NASA/MSFC Project #NNM04AA22C

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# Development of Ultra-smooth Diamond Tooling for Machining Lightweight Mirrors

**Diamond Materials, Inc.**

***Rutgers State University of New Jersey**

**Huntsville, Alabama**

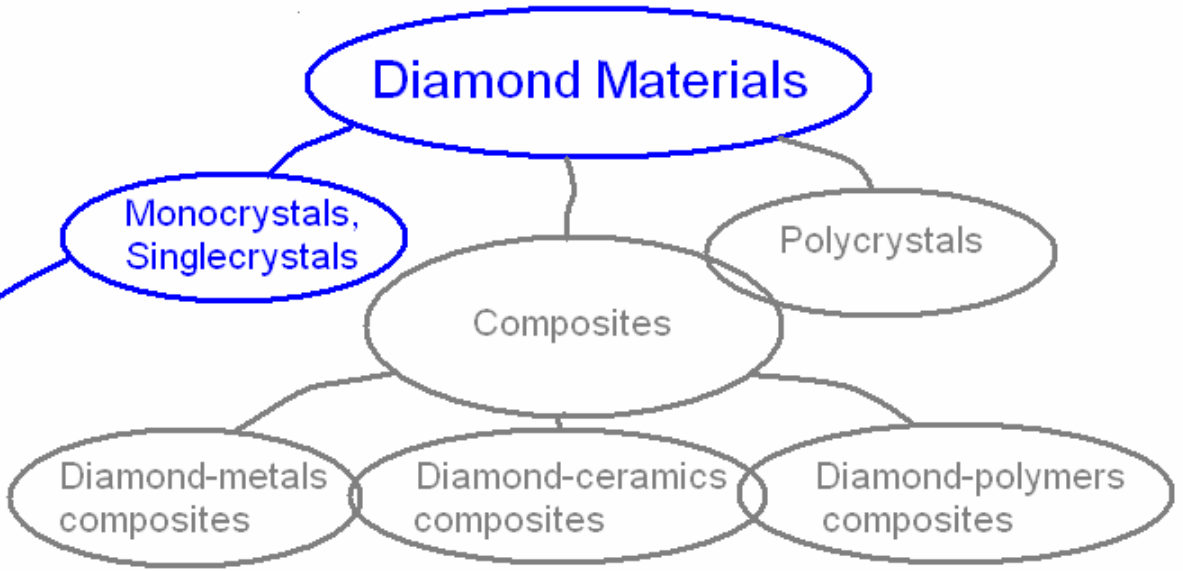
**Mirror Development and Related Technologies,**

