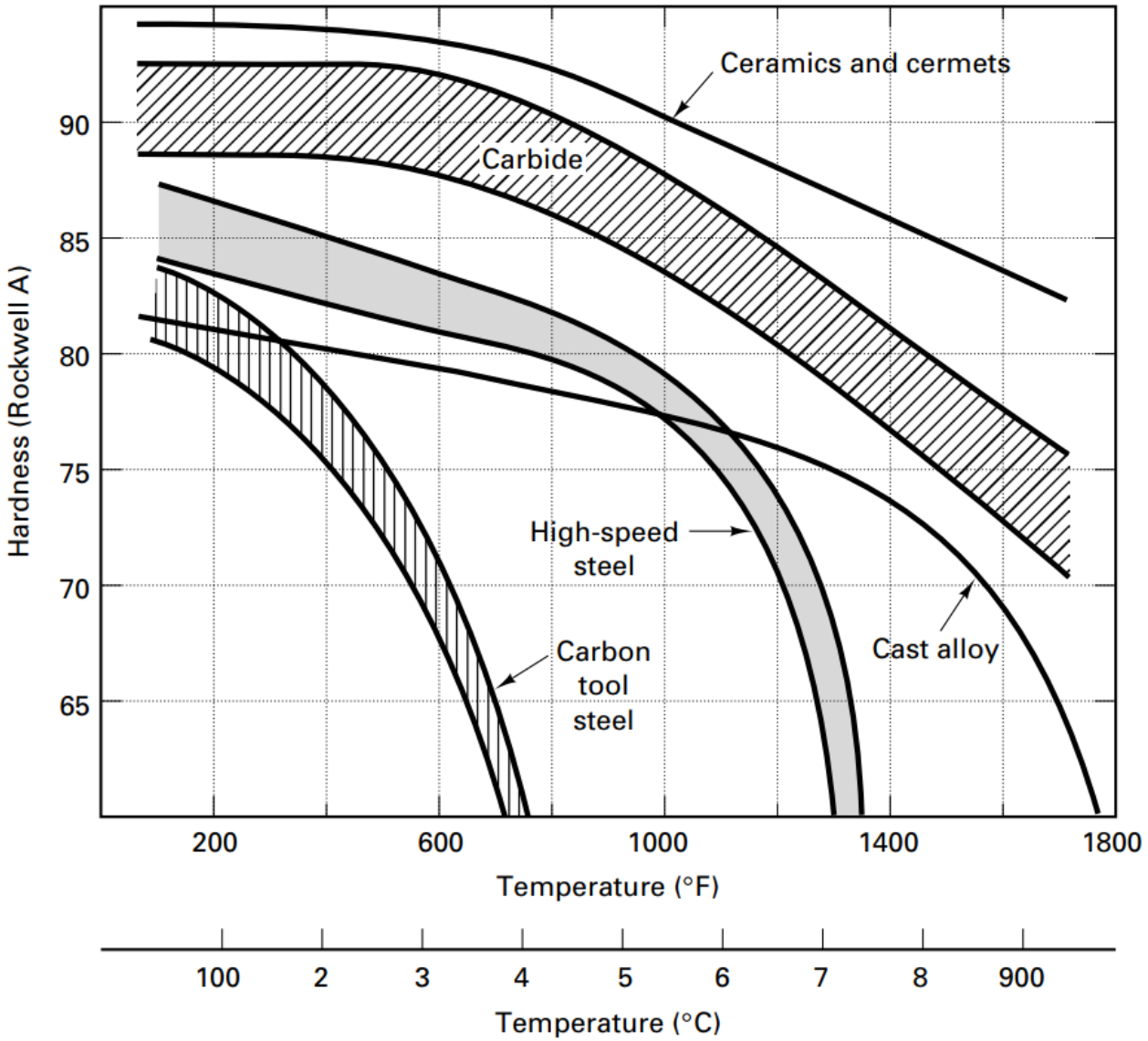
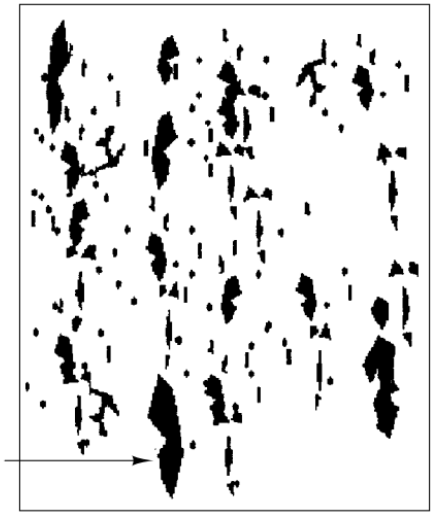
# Desirable Tool Qualities

