

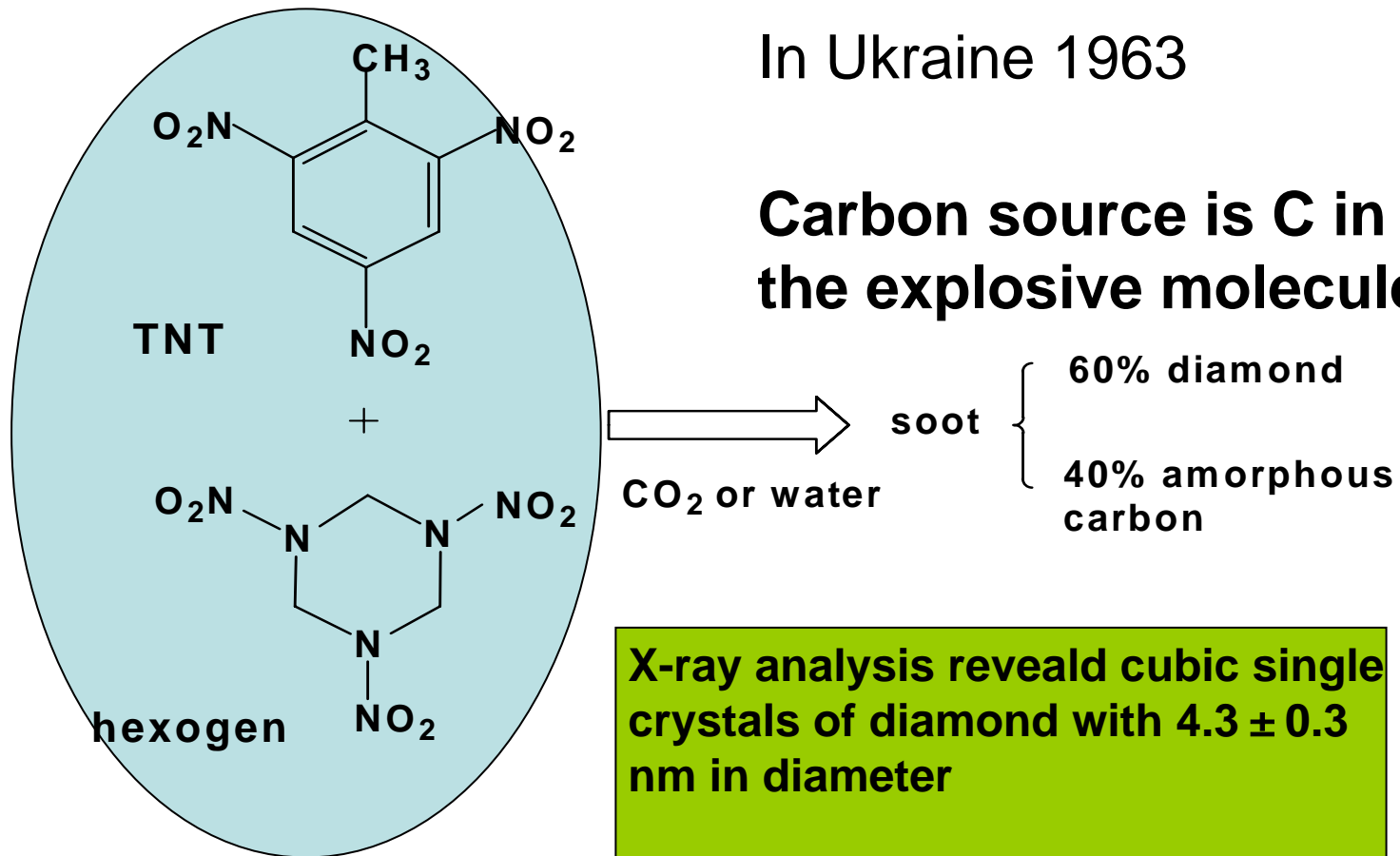
# Diamond from Explosives

*NanoCarbon Research Institute*

# Discovery of Detonation Nanodiamond (DND)

Danilenko, Titov, Volkov  
In Ukraine 1963

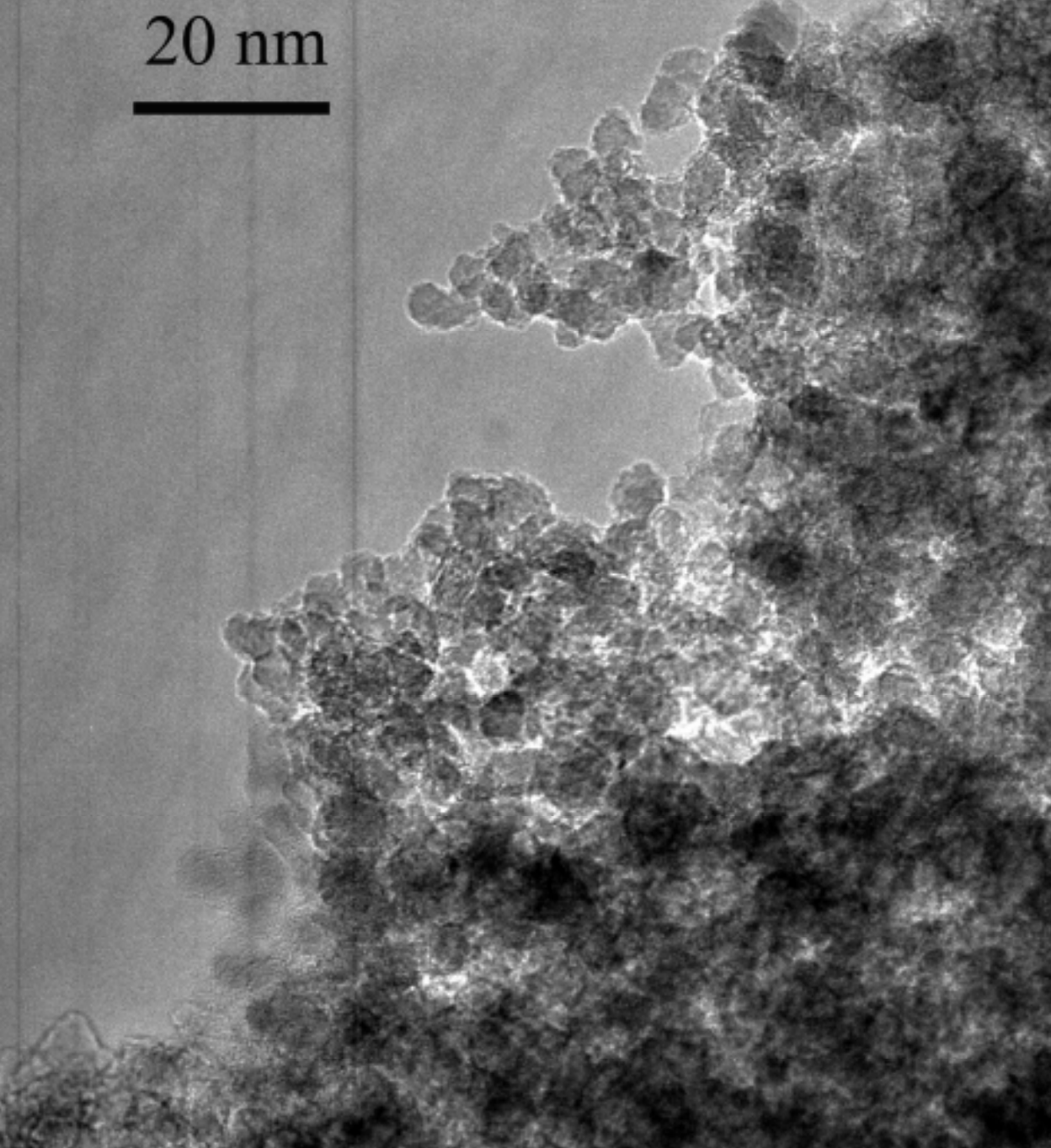
**Carbon source is C in  
the explosive molecules**



