Pass-Through Vacuum Chambers for Research and Production

Presented by Tim Claffey

AIMCAL WEB Coating & Handling Conference
October 21-24, 2012
Pass Through Vacuum Chamber
Company Snapshot
Porous Media Technology

www.newwayairbearings.com
The ideal air bearing design would supply air pressure equally across the whole face of the bearing, and automatically restrict and dampen the air flow to the face at the same time.
In Stock!

Frictionless Motion™

NEWWAY®
air bearings
Air Bar Product Review

- Precision Zone Air Bars
- Transition Zone Air Bars
- Flotation Zone Air Bars
Air Bar System Example

Floating Glass Inspection System

APPLICATION DRAWING

- GRANITE METROLOGY FRAME
- GLASS TRANSLATING MECHANISM ATTACHED
- FLOATING GLASS
- EXTRUDED ALUMINUM FRAMING SYSTEM WITH LEVELING FEET
Air Bar System Configuration

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The Physics of Glass Flotation
FFT results of vibration measurements using New Way Porous Media Precision Chuck

HEPA Filter On/Off

- air_on, fac vac
- air_off, fac vac
- air_on, fac vac, Hepa on
- air_off, fac vac, Hepa on

Current Chuck

Precision Chuck - Test Results
The Sauber wind tunnel is large enough to measure full-size Formula 1 cars.

The Sauber aerodynamicists will work mainly with 60 percent models.
Wind Tunnel Project

Full array of custom vacuum air bearings under the rolling road belt
Wind Tunnel Project

Frictionless Motion™
Wind Tunnel Project
90 m/s Speed with 20 bar in the Gap

Frictionless Motion™

RACE CAR WHEEL

STAINLESS STEEL BELT (300 KPH)

TIRE PATCH BEARING

VACUUM PRESSURE CONTROL AREA

FORCE GAGES

STRUCTURAL SUPPORT

VACUUM PRESSURE CONTROL AREA

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Wind Tunnel Project
Pass Through Vacuum Chamber

Frictionless Motion™

NEWWAY® air bearings
**Project Relevance**

*Why this project is important?*

The success of the project would enable small low cost vacuum or gas containment process modules for speeding the development and manufacturing of web based Displays, PV, LED Lighting, Printed Batteries.....
Project Sponsors

Army Research Laboratory

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Project Partners

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Why this Project Is Important?
Pass-Through Vacuum Chamber

Flexible and Affordable Vacuum Processing

NEW WAY MICRO VACUUM CHAMBER

NOVACENTRIX PULSE FORGE

FILM OUT

FILM IN

NEW WAY AIR BEARINGS
Conventional Technology

Thin Film Deposition and Laser Processing
Conventional Technology

Comparison to Industry Standards

- Today, vacuum deposition is typically done in a large drum-shaped vacuum chamber, usually equipped with side chambers that contain a feed roll and a take-up roll.
- Chamber volume can easily add up to several cubic meters.
Conventional Technology

Comparison to Industry Standards

- Made of stainless steel, they must be built to withstand huge atmospheric loads, making them very expensive.

- Installation requirements and operating services are quite extensive. Thus, the current process is very expensive.
Project Relevance

What is the industry need?

- Vacuum coatings still have the best performance and reliability.
- Current vacuum coating equipment is huge and expensive.
- Small inexpensive systems would greatly expand the field of researchers and developers that can experiment with vacuum or reactive and inert gas processes.
How Will It Change or Improve the Current Industry Status?

- By eliminating the requirement to put a roll in a vacuum chamber, and pump it down for processing, *continuous processing* will become possible.
- The web may flow though one or more vacuum chambers, with other ambient processes inserted in between, and may do so continuously.
Project Relevance

What Improvements in Processing Can Be Achieved?

- Because the film spends less time in deep vacuum, the film has less influence from the vacuum. This means less outgassing of moisture in the film and so less change in size of the film.
- Because of the small chamber size pumped down times are dramatically reduced.
Targets
Targets

Objective
To design, manufacture and test an air bearing assembly with differentially-pumped grooves isolating a vacuum region though which flexible webs may be passed.
Working Prototype

The working prototype would allow for verifying proper input pressures, bearing flows, differential groove vacuum pressure and chamber pressure achieved with actual film.
Target Specifications

- Process chamber vacuum levels of $10^{-4}$ torr or better (well into the molecular flow regime) and to do this in a non-contact manner.

