Performance and Environmental Advantages of Composite Electroless Coatings

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Industry Conditions

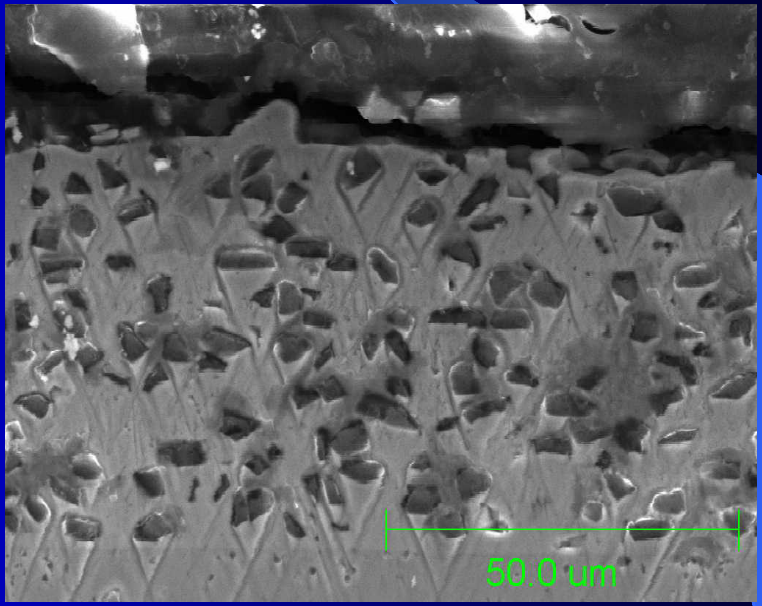
- Chrome / heavy metal restrictions
- Need for higher performance and engineered coatings
- Plating shops' desire for higher value added coatings without significant investment
- Quest for a "chrome replacement"
- Widespread use of composites

The Electroless Nickel Base

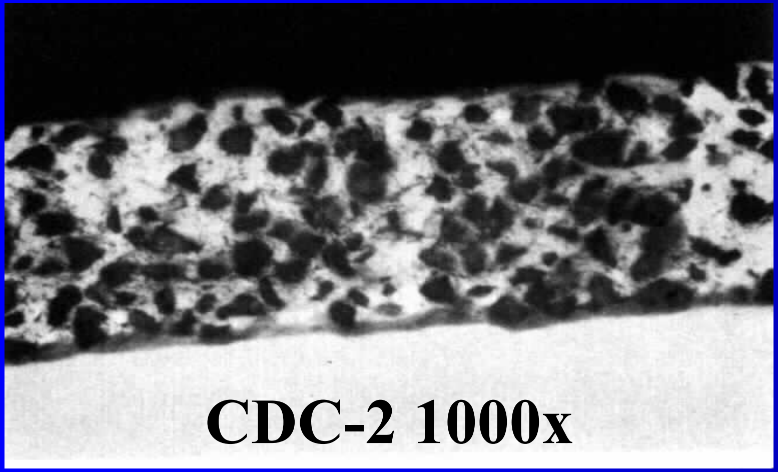
- Hard
- Wear Resistant
- Corrosion Resistant
- Perfect Uniformity
- Non-Line of Sight
- Customizable
- Applicable and Strippable on Many Substrates