**X-ray analysis revealed cubic single  
crystals of diamond with  $4.3 \pm 0.3$   
nm in diameter**

**The best material for  
nanotechnology?**

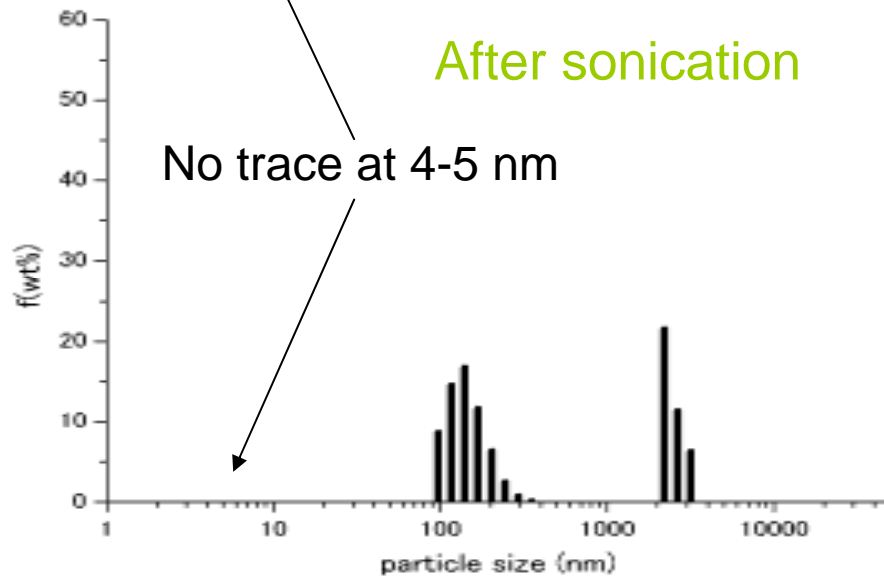
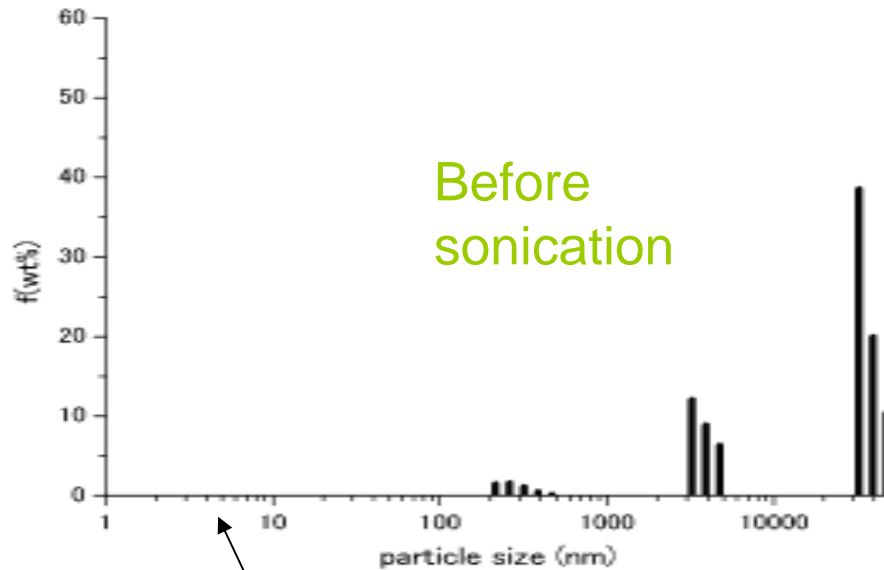
20 nm



TEM picture of  
DND before  
disintegration  
(M. Ozawa).

Has long been  
mis-interpreted as  
isolate primary  
particles.

# Recognition of agglutination



The first determination of particle-size distribution in DND by dynamic light scattering (DLS) measurements (Ogawa, 2002)