**"Triphasic Tooling with Small Oriented Diamonds for Turning and Smoothing Lightweight Mirrors"**

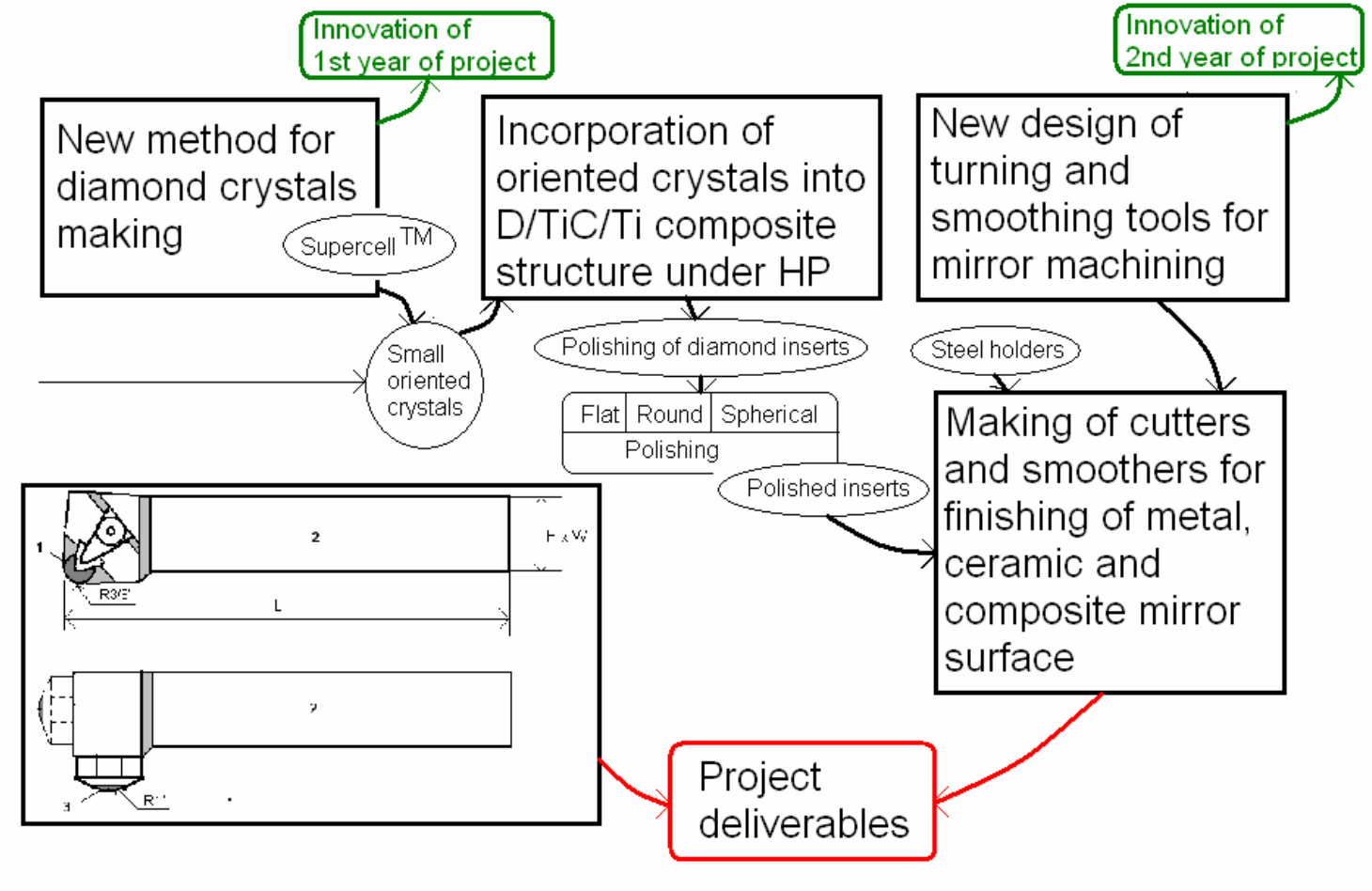
**SMD Conference, August 17-19, 2004**

**Presenter: Dr.Voronov**

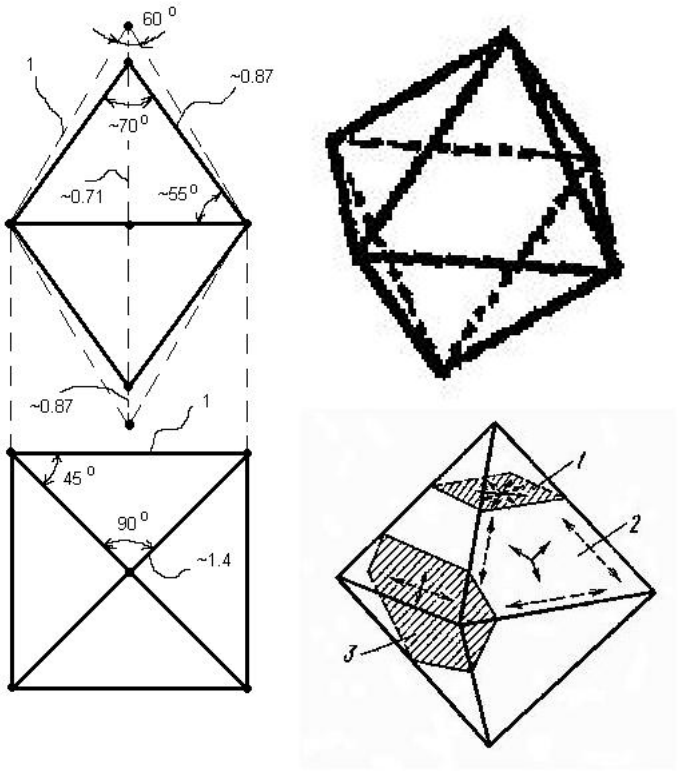
# Diamond Materials



# Structure of Project



# Main idea of project: correctly oriented diamond crystal cuts and smooth better than polycrystals



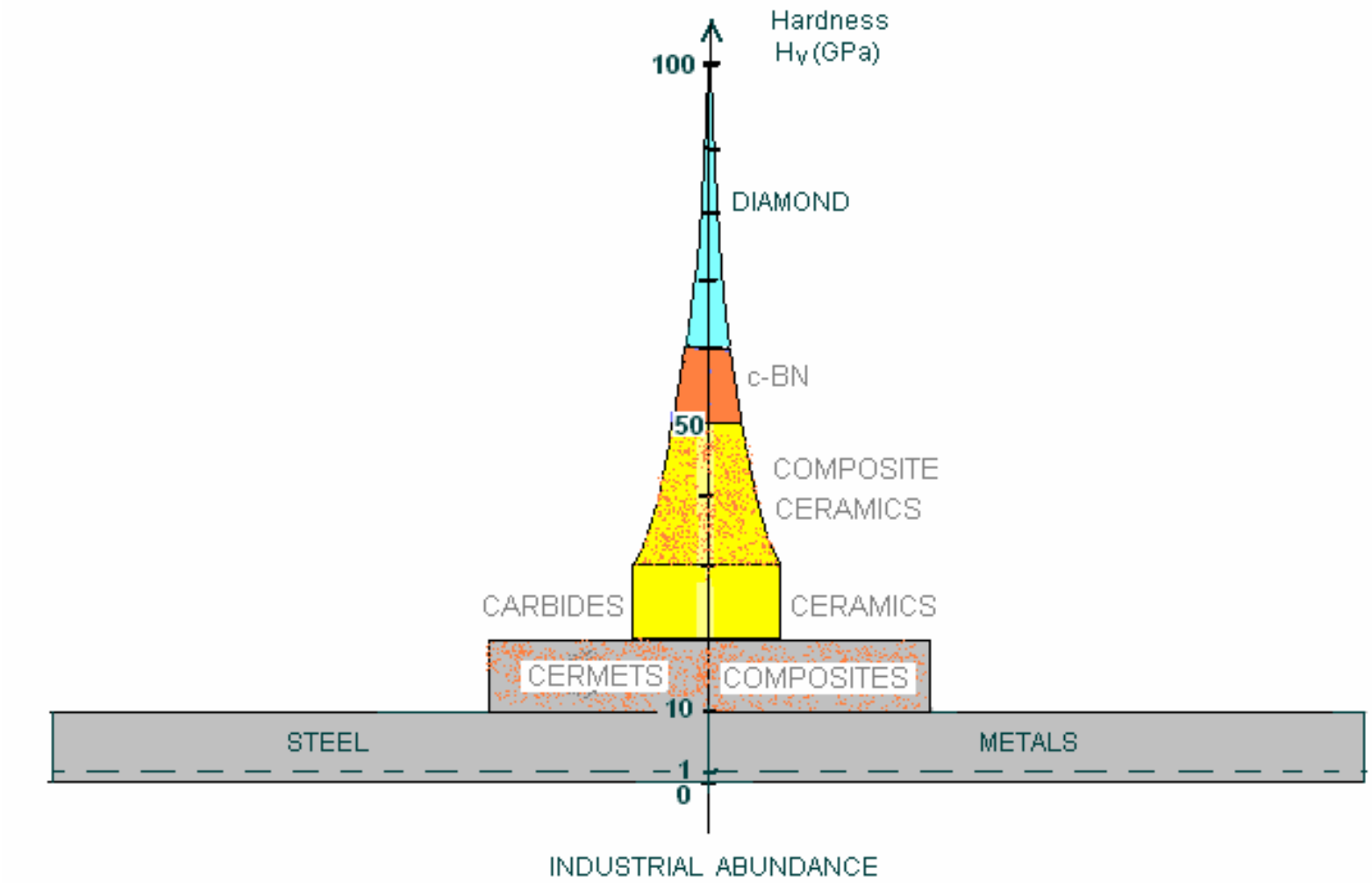

Octahedron

Crystal is anisotropic: hardness of diamond crystal depends on orientation

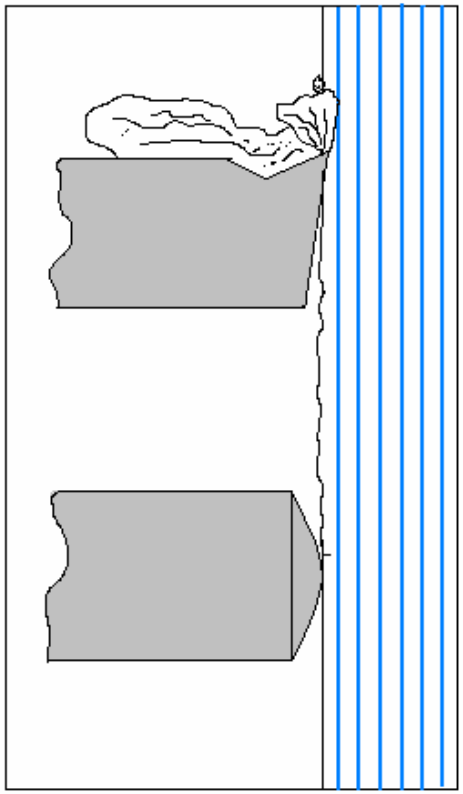
Dependence of wear ratio (mg/min) on diamond crystal orientation

| Plane | Soft Dir. of | Wear rate |
|---|---|---|