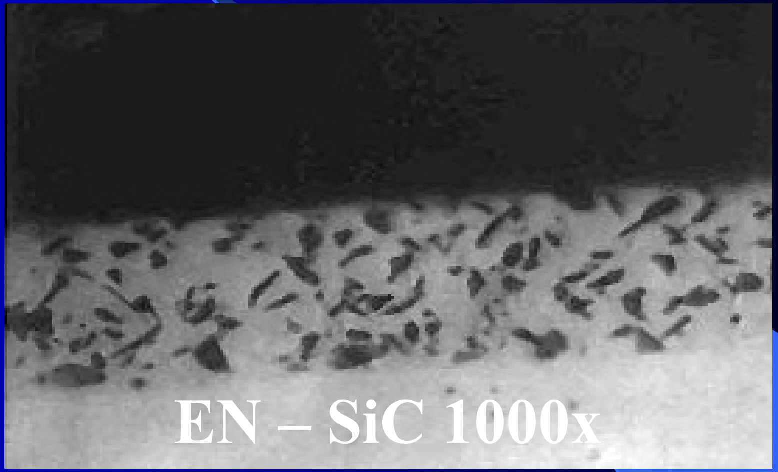
Composite EN

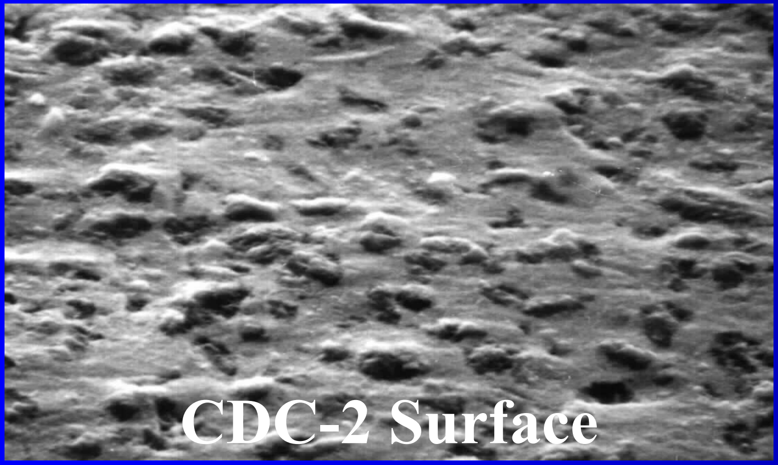
- Structure
- Process/patents
- Parameters
  - Alloy
  - Particle Type
  - Particle Size
  - Thickness
  - Multi-Layer

