Rushford

HYPERSONIC

A CUTTING EDGE NANOTECHNOLOGY COMPANY

NDIA
Joint Armaments Conference

Presentation

19 May 2010

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I. Rushford Hypersonic (Overview)

II. Hypersonic Plasma Particle Deposition (HPPD)

III. Applications

IV. Open Forum

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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*

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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.

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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

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Rushford Hypersonic (Overview cont.)

***Increasing** the **M**ean **T**ime **B**etween **F**ailure*

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

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Hypersonic Plasma Particle Deposition

(HPPD)

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- 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$^{o}K^{+/-}$).
- 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.

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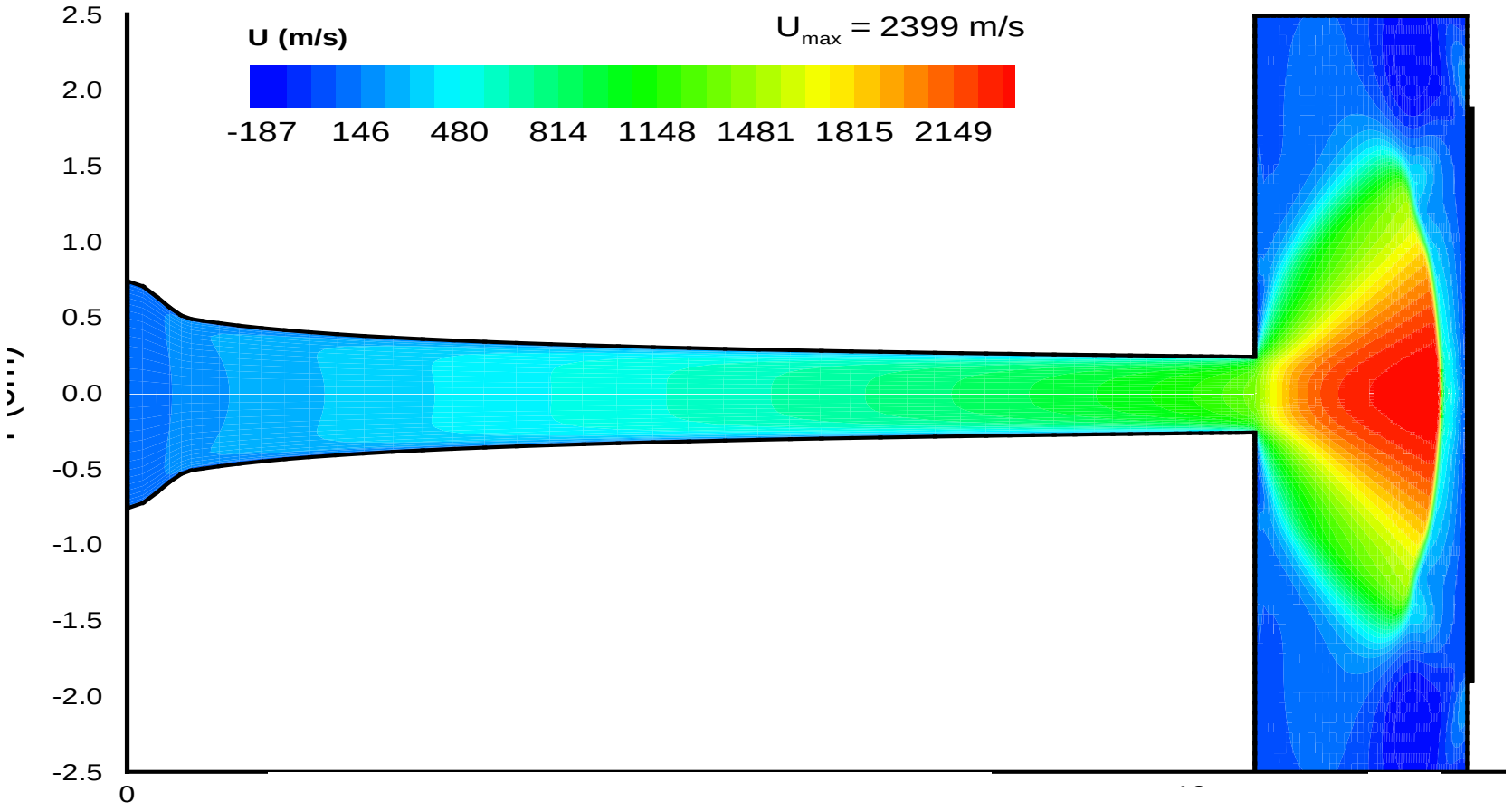