- High hardness
- High hardness temperature (hot hardness) – hardness decreases slowly with temperature
- Resistance to abrasion and wear due to severe sliding friction
- Resistance to chipping of the cutting edges
- High toughness (impact strength) – for interrupted cuts
- Strength to resist bulk deformation
- Good chemical stability
- Adequate thermal properties
- High elastic modulus (stiffness)
- Correct geometry and surface finish

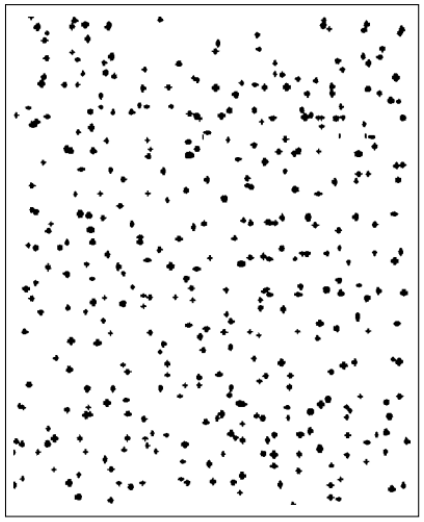
# Hardness and Hot Hardness



# Carbide Distribution




Conventional tool steel microstructure



P/M tool steels microstructure

## Wear Resistance

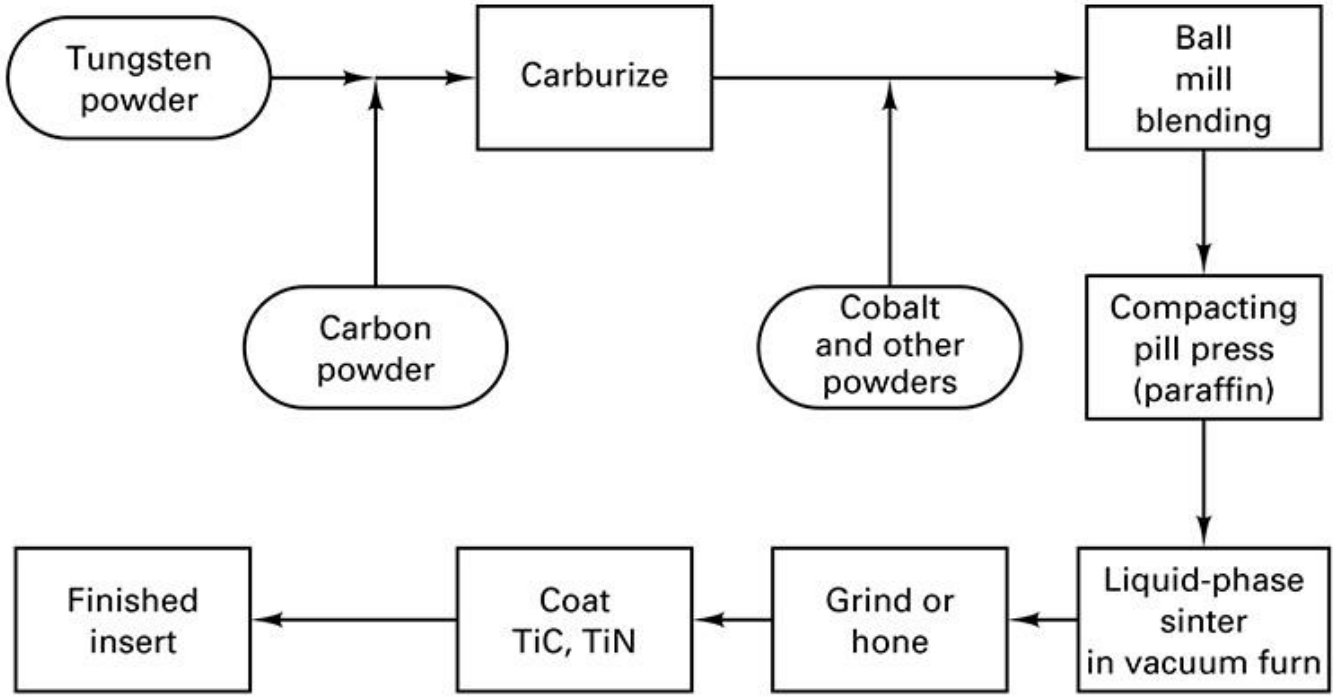
Alloy elements (Cr, V, W, Mo) form hard carbide particles in tool steel microstructures. Amount & type present influence wear resistance.