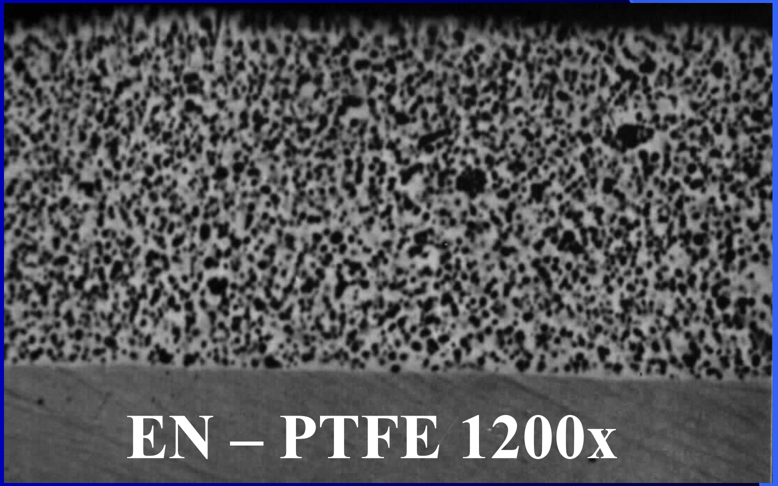


Composite EN Structures





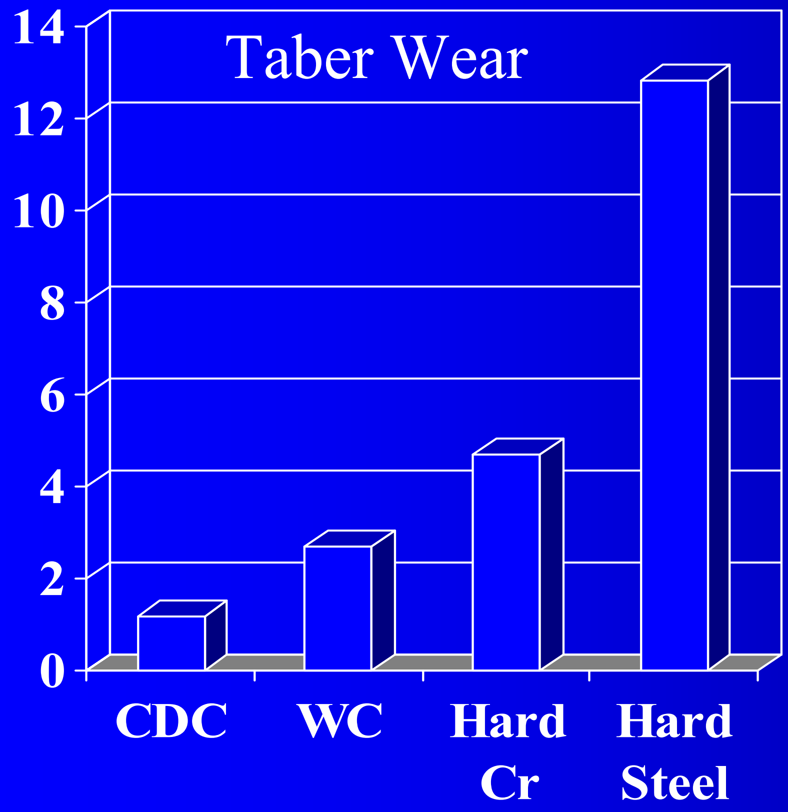


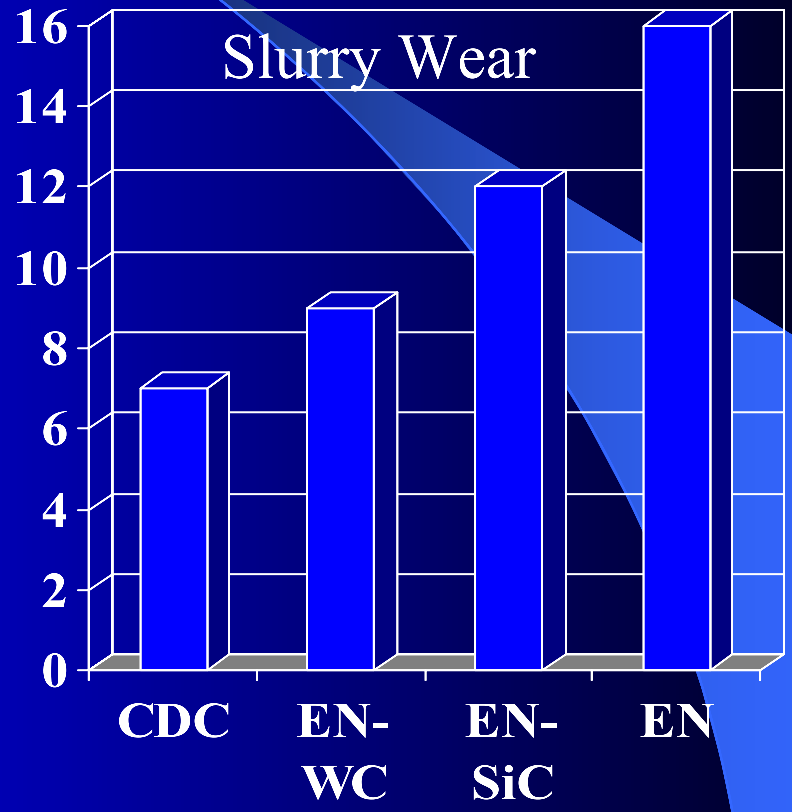


Composite EN Varieties

- Wear Resistant
- Frictional / Light absorbing
- Thermal Transfer
- Low Friction / Lubricating / Release
- Light Emitting
- Flame and Smoke Retarding

Wear Resistance





Composite Diamond Coating™

- Maximum composite EN wear resistance
- Customizable
  - Alloy
  - Particles
  - 0.0002” – 0.02”+
- Strippable