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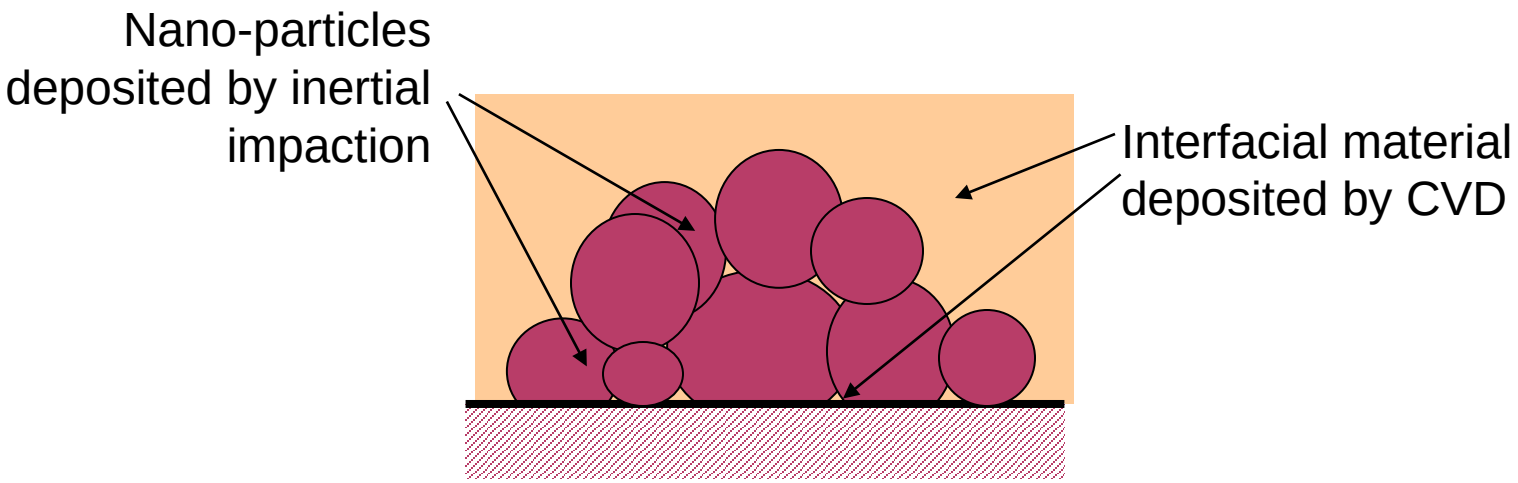
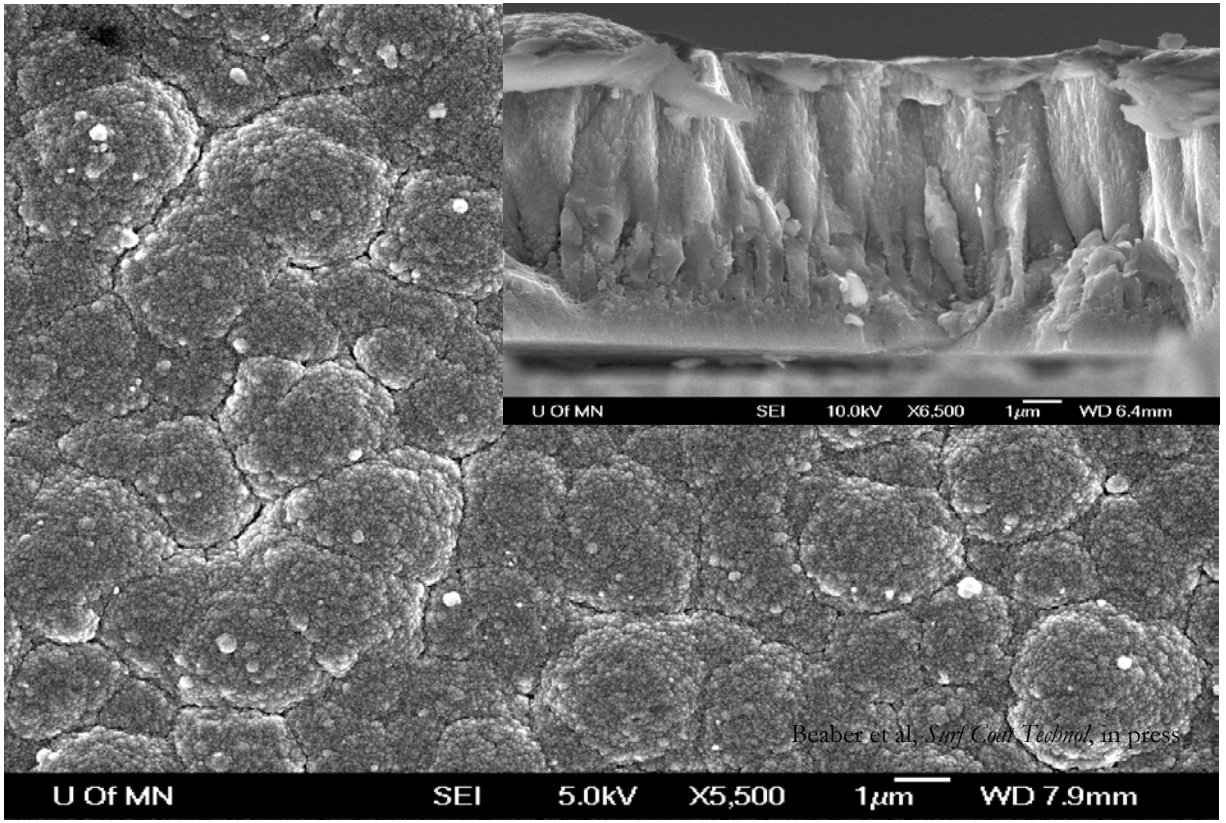