## Hardness of carbides:

| | |
|---|---|
| • Hardened steel | • 60/65 HRC |
| • Chromium carbides | • 66/68 HRC |
| • Moly, tungsten carbides | • 72/77 HRC |
| • **Vanadium carbides** | • **82/84 HRC** |

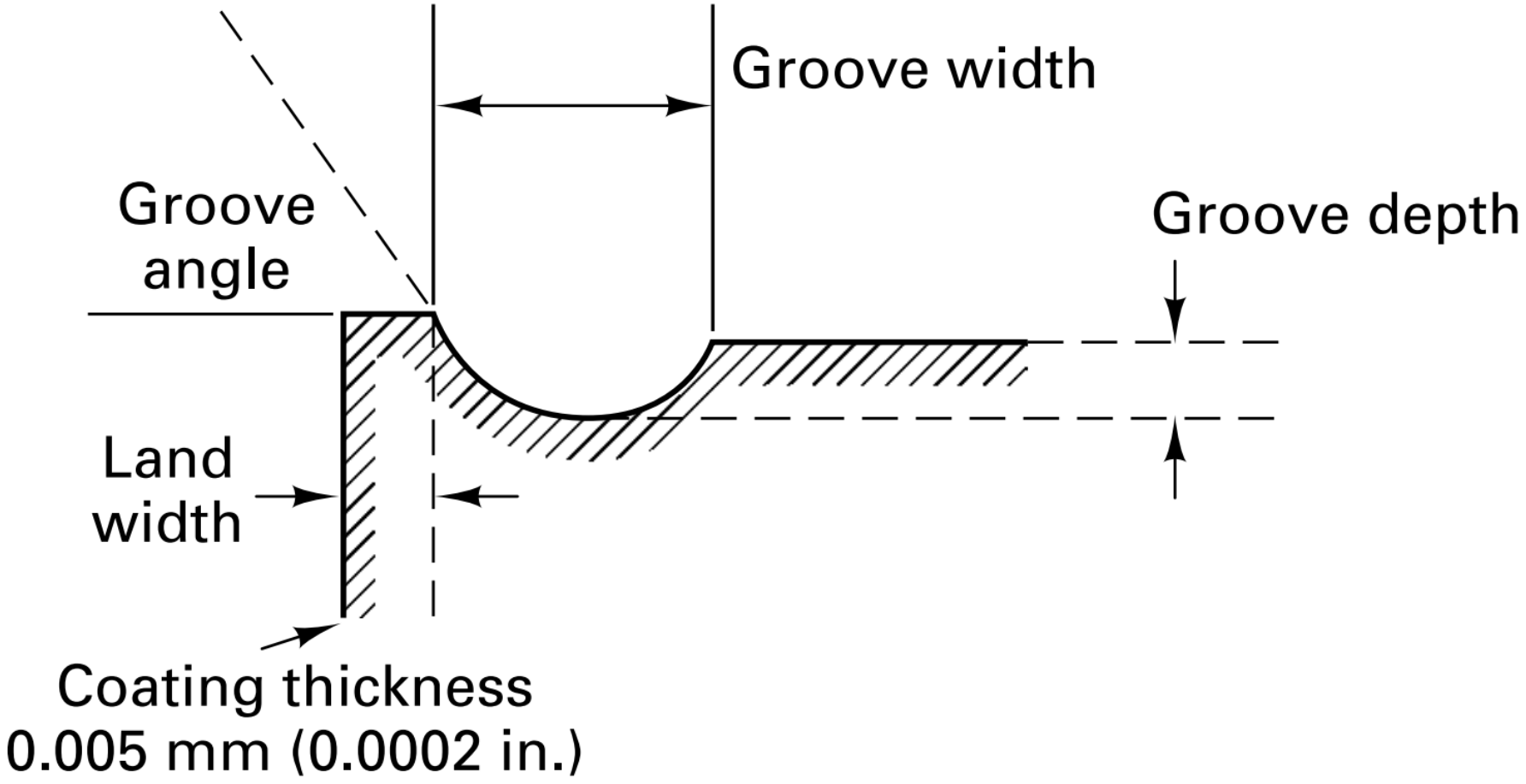
Microstructure of P/M tool steel versus conventional tool steels shows the fine carbide distribution, uniformly distributed.