Environmental Benefits

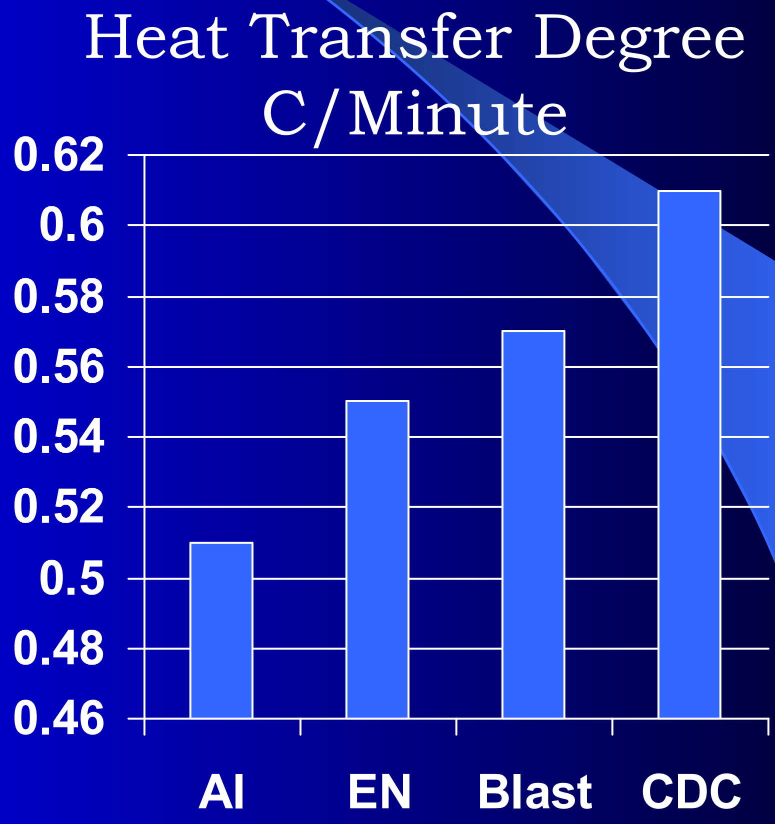
1. Composite EN uses no chrome, so there are no chrome related health or environmental problems.
2. Composite EN coatings can be made with no heavy metals and even no nickel.
3. Composite EN can be up to 40% by volume of particles, so about 40% less nickel is used than typical EN of the same thickness.
4. Because Composite EN can have superior wear resistance, the thickness can be significantly less than normal EN or other coatings. This means even less nickel needs to be used released into the environment as the part wears or is disposed.
5. Composite EN coatings can also last longer, so parts can be recoated or replaced less frequently. Again, resulting in even less nickel used.
6. Because composite EN can be chemically stripped, used parts can be stripped and recoated, thereby reclaiming the nickel metal in solution form for recycling.

Typical Wear Applications

Textile	Glass	Molding	Plastics	Paper
Petrol-chemical	Medical-Dental	Files	Milling	Fertilizer
Aerospace	Golf	Ceramic	Blades	Pumps