Inherent CVD then fills in pores left by nano-particle impact

SiC film morphology



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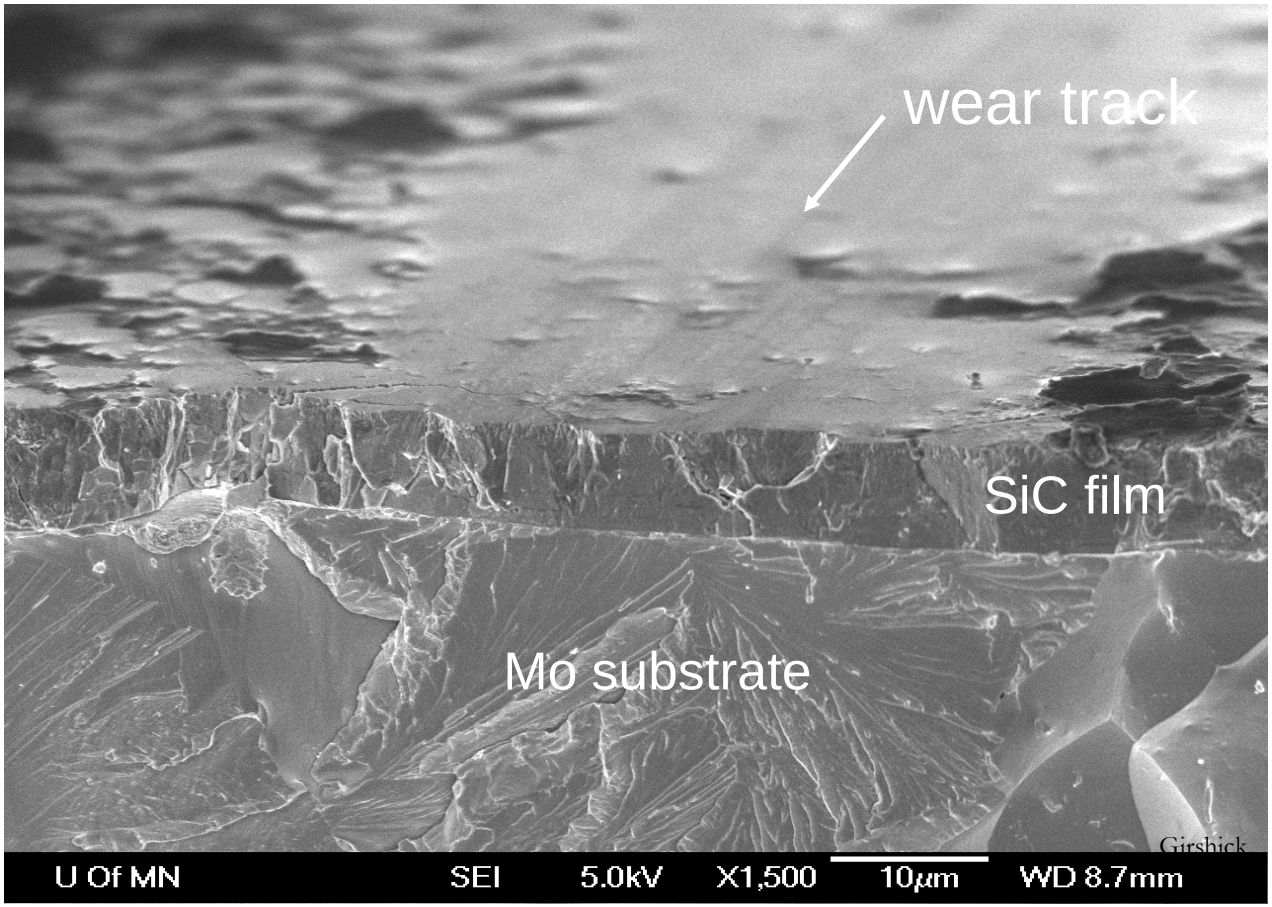
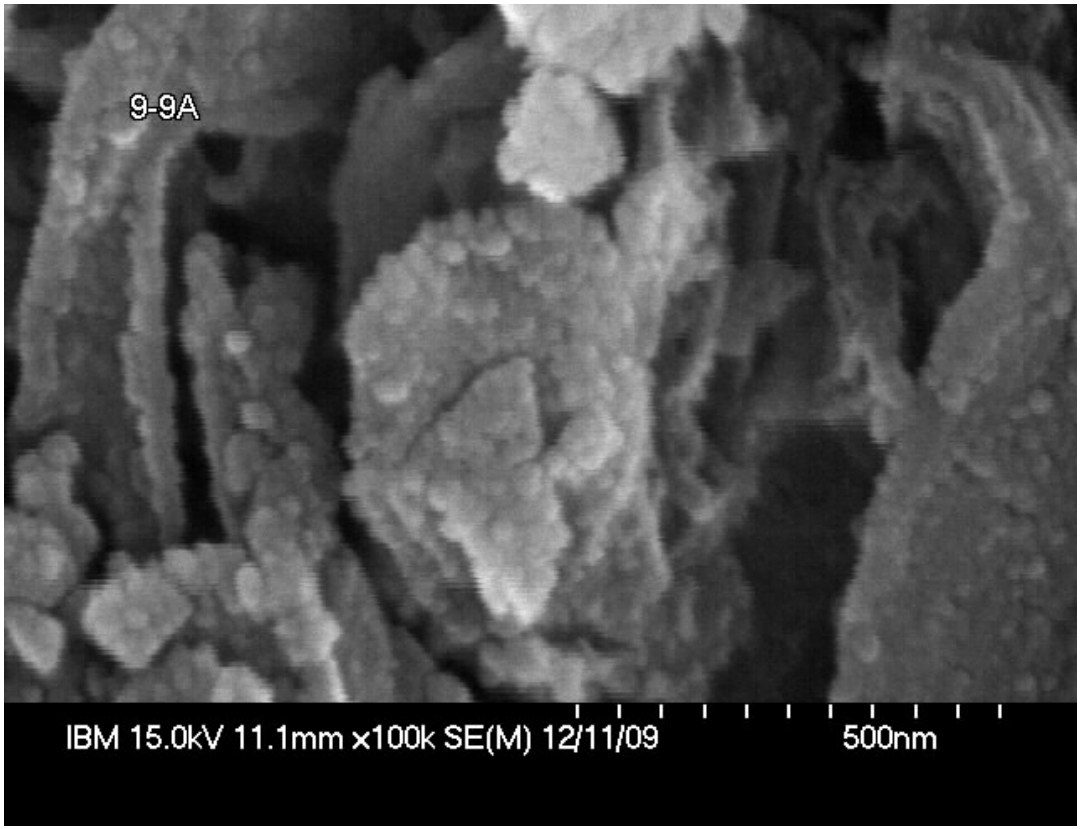


Pin-on-disk wear track at *r* = 6 mm

Qualitatively, wear resistance appears excellent

SiC film morphology



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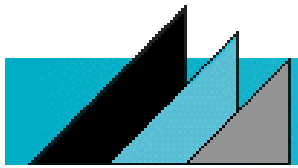
University of Minnesota