# Powder Metallurgy Process



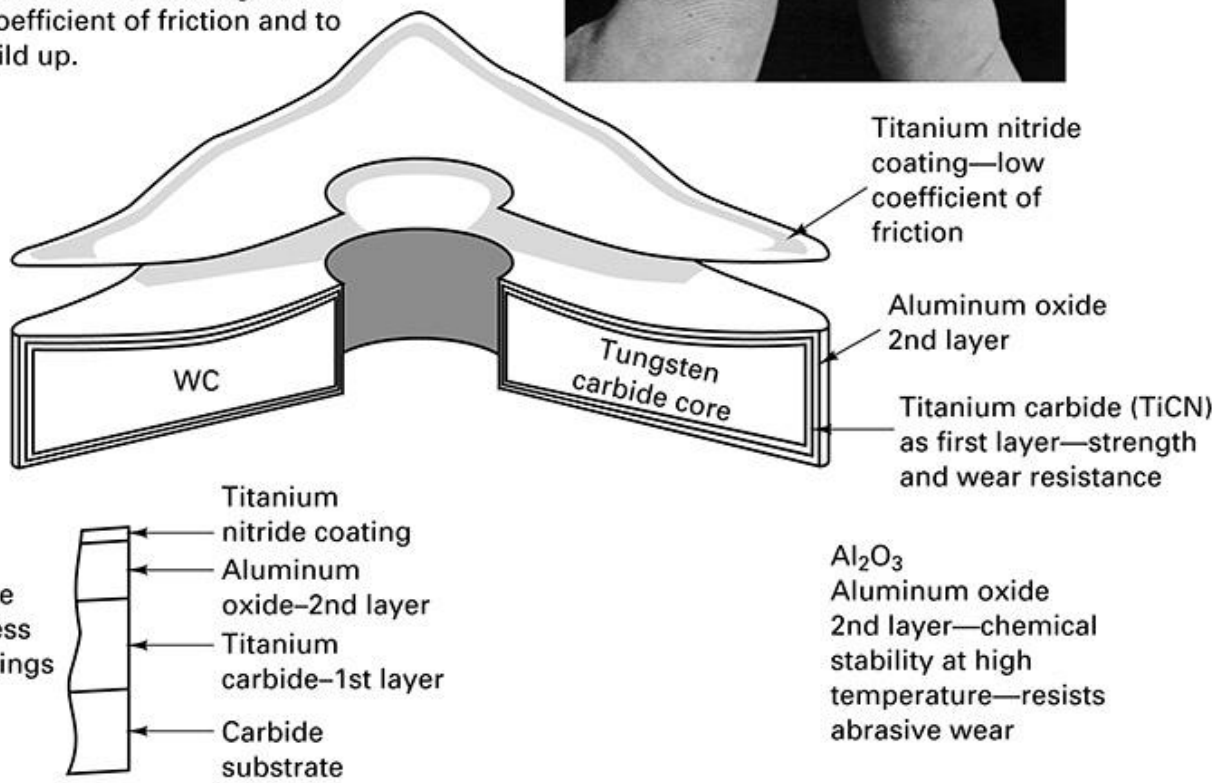

Tungsten is carburized in a high-temperature furnace, mixed with cobalt and blended in large ball mills. After ball milling, the powder is screened and dried. Paraffin is added to hold the mixture together for compacting. Carbide inserts are compacted using a pill press. The compacted powder is sintered in a high-temperature vacuum furnace.The solid cobalt dissolves some tungsten carbide, then melts and fills the space between adjacent tungsten carbide grains. As the mixture is cooled, most of the dissolved tungsten carbide precipitates onto the