I. Rushford Hypersonic (Overview)

II. Hypersonic Plasma Particle Deposition (HPPD)

III. Applications

IV. Open Forum
Rushford Hypersonic

Hypersonic was founded in October of 2007 and was facilitated and supported by:

- The Rushford Institute for Nano Technology
- Rushford, MN - Economic Development Authority
- Southern Minnesota Initiative Foundation
- U of MN – Office of Technology Commercialization
Location - Rural S.E. Minnesota

- The work force is well educated and posses a strong work ethic!
- Manufacturing floor space, utilities and labor are much lower than in major metropolitan areas! It is estimated that Hypersonic has saved in the range of $1.5 - $2.2 million to date due to the lower costs in a small community vs. locating in a major metropolitan area and less turnover of labor force.
Rushford Hypersonic (Overview cont.)

Hypersonic was founded to utilize the University of Minnesota’s *Patented - Hypersonic Plasma Particle Deposition (HPPD)* and *Focused Beam (FIB)* processes (which Hypersonic has *exclusive rights*) to coat and or modify high wear surfaces such as Gears, Bearings, Compressor wheels, Rotor-Blade Wear strips, Cutting tools and Implantable medical devices, etc… with the focus on
Rushford Hypersonic (Overview cont.)

**Increasing the Mean Time Between Failure**

thus *Reducing the end cost* of the product by:

- Extending the useful life span of the part or tool
- Reducing change over time
- Increased Service Life
- Less Scrap due to increased life span and reduced dimensional and thermal changes during operation of the part or tool
Hypersonic Plasma Particle Deposition

(HPPD)
The Patented HPPD process is a “Innovative process in which Hypersonic particle impaction is crossed with a thermal plasma CVD.

In this process we add various reactant materials and then disassociate them into their atomic elemental states in a reactor (Intellectual Property) which operates between (4,000 – 10,000°K+/-).

We then reassemble the elements into nano-particles ranging from ~2nm – 20nm in size and of the material composition we have designed for the specific application.

The particles are then accelerated and impact the substrate at hypersonic velocities of Mach 8+ in which they go thru a phase-change upon impaction with the substrate and form a chemical weld in addition to the cut impaction of ~3 - 5 nm.
Distance from nozzle inlet (cm)

\begin{table}[h]
\centering
\begin{tabular}{cccccccccc}
\hline
\textbf{Distance} & \textbf{Value} \\
\hline
0 & 2399 m/s \\
1 & 2149 \\
2 & 1815 \\
3 & 1481 \\
4 & 1148 \\
5 & 814 \\
6 & 480 \\
7 & 146 \\
8 & -187 \\
\hline
\end{tabular}
\end{table}
Inherent CVD then fills in pores left by nano-particle impact.
SiC film morphology
Qualitatively, wear resistance appears excellent.

Pin-on-disk wear track at $r = 6$ mm
SiC film morphology
Mo sample with thick coating
The SiC is moissanite, the hardest material known and the ideal coating.
Why HPPD is Different!

1. **HPPD deposition material is 30-50% harder** than the most industrial Ceramic Carbide material in use >36GPa.

2. The **HPPD coating produced is up to 100% more fracture resistant** than current materials going from ~ 3MPa m$^{1/2}$ to 6+MPa m$^{1/2}$

3. Superior Wear Resistance

4. Deposition of HPPD process is up to 1000x faster than current CVD Processes

5. HPPD coatings are chemically welded to the substrate vs. just being a coating

Rushford Hypersonic LLC has Licensed exclusive rights from U of MN for HPPD and FIB technology

<table>
<thead>
<tr>
<th>Test #</th>
<th>Peak Load (mN)</th>
<th>Crack Lengths (µm)</th>
<th>$K_c$ (MPa·m$^{1/2}$)</th>
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<tr>
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<td>2</td>
</tr>
<tr>
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Connaughty Industries
In house analysis run
of
Rushford Hypersonic LLC’s
HPPD coated Drill bits vs. HSS - Carbide and Cobalt
Dry Drilling Analysis

Dry Drilling Comparative Analysis of Rushford Hypersonic's Hypersonic Plasma Particle Deposition Process (HPPD)
HPPD Coated HSS Drill Bit vs. Plain HSS, Cobalt and Carbide Jobber Bits

- HPPD 1 Coated HSS Drill Bit
- HSS 0
- *Carbide 2
- HSS 1
- HSS 2
- Cobalt
- HSS 2

Test material - 304 ss - .5 in thick
Drill Size - 250 in.
Machine - Hurco VMX42
RPM - 600
Feed Rate - 1.5 in/min
Peck - .050 in.
Coolant - None
Lubrication - None
Video Recorded Run - Yes
*Carbide 2 run at 1500 RPM

Test Performed at Connaughty Industries Machining Division Rushford, MN

*HPPD 0 - Failed due to programming error on feed rate at hole #41, Carbide 0 & 1 failed in hole #1, 1000 & 3000 RPM - Feed Rate 3 and 6 in/min
Customer / Collaboration Base

- Fastenal
- Pyramid Abrasives
- UK Aero, Inc.
- VAH
- High-Tek Tube Corp.
- Mayo Clinic
- Centennial Carbide
- Reiland's Hair Clinic, Inc.
Rushford Hypersonic LLC

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