Characterization Facility

X-ray Scattering Lab

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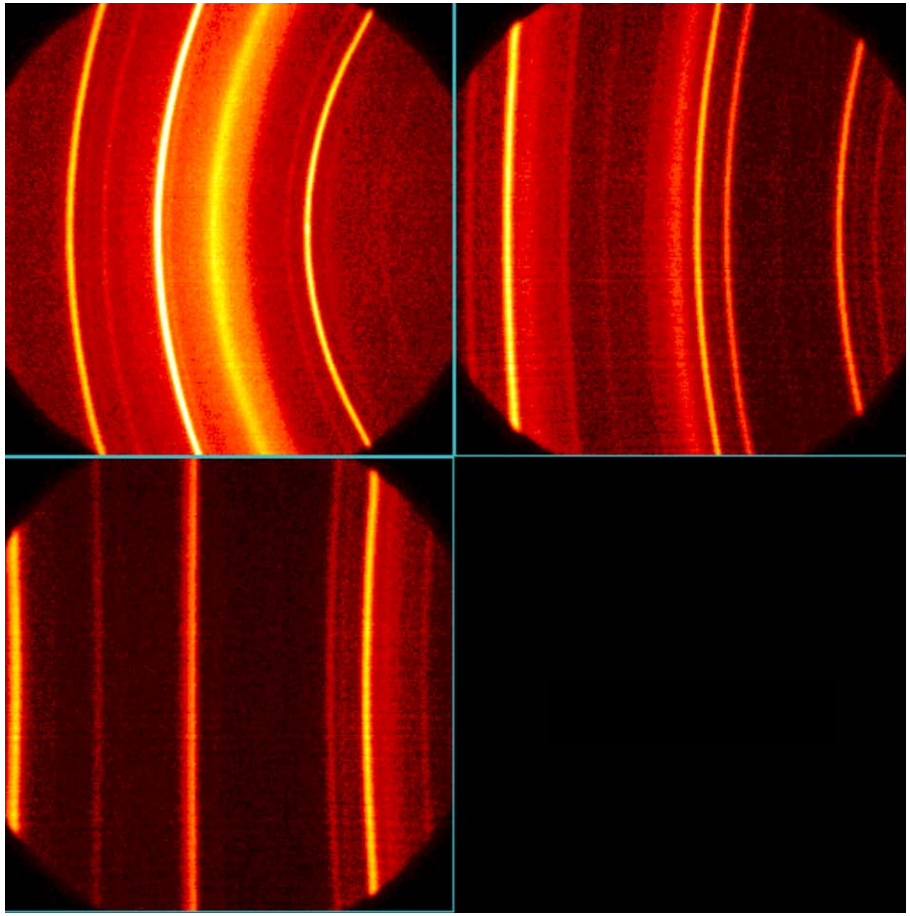
Mo sample with thick coating



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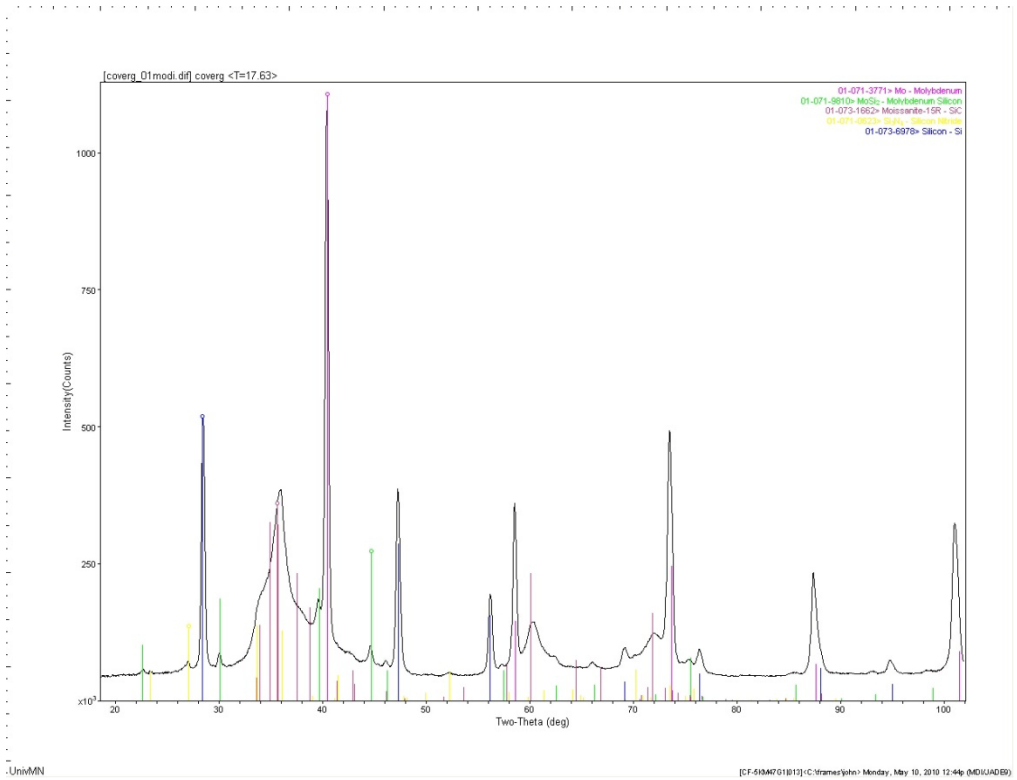

…The SiC is moissanite, the hardest material known and the ideal coating.