| 1 | Cube | 3 |
| 2 | Octah. | 0.5 |
| 3 | R.Dod | 5 |

# Hardness

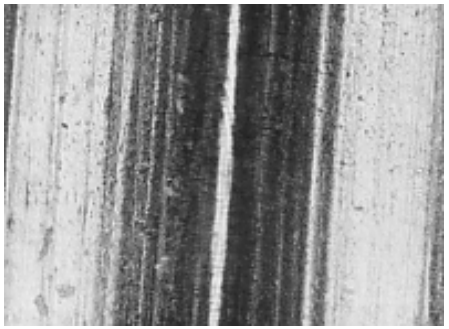

Hardness
Hv (GPa)
100
DIAMOND
c-BN
50
COMPOSITE
CERAMICS
CARBIDES
CERAMICS
CERMETS
COMPOSITES
10
STEEL
METALS
1
0
INDUSTRIAL ABUNDANCE

## Turning and Smoothing of Metals



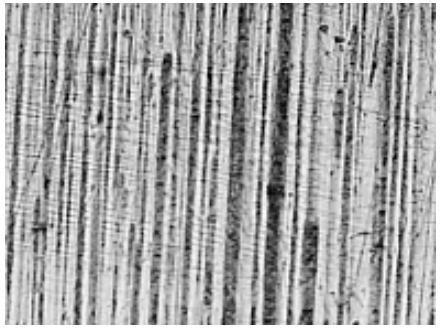
## Surface Irregularities

Rough Turning

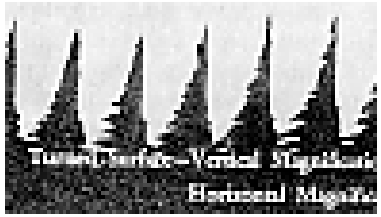


μmRa 12.5 x100

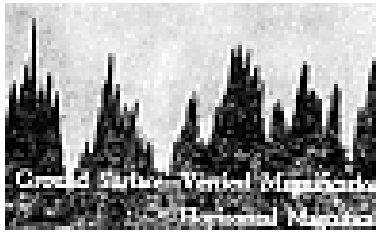
Smooth turning



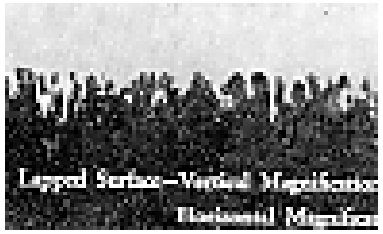
μmRa 0.4 x100
Standard ANSI B46.1—1978
Military Standard 45662



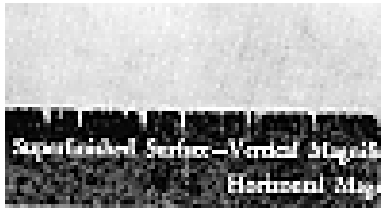
Turning (v x425, h x17)



Grinding (v x4300, h x167)