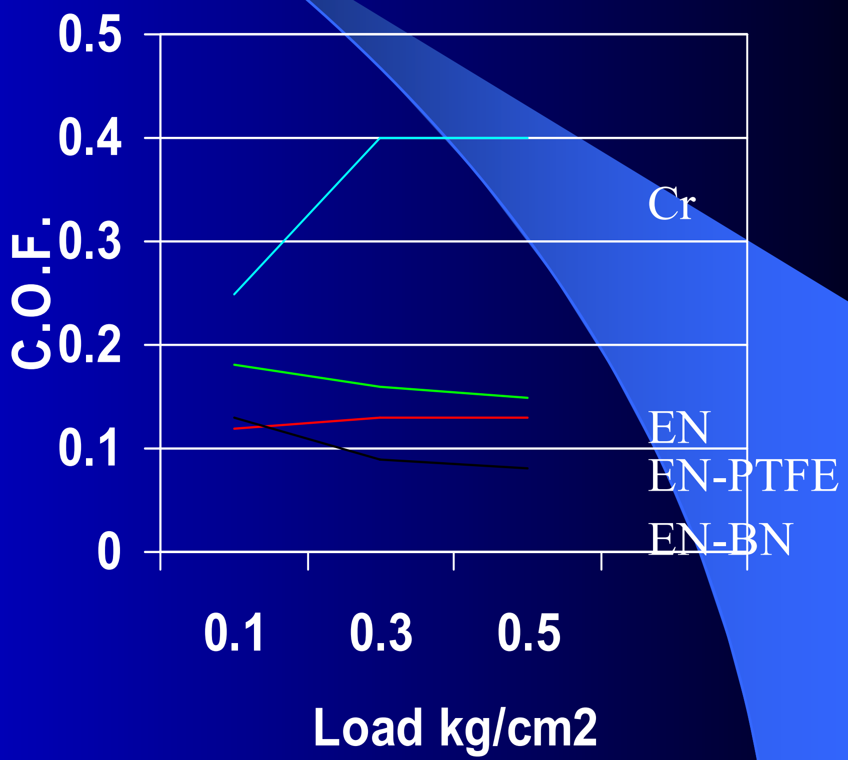
Thermal Transfer

- Methodology
- Applications
  - Electronics
  - Heat Sinks
  - Aerospace
  - Automotive



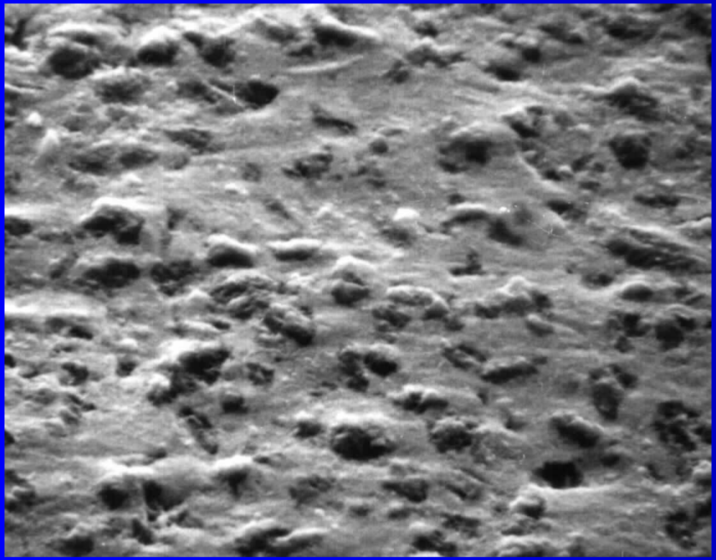
Low Friction Lubricating / Release

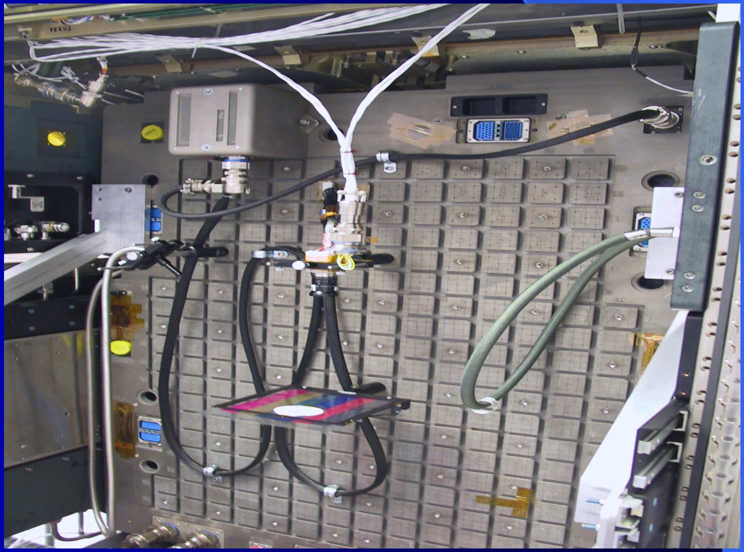
- Typical Specifications
- PTFE vs. Inorganic Particles
- Applications