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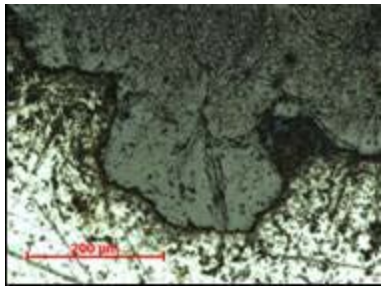
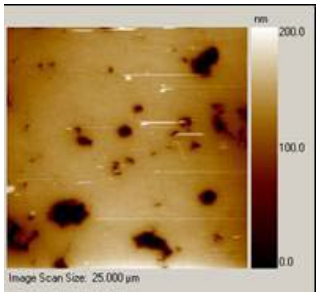




Sample #	E_r (GPa) *Ave ± StDev*	H (GPa) *Ave ± StDev*
4	254.7 ± 11.2	37.01 ± 1.95

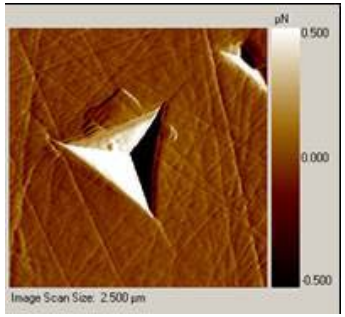


Table 1. Results from fracture toughness tests

Test #	Peak Load (mN)	Crack Lengths (µm)				K_c (MPa*m$^{1/2}$)
		1	2	3	Ave	
1	30.00	0.97	0.93	0.82	0.90	3.29
2	30.00	0.97	0.98	0.93	0.96	3.02
3	30.00	0.90	0.93	0.84	0.89	3.37
4	30.00	1.06	1.04	0.77	0.96	3.02
					Ave	**3.17**

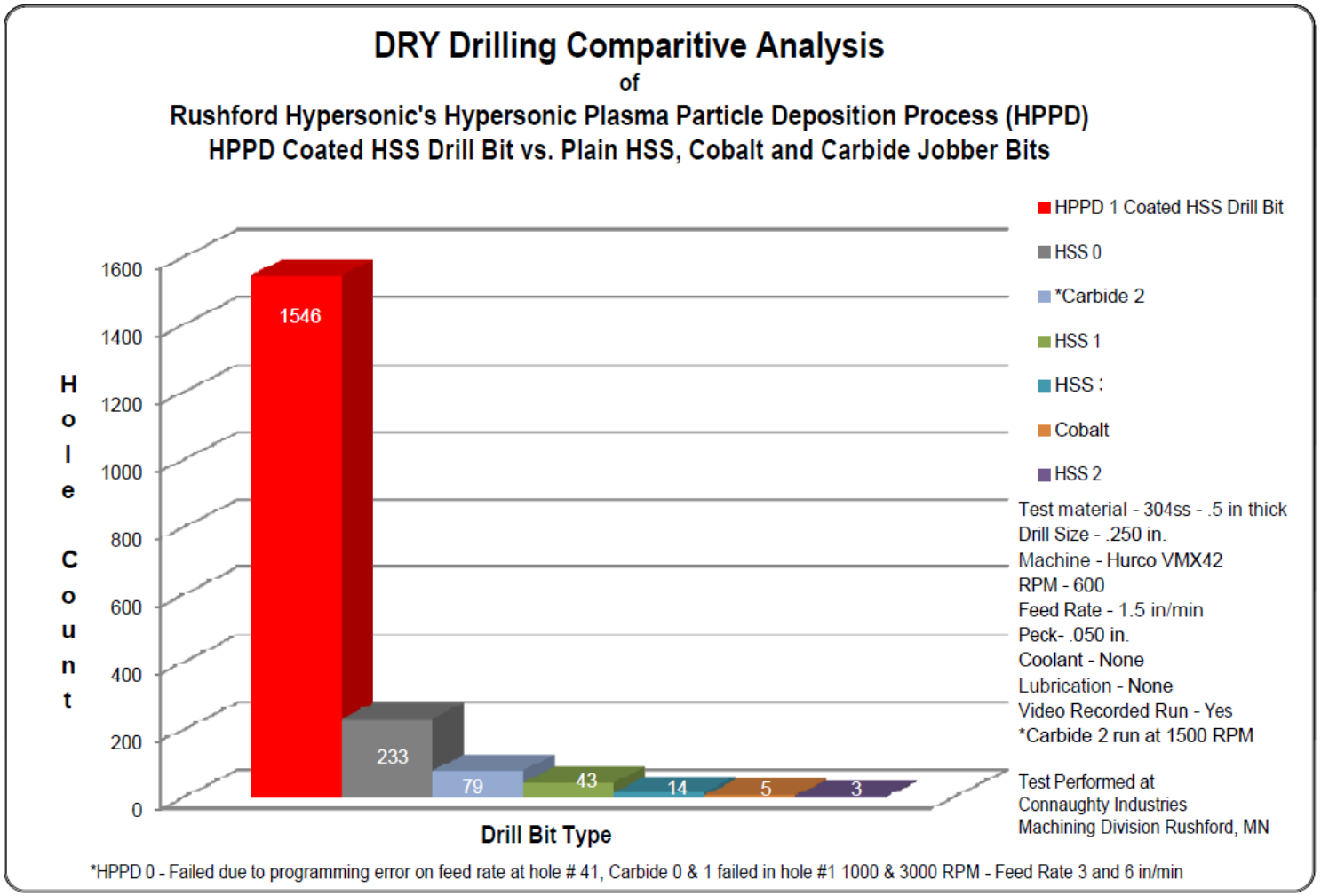
Why HPPD is Different!