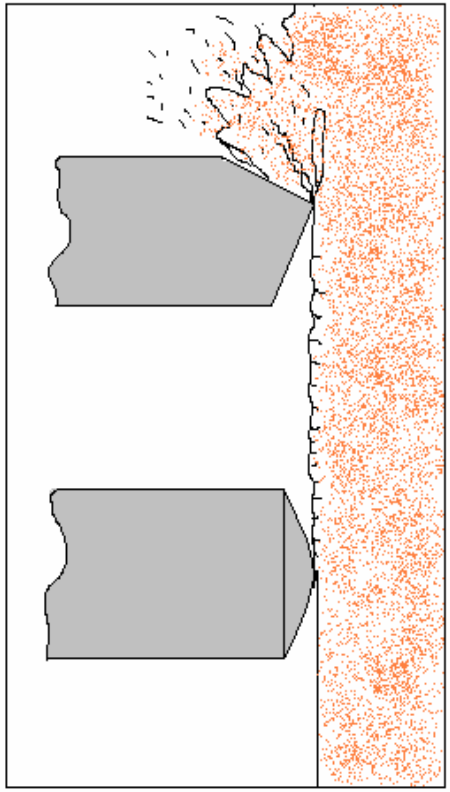


Lapping (v x5000, h x200)



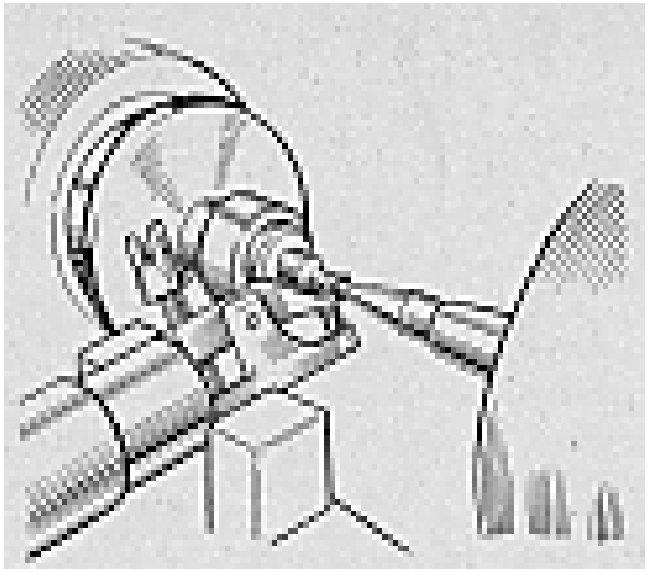
Super-finishing (v x6000, h x240)

## Turning and Smoothing of Ceramics

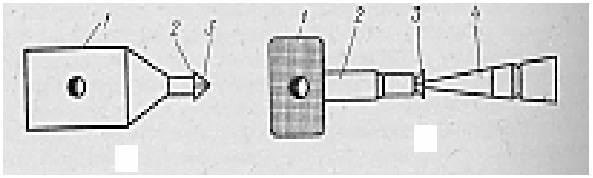


Goal: ≤ 1 nm roughness and irregularities

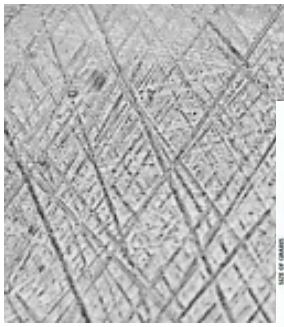
# Industrial Turning and Polishing of Diamond Materials



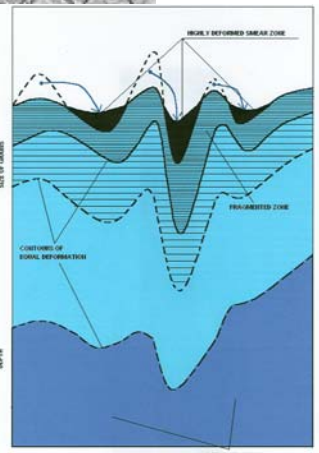
Set-up for turning of diamond by diamond cutter



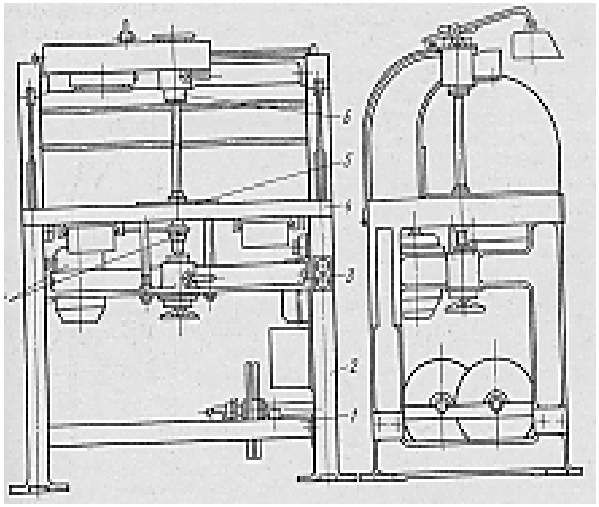
Industrial surface roughness standard for polishing



μmRa 0.05 x400



Schematic model of mechanical deformation resulting from grinding and polishing operations