Frictional / Light Absorbing

- Typical Specifications
- Applications



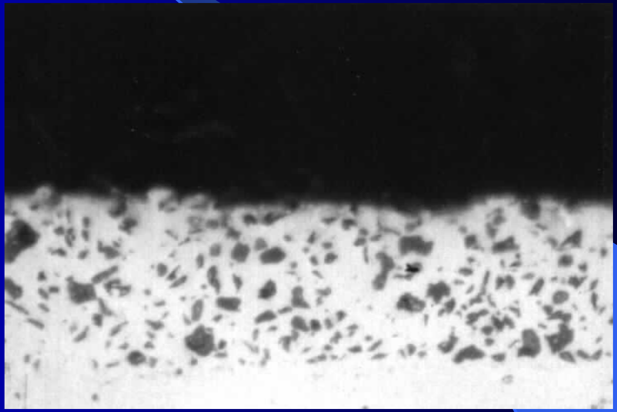


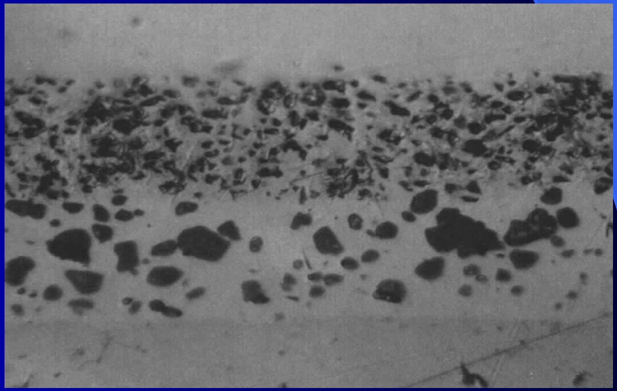
Light Emitting

- Typical Specifications
- Applications
  - Authentication
  - Indication

Multi-Layer Composite EN

- Under layers
- Overcoats
- Combination composites





Frequently Asked Questions

- Appearance
- Uniformity
- Thickness
- Particle density
- Particle quality
- Particle size
- Surface finish
- Hardness
- Wear resistance
- Cost
- Substrates
- Masking
- Post treatment
- Environmental Benefits

Appearance

- *Composite Diamond Coating* is a unique and attractive matte gray color. When used or polished the coating becomes shinier and more metallic in appearance. The Nano-Plate version of *Composite Diamond Coating* is inherently a shinier nickel colored coating. The color of these coatings cannot be changed. They can however be subsequently coated with other materials if an alternate final appearance is desired. Other composites with hard particles are similar in appearance. Composite EN-PTFE is either a silver/gray or blue/gray finish.

Uniformity

- Because of the electroless chemical method of deposition, Composite EN covers all surfaces of the work piece with essentially perfect uniformity. There is no build up on edges, corners, inner diameters, or any other surface. Another significant advantage of composite EN over other coating processes such as electroplating, spray, and other types coatings is that composite EN can be applied with uniformity to all surfaces of parts regardless of geometry. Recesses, holes, inner diameters of any size; there is no “line of sight” requirement for composite EN.

Thickness

- The thickness of Composite EN can be customized according to the requirements of each specific application. Any thickness from 0.0001” (2.5 microns) to over 0.025” (625 microns) can be produced with composite EN, although most applications use a standard coating thickness of 0.001” (25 microns) to 0.005” (125 microns). Any thickness can be applied to a tolerance of about +/- 2 microns.

Particle Density

- The density of particles within composite EN depends on a number of factors, especially particle size. The larger the particles, generally the higher the density. Typical densities are from 20-40% by volume. Higher and lower densities can be produced as needed, but the standard range serves well in virtually all applications. Too little particles in the coating will not sufficiently provide the properties desired in the coating. Too much particles in the coating creates the risk that there will not be enough of the metal matrix required for adhesion to the part and structural integrity of the coating itself.