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

Connaughty Industries
In house analysis run
of
Rushford Hypersonic LLC's
HPPD coated Drill bits vs. HSS - Carbide and Cobalt

Dry Drilling Analysis



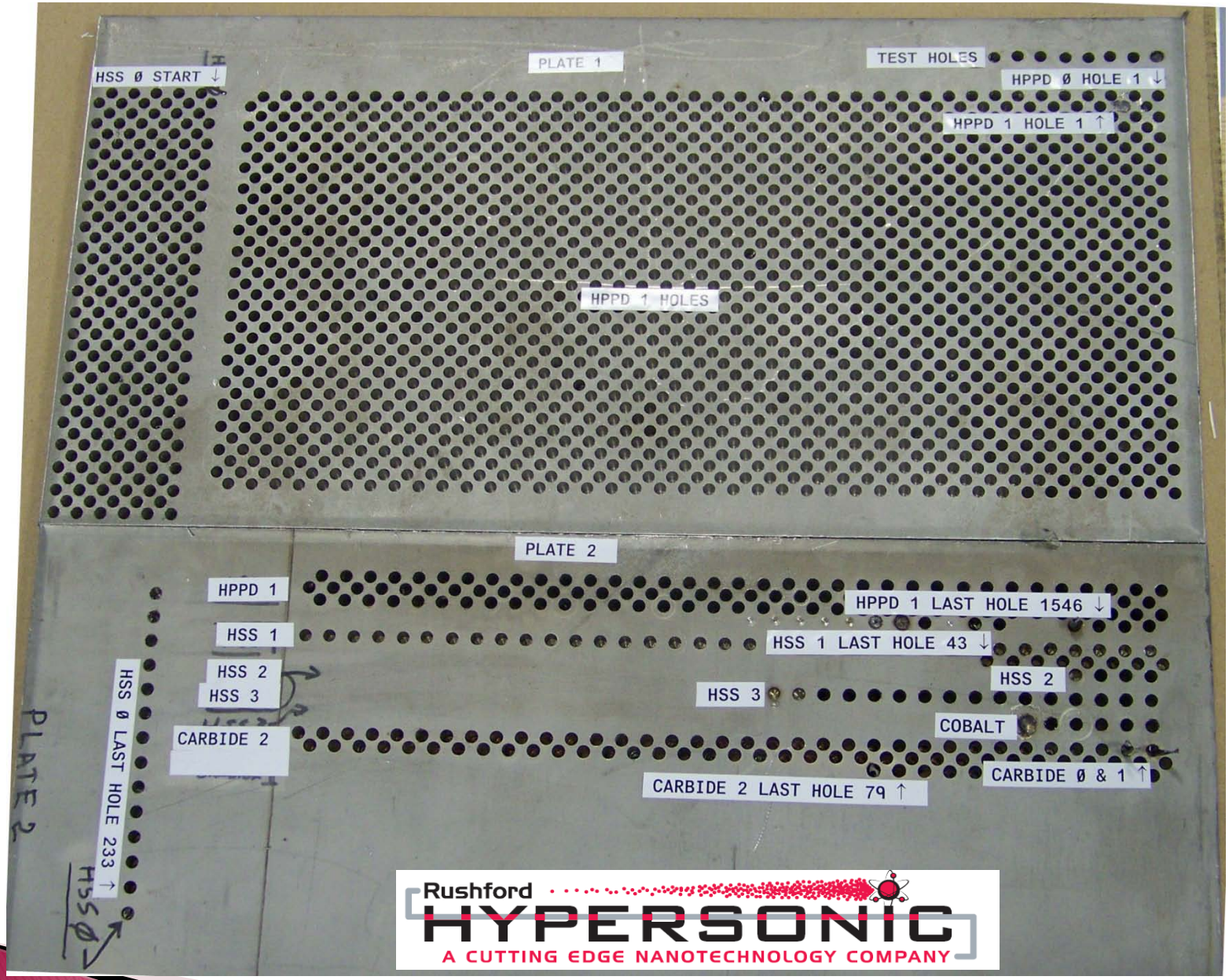


PLATE 1
HSS Ø START ↓
TEST HOLES
HPPD Ø HOLE 1 ↓
HPPD 1 HOLE 1 ↑
HPPD 1 HOLES
PLATE 2
HPPD 1
HPPD 1 LAST HOLE 1546 ↓
HSS 1
HSS 1 LAST HOLE 43 ↓
HSS 2
HSS 3
HSS 2
HSS 3
COBALT
CARBIDE 2
CARBIDE Ø & 1 ↑
CARBIDE 2 LAST HOLE 79 ↑
HSS Ø LAST HOLE 233 ↑
PLATE 2