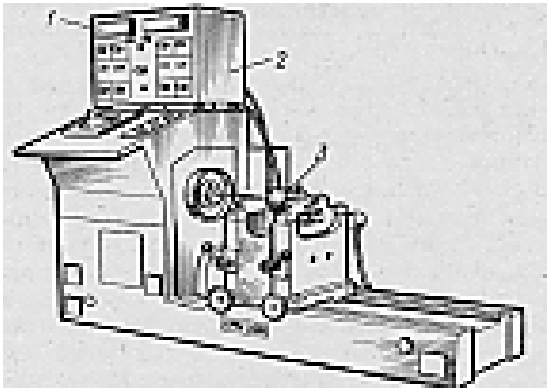


Flat grinding and polishing of diamonds by balanced iron wheel

## Materials:

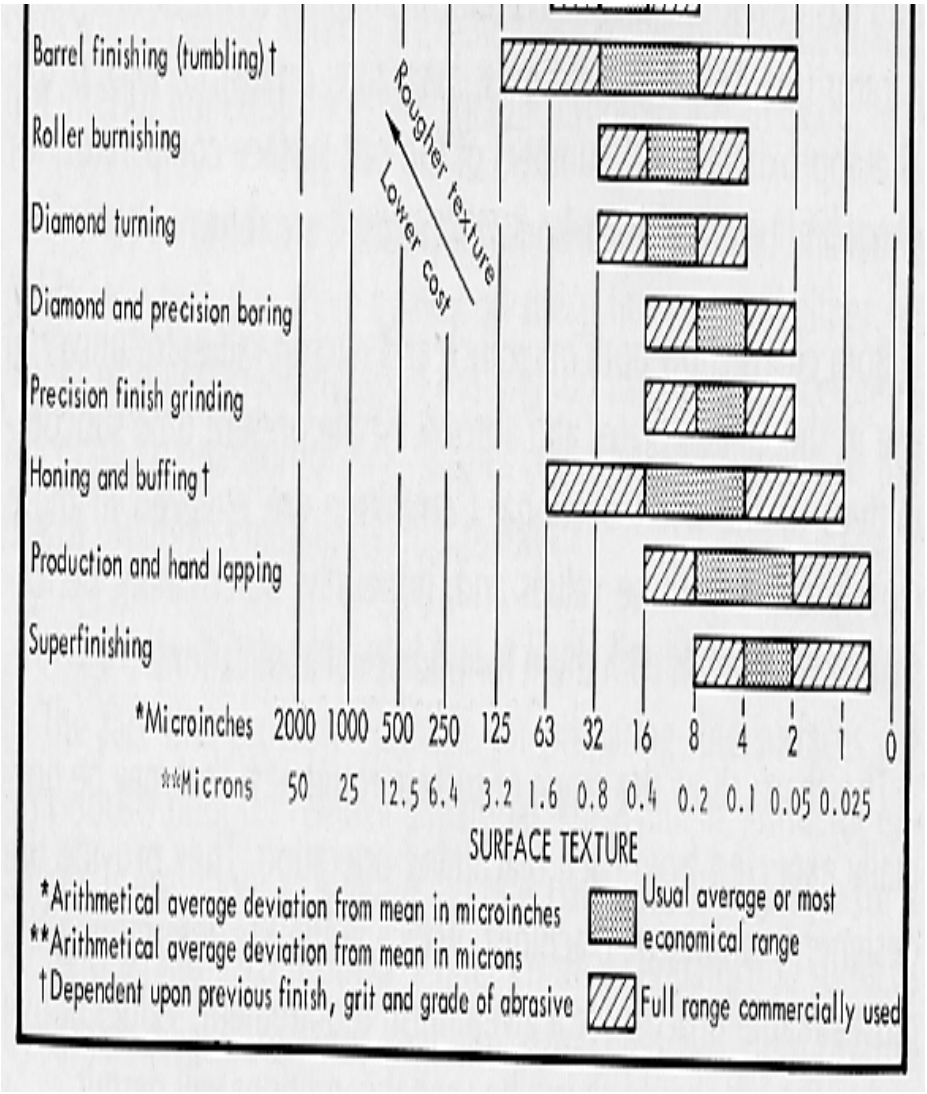
1. diamonds
2. diamond powders (0.5 μm-50 μm range)
3. diamond wheels

