RAY TECHNIQUES LTD
Nanodiamonds Technologies
Energy Saving Lubricants

2016
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Ray Techniques (RT) Technologies

1. Pioneering technology for nanodiamond (ND) synthesis
2. Creation novel ND-based products with desired properties
Why ND Composites?

ND Primary Particle

- Diamond core with average size: 4-5 nano-meters having unique diamond properties
- Graphene-like (or OLC) structure
- Active surface shell of functional groups and unpaired electrons

Chemically active shell enables to attach inert tiny diamond crystals to molecules of chosen material, to transfer them **unique diamond features** and to create new objects and materials with desired properties.
Unique Diamond Features

- Extreme mechanical hardness
- Highest wear resistance
- Highest thermal conductivity
- Lowest thermal capacity
- Very good electrical insulation
- Chemical and radiation resistance
- Outstanding optical properties
- Biological compatibility and non-citotoxicity
Nanodiamond Applications

- Filler reinforcing polymers
- Abrasive in fine polishing
- Additive in various coatings
- Anti-friction additive in lubricants
- Catalyst in power applications
- Delivery/contrast agent for bio-med
Existing Technology, the Problem

Polluting & dangerous technology

ND of insufficient quality, complicated to use and expensive

ND composites do not use full potential of ND

- Detonation of explosives (TNT & RDX)
- ND separation & purification by boiling in nitric acid

ND reactor in Sarov, Russia
RT Technology of ND Synthesis

The process:
- controllable
- non-dangerous
- environment-friendly
- unique & patentable

The main product: monodispersed ND of the highest quality (RayND)

1. Preparation of carbon soot from pure graphite
2. Forming special target from soot & binder
3. Laser treatment of special targets in liquid
4. ND separation by flotation method, washing & drying
The tiny size and the ball shape of Nanodiamond enable boundary friction of work surfaces.

Under the high temperature and pressure conditions nanodiamond is turning into a carbon onion.
RT Technology for ND Compounds

Additives to Lubricants

- Energy saving is one the main goals of modern technology development
- Decrease in friction is the first issue in the energy saving
- Our solution: ND additives to lubricants reducing the friction

RT Special Techniques

- ND surface modification
- Disaggregation
- ND & chosen material molecules covalent bonding

Matrix synthesis

Nondiamond Particle

ND Coagulation
Size 200–500nm

ND Dispersion
Size 5–35nm
ND Lubrication: Process & Benefits

Physical Processes

- Fine polishing and creating surfaces of very low roughness
- Introducing ND particles into a metal surface and creating protective nano-coating film with high wear resistance
- Formation of an onion-like carbon (OLC) structures on the ND surface allowing them to work like nano-ball-bearings, significantly reducing friction

Benefits

- Reduced energy consumption
- Easier cold starts
- Decreased noise
- Reduced exhaust gas emission (in the case of an internal combustion engines)
- Enhanced horsepower and airproof capacity of engines
- Increased reliability
- Service life of friction pairs increased by a factor of 2 to 3
ND Lubricant Testing Results

**End-milling machine**
Gearbox treatment caused:
- 12% electricity consumption decrease
- decrease in wear by the factor of 2
- raising the compression up to par

**Combine John Deere 9500**
Engine and gearboxes treating with ND lubricant led to productivity increase in 12%

**Compressors NEC**
ND lubricant treating leaded to 10% savings in electricity and significant increase TBO

**Mine Electric Pump D-6300**
ND lubricant treating led to electricity saving of 1200 – 1600 kW/hour
Additive to Lubricants RT-Lub

RT-Lub is intended for significantly improve the protective properties of lubricants, repair and wear protection of friction units of various machines and mechanisms, increasing their effective service life.

RT-Lub is recommended for use in lubricating compositions for automobile, tractor, locomotive and marine engines, gearboxes, transmissions, hydraulic systems, compressors and other machinery where friction and stress play a crucial role in the process of deterioration.
ND Antifriction Already in the Market

- Tianjin Chanyu Superhard Sci-Tech Co
- HeYuan ZhongLian Nanotechnology Co
- Xunsn Energy Technology Co
- GENCO (South Korea)
- Shenzhen Jingangyuan New Material Development Co
- HeYuan ZhongLian Nanotechnology Co
- Plasmachem (Germany)

- NanoLubes High Concentrates
- Nano-Oil (USA)
- Industrial, Automotive Marine Applications

Price:
- 35 $ / liter
- $4.42 - 5.79/100 ml
Advantages of RT Technology

- Environmentally friendly and non-hazardous
- Control of the ND crystal’s dimensions and defects
- Ability to obtain monodispersed ND of high quality (RayND):
  - high purity
  - controlled sp2 crystal shell
  - high homogeneity of ND dimensions
  - high homogeneity of ND surface chemistry
- Better results in the reaching fine stable ND dispersion in oil
- Lower cost in mass production
RT-Lap Testing Results

- Performance testing was conducted by Acuitas GmbH (Switzerland)
- Application: motor bearings (2QTY Kaydon; 180ARO)
- RT-Lap –A (ND antifriction grease) was compared with special lubricating grease Klüberplex BEM 34-132

<table>
<thead>
<tr>
<th>Lubricant</th>
<th>Coulomb Friction, Nm</th>
<th>Viscose Friction, nm/deg/sec</th>
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<tbody>
<tr>
<td>BEM 34- 132</td>
<td>3.50</td>
<td>0.070</td>
</tr>
<tr>
<td>RT-Lap</td>
<td>1.15</td>
<td>0.003</td>
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</tbody>
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Conclusions:
Treating bearings with RT-Lap & RT-Lub has resulted in:
- Coulomb friction decreased by the factor of 3 (RT-Lap only)
- Viscous friction decreased by the factor of 23 (RT-Lap and then RT-Lub)

Using ND antifriction treatment in engines, power generators and turbines should result in high increase in the energy productivity.
Thank you for your attention!

- **Boris Zousman**: Co-founder, CTO; M.Sc. in Electrical Engineering; inventor of RT technologies of ND synthesis & applications

- **Michael Farber**: Chemist, PhD in Chemical Engineering; printing, lamination & nano-coatings, wide experience in industrial processing

- **Valery Pedan**: Chemical Engineer, PhD in technology of organic reagents and preparations, unique experience in lubricant formulations

- **Our consultants**: Prof. Izhak Etsion (Technion), Prof. Antonino La Rocca (Nottingham University)

- **Our collaborators**: best experts in Business Development and Marketing

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