- We have achieved $10^{-6}$ torr using solid structures with differentially-pumped grooves in the past; we expect to achieve results that are similar.
Target Specifications

- $10^{-6}$ torr is the stretch goal.
- If we can achieve this it should be relatively easy to use the system as a process chamber containing reactive or inert process gasses.
- A later goal will be to deposit quality thin films consistent with those from conventional vacuum deposition and vacuum plasma equipment.
Current Techniques

Keeping Mechanization Outside the Vacuum Chamber

- Methods have included linear and rotary contact seals, rotary Ferro fluidic seals, and expanding/contracting bellows.

- Air bearing structures separated from the vacuum chamber by integral differentially-pumped grooves that support some sort of a moving member through an aperture in the vacuum chamber wall.
Technical Approach
Technical Approach
Technical Approach

Bottom half of unit showing the differentially-pumped grooves and chamber

Porous media air bearings

Differentially-pumped vacuum grooves.
Technical Approach

From our previous experience with air bearings for deep vacuum (Ion Implant and DUV) we believe it is possible to pass a web through air bearing guides and differentially-pumped grooves, into a vacuum processing chamber and back out the same way.

LASER LIGHT
OR
DEPOSITION SOURCE

WEB
Pass-Through Vacuum Chamber Concept
Pass-Through Vacuum Chamber Concept

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## Results

**DATE:** 3/21/11  
**TESTED BY:** JHA  
**DESCRIPTION:** TEST OF SYSTEM PERFORMANCE WHEN ALL PUMPS ARE TURNED ON. TURBO PUMP HAS BEEN REBUILT.

### Vacuum Pressure Data

<table>
<thead>
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<th>INPUT PRESSURE (PSI)</th>
<th>OUTER EDWARDS M30 ROTARY VANE PUMP (MM/HG)</th>
<th>MIDDLE ALCATEL 2004A ROTARY VANE PUMP (TORR)</th>
<th>MIDDLE ALCATEL 2005 ROTARY VANE PUMP (TORR)</th>
<th>INNER W/TURBO PUMP? (Y/N-LED LIGHTS LT*)</th>
<th>DESCRIPTION OF FILM MOVEMENT</th>
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<tr>
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Commercialization Plan
Prototype Integration

▪ The unit will be shipped to Novacentrix where it will be mated with one of their pulse forge curing systems.
▪ Using the system for deep vacuum and to contain process gases, their pulse forge system will be used for curing a PV flexible substrate.
▪ If successful we will offer a commercial system to accompany Novacentrix equipment and look for other applications.
Prototype Integration

- Vacuum-assisted deposition achieves the highest quality films and the best barrier performance.
- Continuous web flow through integral vacuum chambers will be a significant advantage for the Flexible Display Industry, because it will dramatically reduce the cost and effort of vacuum deposition processes for solid state lighting and solar energy applications.
Commercialization Plan

- It is anticipated that the small modular process/vacuum chambers could be sold commercially for about $50,000.
- This is a small fraction of the cost for the conventional system described above.
- The vacuum pumps and services required are much smaller and easier to deal with.
- There is great flexibility in where the vacuum chamber is positioned in the line and how many are used.
Commercialization Plan

- New Way currently sells motion systems for reaching into ion implantation chambers through differentially-pumped grooves.
- This initiative is a logical extension of our current business model, marketing to semiconductor equipment builders.
- New Way has experience with ultra-accurate motion systems.
- We can improve the position precision and tension of webs in combination with this vacuum technology.
Wide Pass-Through Vacuum Chambers

Section C-C

Section A-A

Section D-D

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS (MM).
2. ALL DIMENSIONS ARE REFERENCE TO DRAWING IN ORIGINAL ISSUE.
3. DRAWING IS FOR REFERENCE PURPOSES ONLY.
4. SCALE 1:4

WEBCR-670-20

CUSTOM VACUUM CHAMBER

NEWWAY

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WIDE PASS-THROUGH VACUUM CHAMBERS
Non-Contact, Continuous Vacuum Processing

United States Patent Application

Abstract

A method and apparatus for mining and handling of solid bodies, such as mineable minerals or other solid objects, wherein the bodies are conveyed in a continuous and essentially frictionless manner.

Related U.S. Application Data

Publication Date: Aug. 2, 2000

Publication Classification

U.S. Cl. 136/360.4R

ABSTRACT

A method and apparatus for mining and handling of solid bodies, such as mineable minerals or other solid objects, wherein the bodies are conveyed in a continuous and essentially frictionless manner.

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Pass Through Vacuum Chamber

Frictionless Motion™
Thank You