**Trueing of wheels**
**Dressing of wheels**
**Buffing of samples**

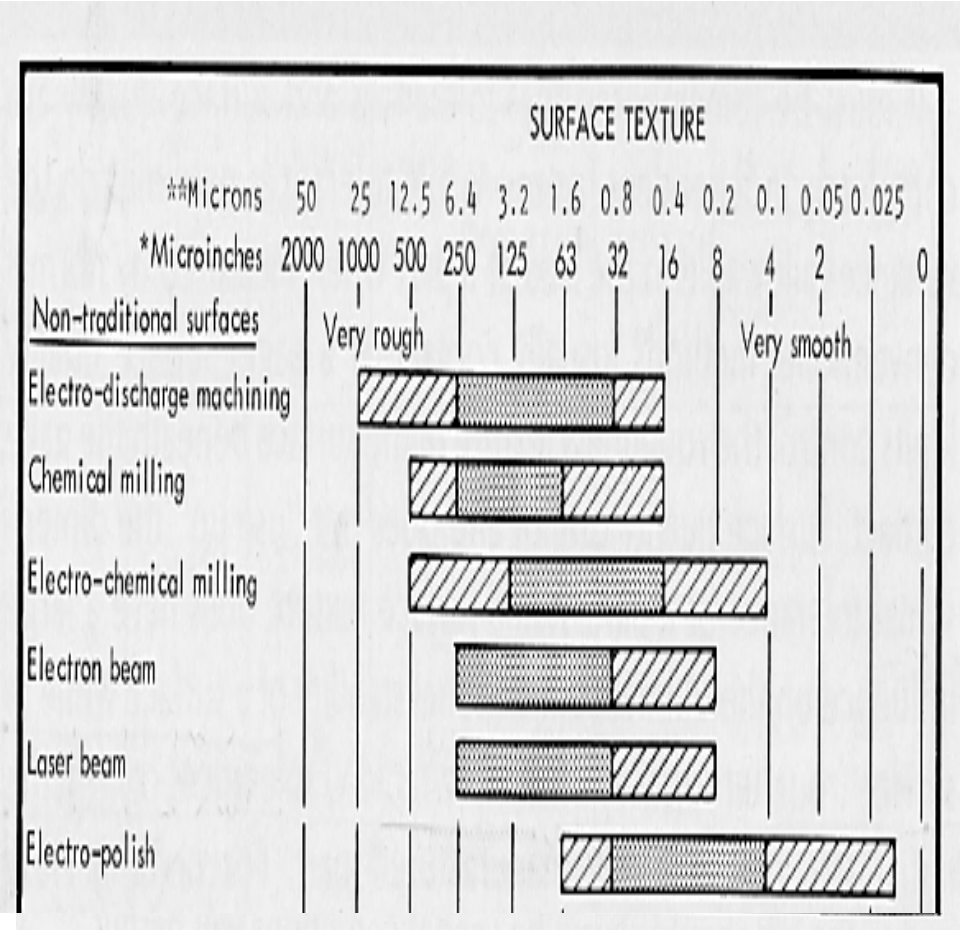


**Spherical polishing of diamond is to be developed under this project**

# Industrial Turning and Polishing by Diamond Materials



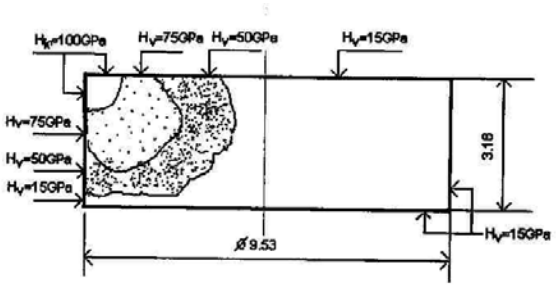

Turning, lapping and finishing

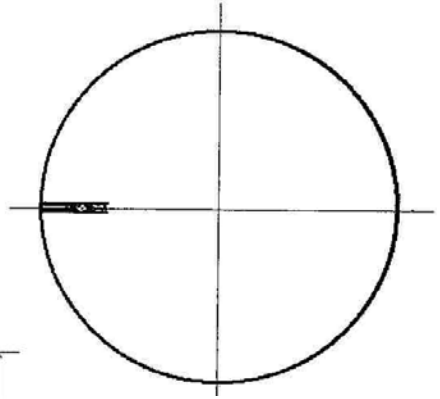



Special methods for surface quality

# Cutting and Smoothing Inserts

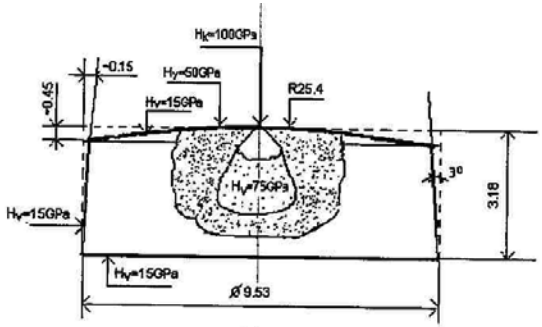