Particle Size

- The standard and most commercially used versions of composite EN, especially those for wear resistance, incorporate particles with a mean particle size of 1 to 8 microns respectively. Other sizes may also be used. Particles of up to about 50 microns in size may be used when required for a specific application. On the smaller side, the Nano-Plate version of *Composite Diamond Coating* features diamond particles in the nanometer size range. Composite EN with PTFE also use sub-micron particles of PTFE.

Particle Quality

- For quality, consistency, and proper bath operation, the particles incorporated into composite EN should be very precisely specified for composition, size and shape. As the particles interact with the reactive electroless nickel bath, the purity of the particles must be exceptional. And to insure both the optimal density of particles within the coating and the surface characteristics of the coating, the diamond must be tightly sized and shaped. This high quality requirement is especially true for diamond particles due to the prevalence of low quality stock in the world market, and the metallic inclusions often found in poor quality diamond particles.

Surface Finish

- Composite EN coatings can be produced with either a very smooth surface or with a rougher texture when needed, by selecting the appropriate particle size and density.
- In certain especially delicate applications where even greater smoothness is required:
  - Standard coatings can be lightly sandblasted, polished, or tumbled before use.
  - An EN overcoat may also be applied to provide an even smoother surface for parts upon initiation of their usage.
- If a rough surface is desired, in addition to using larger particles, the substrate should be made rough before the coating is applied which will replicate and preserve the exact roughness profile.

Hardness

- The hardness of a composite EN coating is a combination of the metal matrix and the particles used. The hardness of typical heat-treated electroless nickel is about 950 Vickers. Particles harder than this level will increase the composite hardness, whereas softer particles such as PTFE will lower the composite hardness. The ratio, however, may not be linear. For example, while diamond is 10,000 Vickers, the hardness of *Composite Diamond Coating* is about 1,200 Vickers. This underscores why hardness may not be the most important parameter, and it is better to focus on the wear resistance, lubricity, friction, or other key property of the composite coating.

Cost

- Composite EN is economical for a number of key reasons:

1. Composite EN can be applied in routine industrial production.
2. The production costs of composite EN (pretreatment, inspection, EN, heat treatment, labor, energy, overhead, profit) are all the same as traditional EN, except for the addition of the particles.
3. The cost of composite EN is relatively low when consideration is given to the performance advantages it provides including longer life and greater reliability.
4. Given the properties of composite EN, many customers are able to change the base material of their parts to one that is less expensive, lighter, or easier to manufacture.
5. As composite EN can be chemically removed, used parts can be stripped and re-coated to yield a part that is as good as new without the cost of manufacturing another part.

Substrates

- Essentially any metal or alloy can be enhanced by composite EN. The most common materials coated are carbon or tool steels and aluminum alloys. Copper, brass, bronze, stainless steel and titanium are also regularly treated with Composite EN. It should be noted, that the simpler pretreatment process employed for common steels or aluminum make these materials the most economical to coat. Fortunately, the exceptional wear and corrosion resistance of coatings like *Composite Diamond Coating* facilitates the use of these less expensive materials.

Selective Coating

- Selective deposition of any composite EN coating is achievable when required. Masking techniques are similar to traditional EN. It is important to know for each part which critical areas must be treated, which areas may not be treated for specific reasons, and which areas may or may not be treated depending on the greatest economy and expediency of the coating process. Often it is less expensive and faster to coat "non-critical" areas than to mask off these areas.

Post Treatment

- After coating, a heat treatment step is generally desirable to provide improved adhesion of the coating, greater hardness of the matrix, and maximum wear resistance. A heat treatment of up to 750°F is normally preferred. Other temperatures can be implemented as needed for specific applications.
- Blasting
- Polishing
- Over-coating
- Other