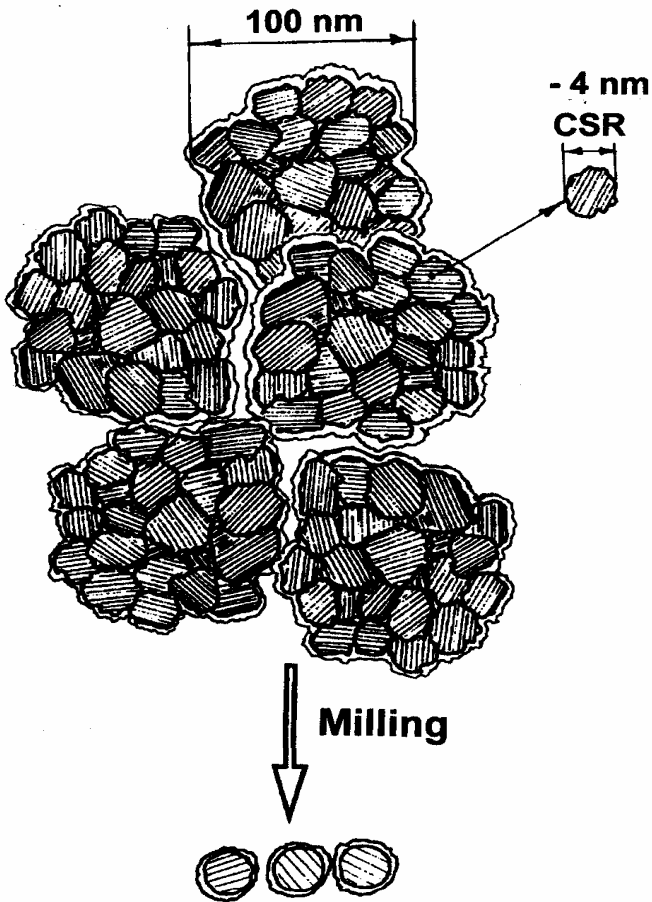


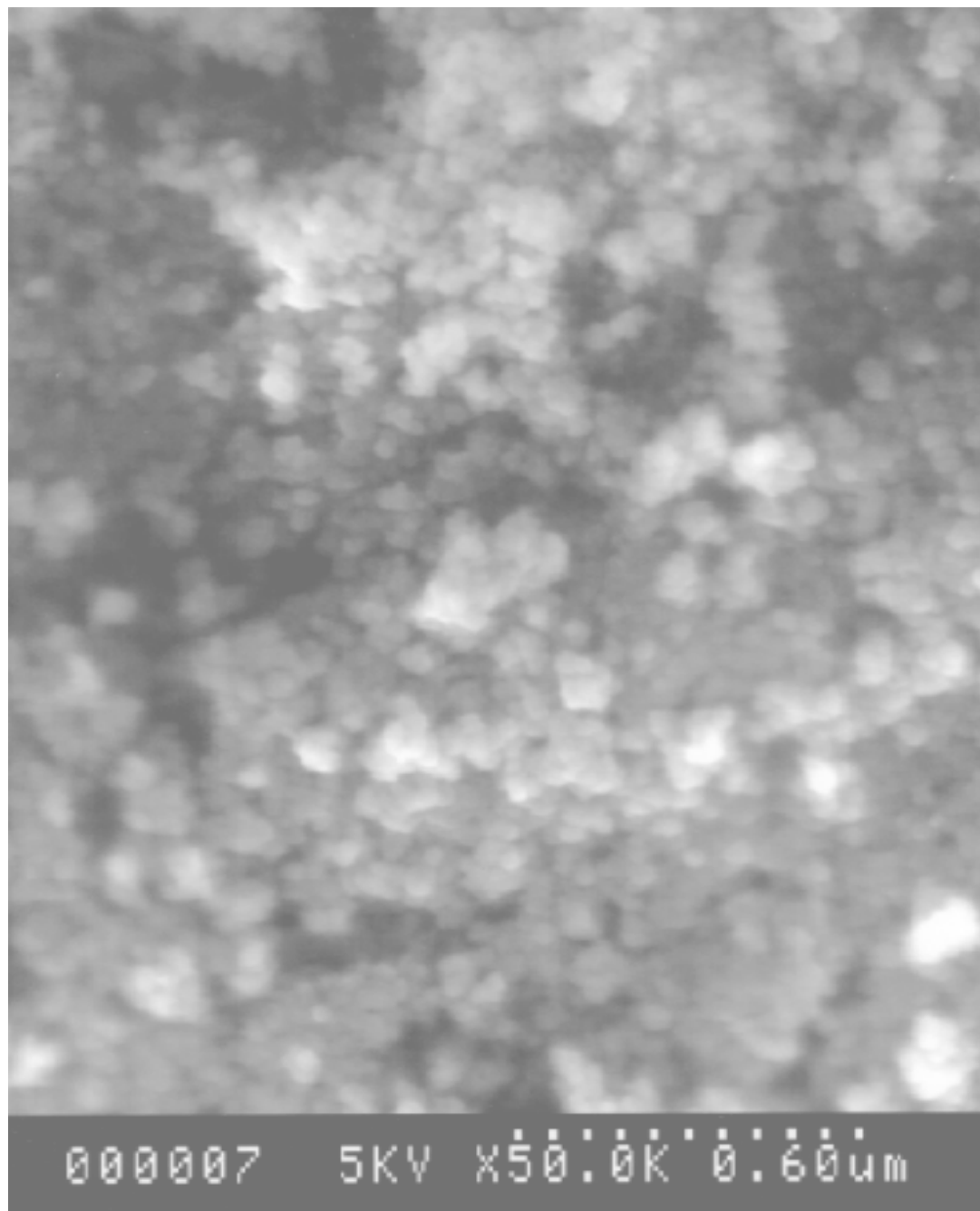
Illustration by (Vul' *et al.*)