## Turning

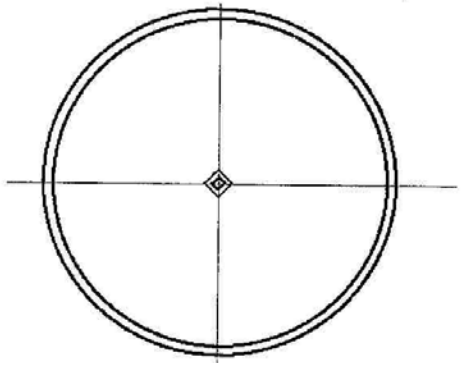


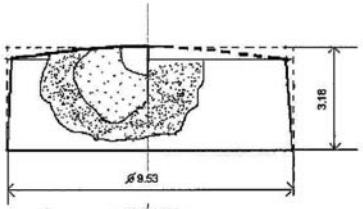
Cylindrical insert

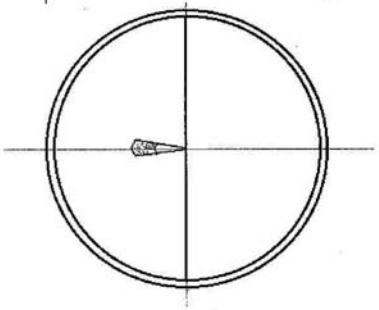
## Smoothing



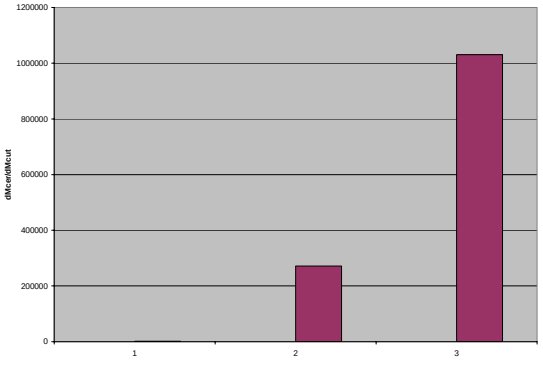
Spherical insert



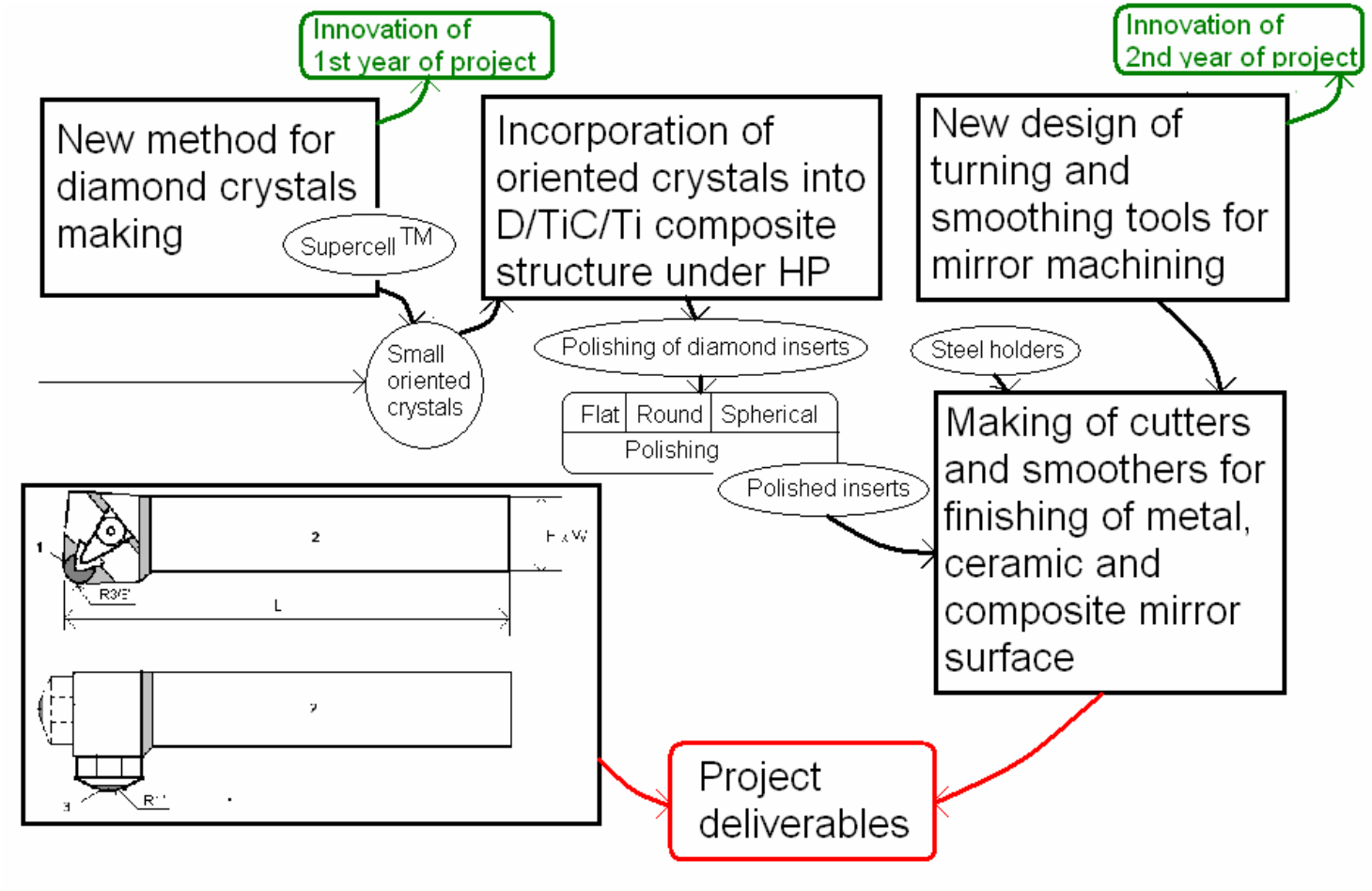



Spherical insert

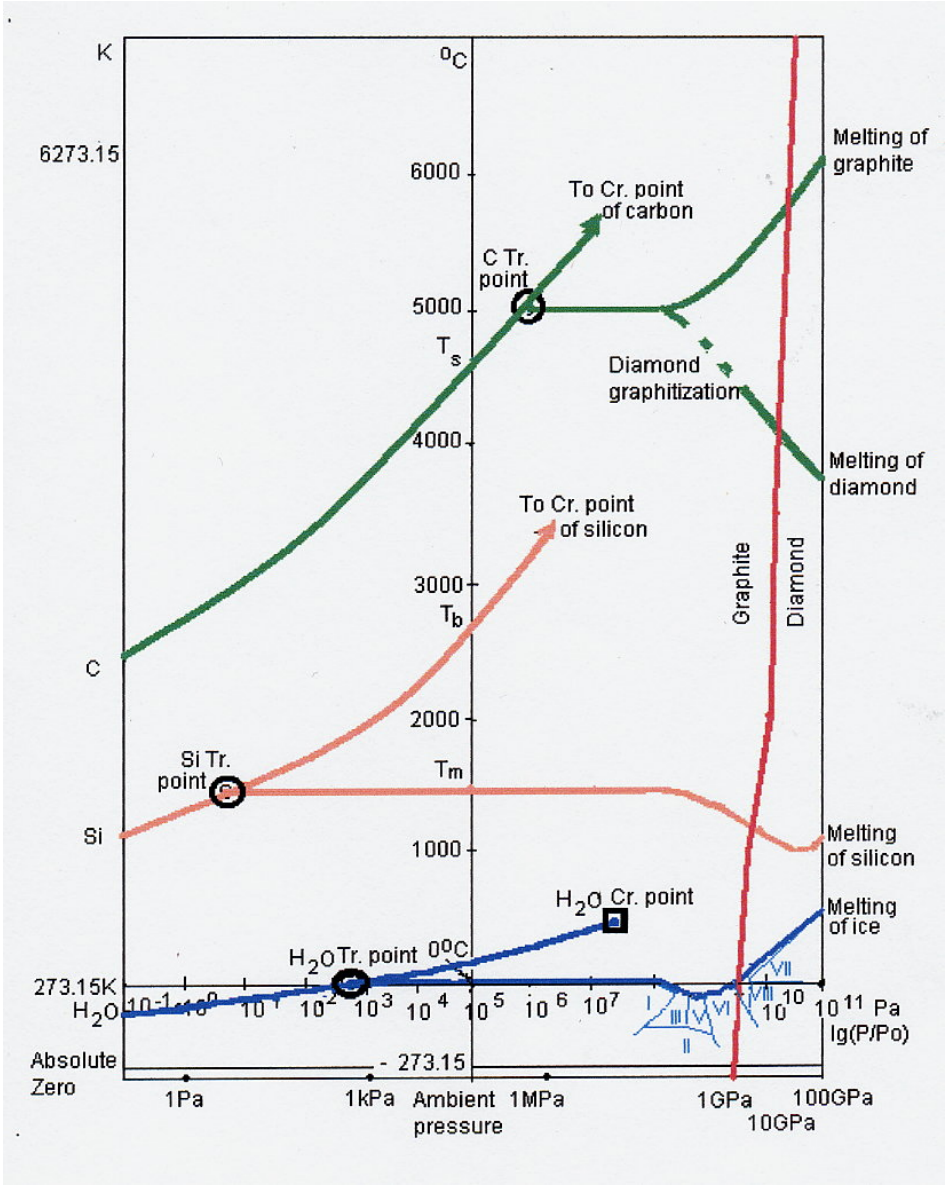
**Previous results on wear rate of inserts with small oriented diamond**