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Customer / Collaboration Base

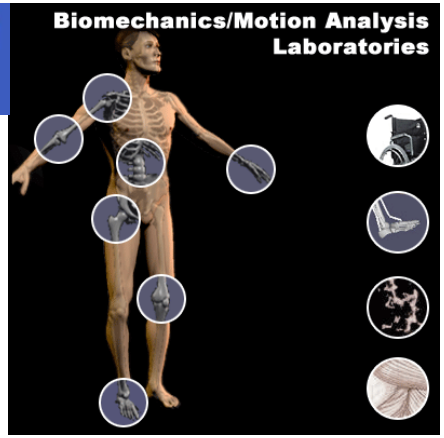
FASTENAL

PYRAMID ABRASIVES
Manufacturer of:
SHARXTOOTH WoodMaster Angelfeet

UK AERO, INC.

HIGH-TEK TUBE CORP.

MAYO CLINIC



Centennial Carbide

Reiland's Hair Clinic, Inc.

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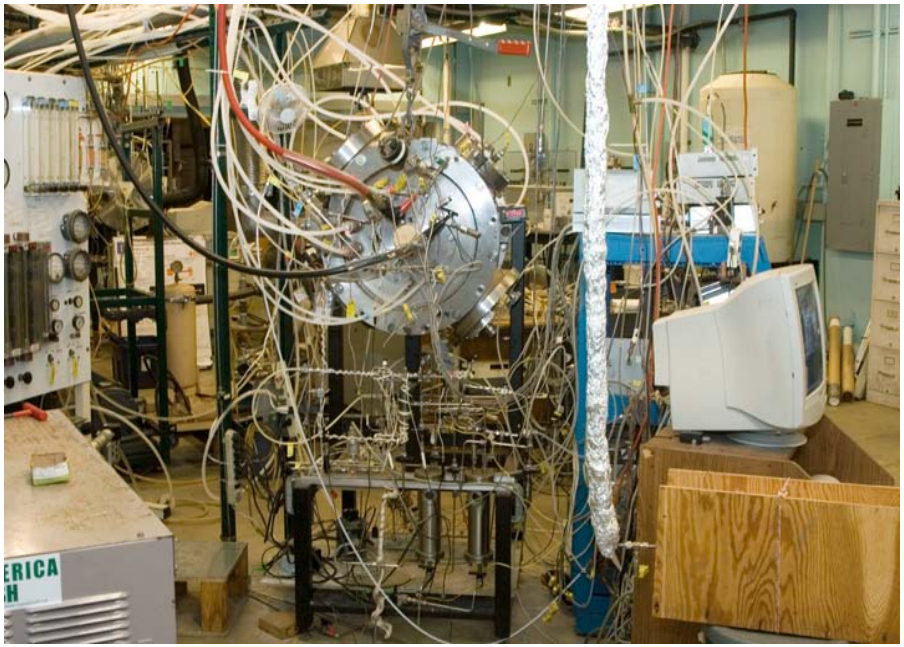

University of Minnesota HPPD Lab Machine

Hypersonic's HPPD-001 Deposition Chamber

Contact Information

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