Hypothesis 1: the smallest particles that could be reached by sonication (100-200nm) are secondary aggregates

The size of primary particle is 4 nm by the determination of coherent scattering region, but they form core aggregates (agglutinates) by forming chemical bonds.

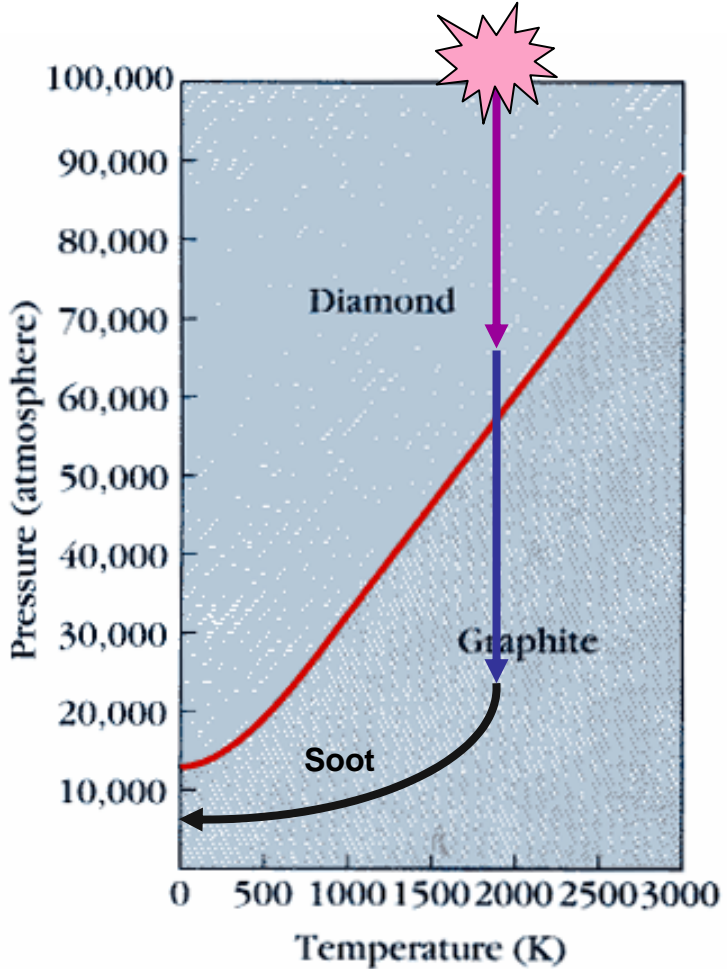
Stirred-media milling with ceramic beads effectively destroys agglutinates (2002).