surface of existing grains. After cooling, inserts are finish ground and honed or used in the pressed condition.

# Carbide Insert Contours

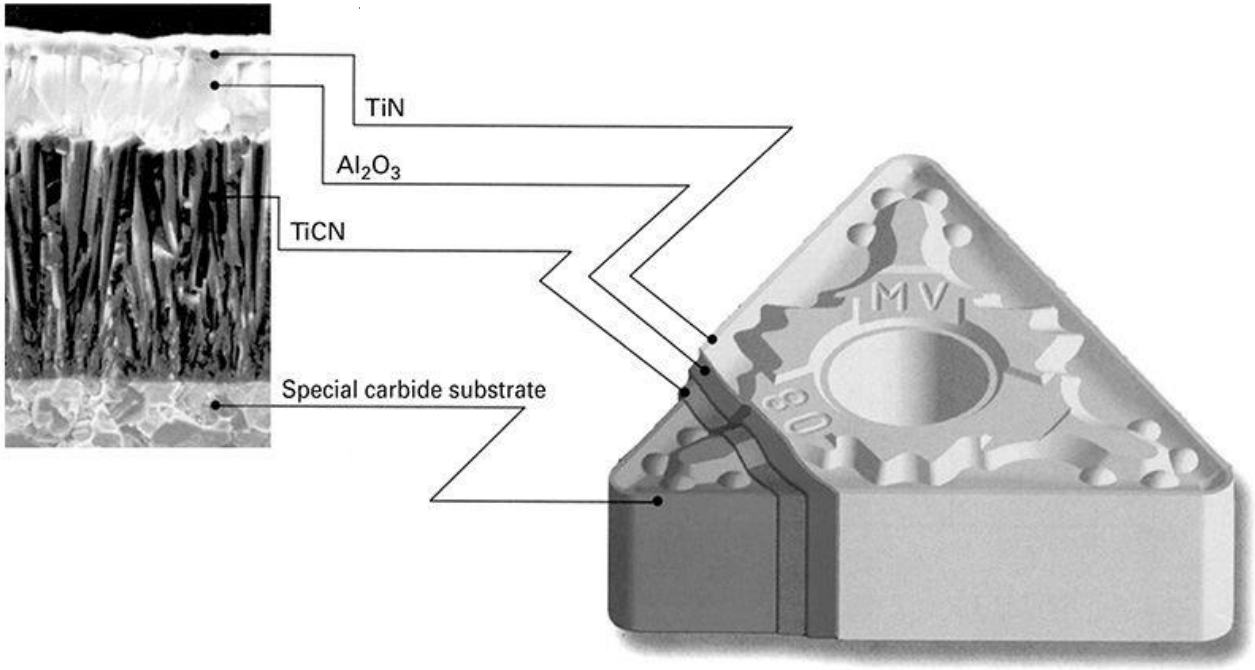


# Coated Carbides

Titanium carbide remains as the basic material covering the substrate for strength and wear resistance. The second layer is aluminium oxide, which has proven chemical stability at high temperatures and resists abrasive wear. The third layer is a thin coating of titanium nitride to give the insert a lower coefficient of friction and to reduce edge build up.



# Coated Carbide with Chip Groove



# Cermets vs. other materials