# Structure of Project



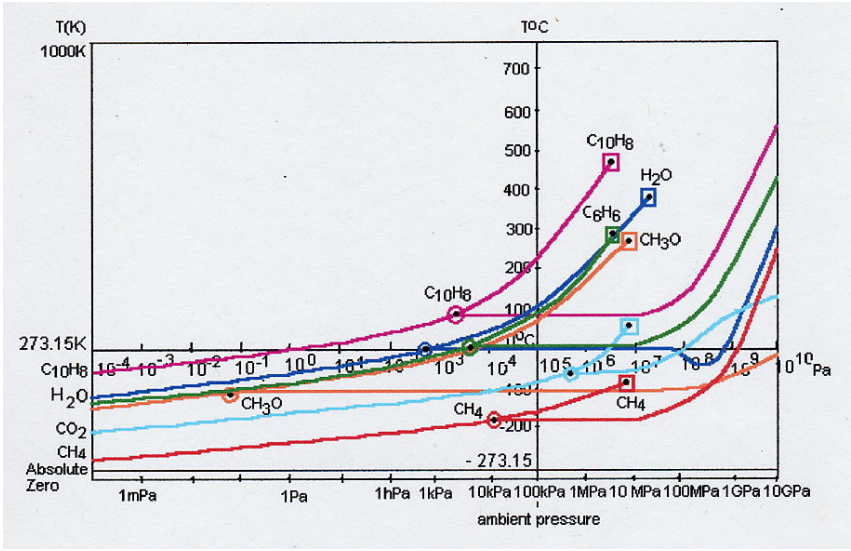
# Carbon, Silicon, and Water State and Phase Diagrams




**Our main assumptions were:**

1. **Diamond crystals can be grown from solid and liquid states in a very high pressure range**
2. **Graphite melts at higher temperature than diamond in P=1-100 GPa range**

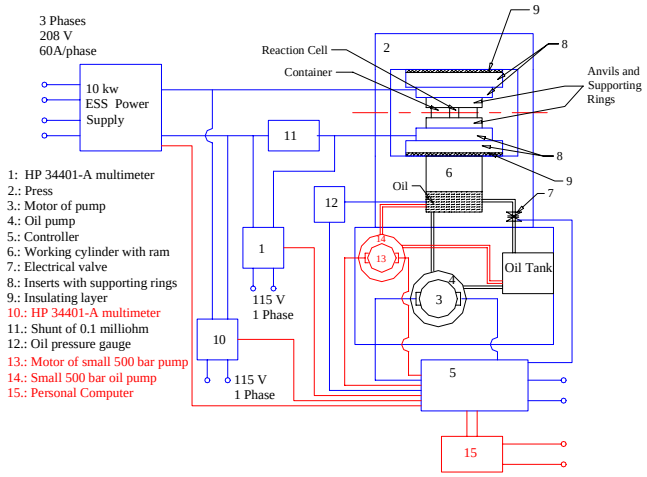
**State diagrams of some organic compounds in similar coordinates**




**Methane, methanol, carbon dioxide, water, benzene, naphthalene**

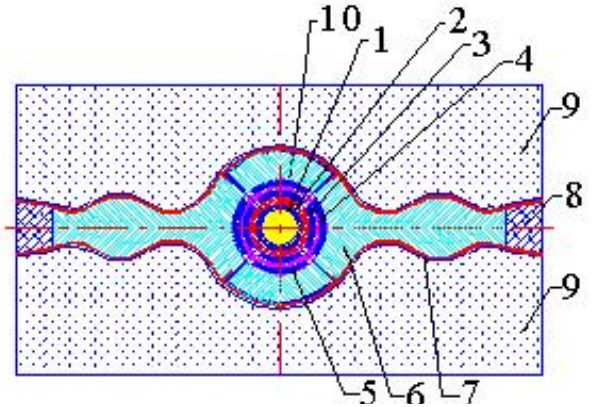
# Supercell™--a device for generation of very high static pressure and temperature in relatively large volume

**Prototype equipment**




**Schematic of Supercell™**

**Schematic of HPHT zone**




Capable of growing diamond crystals from carbon melt. Crystals grow at high rate at such high temperature and pressure-minutes instead of hours.

$$P \sim \frac{F}{S + \frac{F}{H_v}}$$

**P – pressure**
**F – force**
**S – area**
**$H_v$ – microhardness of anvils**