**SEM image of  
agglutinates  
(Vul' *et al.*)**

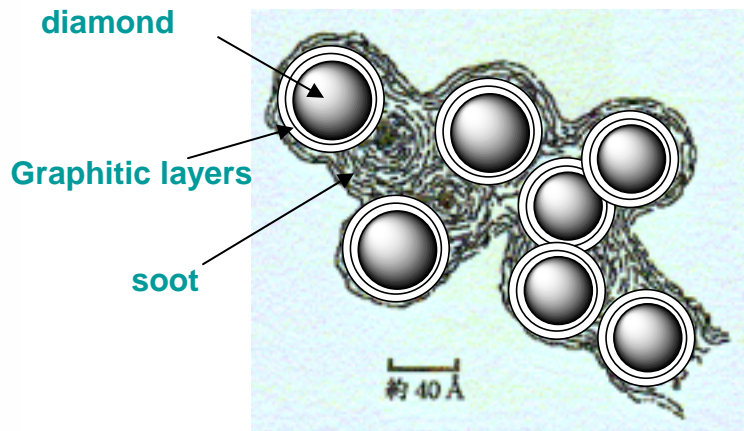


# How agglutinates are formed ?

Hypotheses 2: Amorphous carbon layers grow under HTHP conditions of explosion with diamond as nuclei.

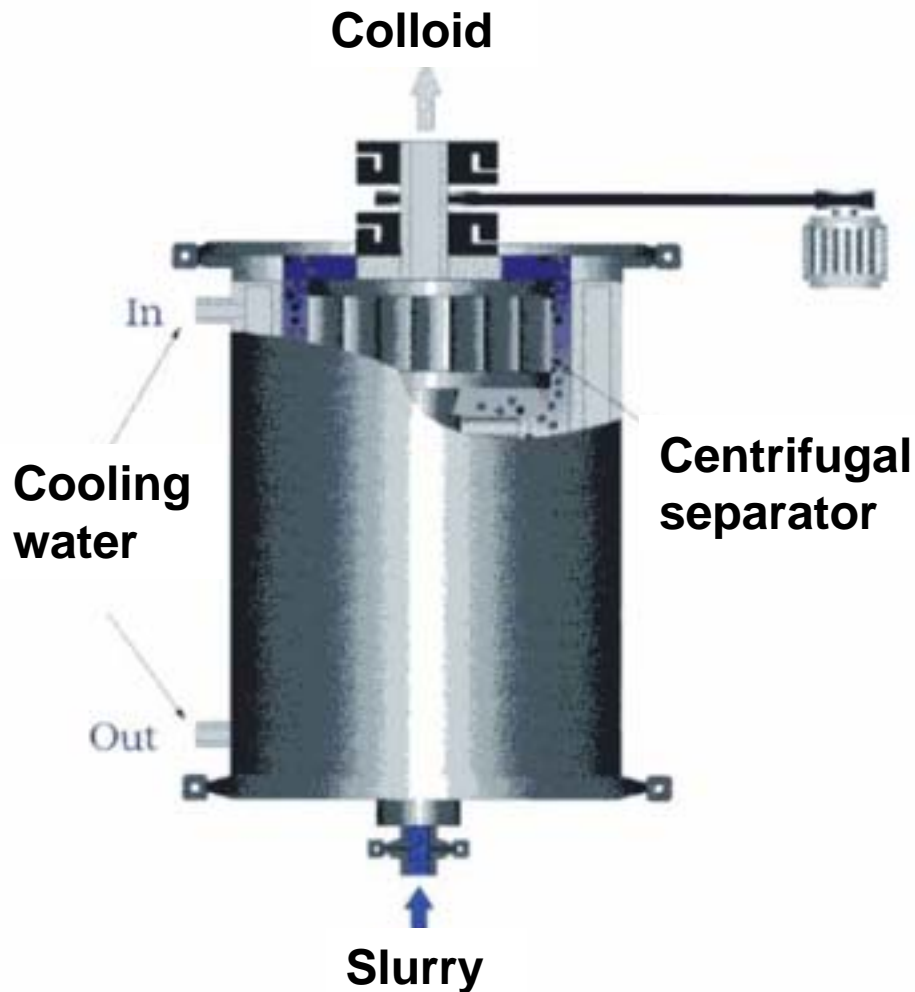


Model of soot (carbon blacks) by T. Osugi



Model of diamond/soot agglutinates

# Disintegration of agglutinates by bead-milling



- ( 1 ) Milling room was charged with microbeads to the extent of 70-80% of available space.
- ( 2 ) Slurry of DND agglutinates is circulated through the milling space.
- ( 3 ) High speed rotation of slurry/beads mixture (~4000 rpm).
- ( 4 ) Mechanical sealing
- ( 5 ) At the exit of milling room DND is continuously separated from ceramic beads by centrifuge.

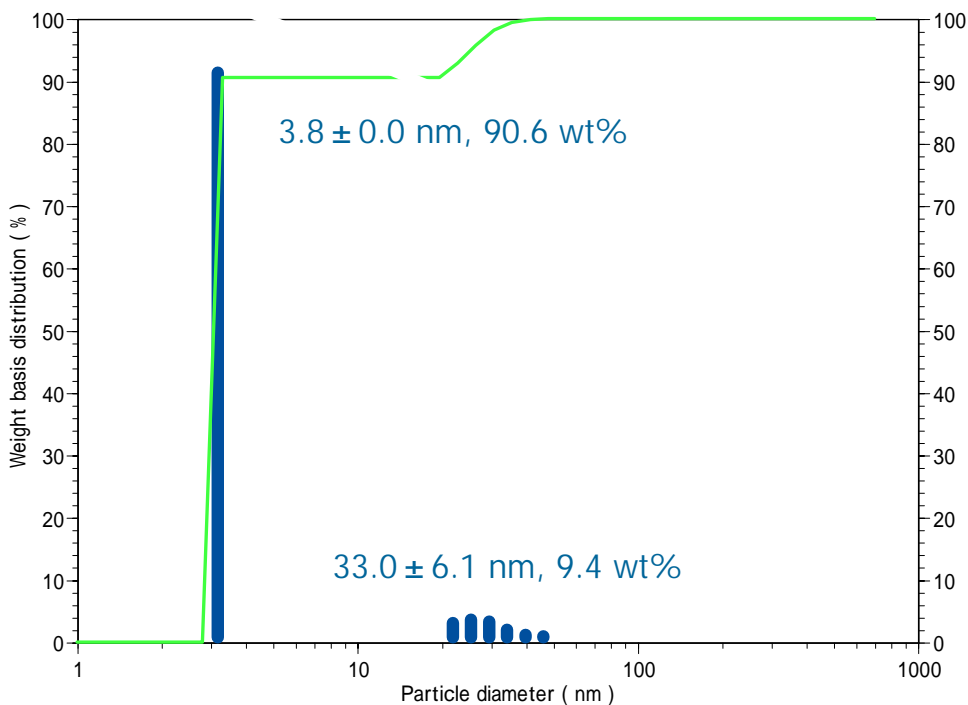
Beads: 30, 50  $\mu\text{m}$   $\text{ZrO}_2$

Wet media : water

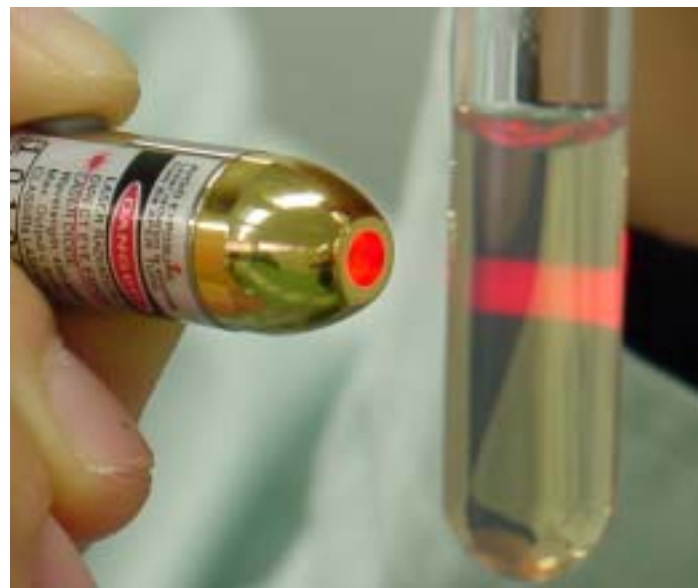
Slurry concentration: 10%



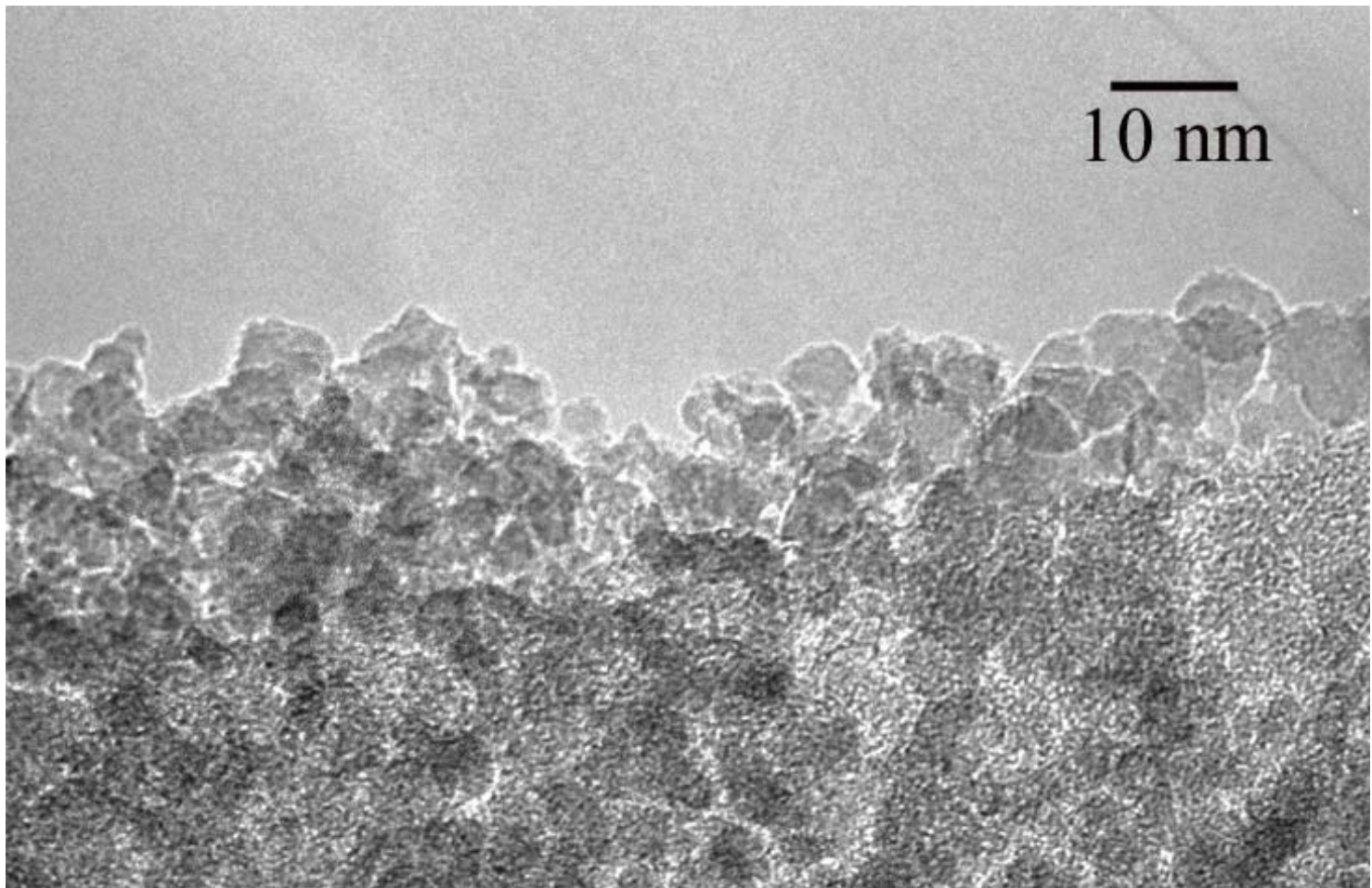
# Results of beads milling are dramatic !



**Single-nano diamond crystallites obtained for the first time (2002)**



**Invisible primary particles display Tindall phenomenon**



**Isolate primary particles of DND (M. Ozawa).**

Re-aggregated during drying for taking the TEM picture, but can be readily dispersed back to colloid upon sonication.