Center of ultrasonic technologies

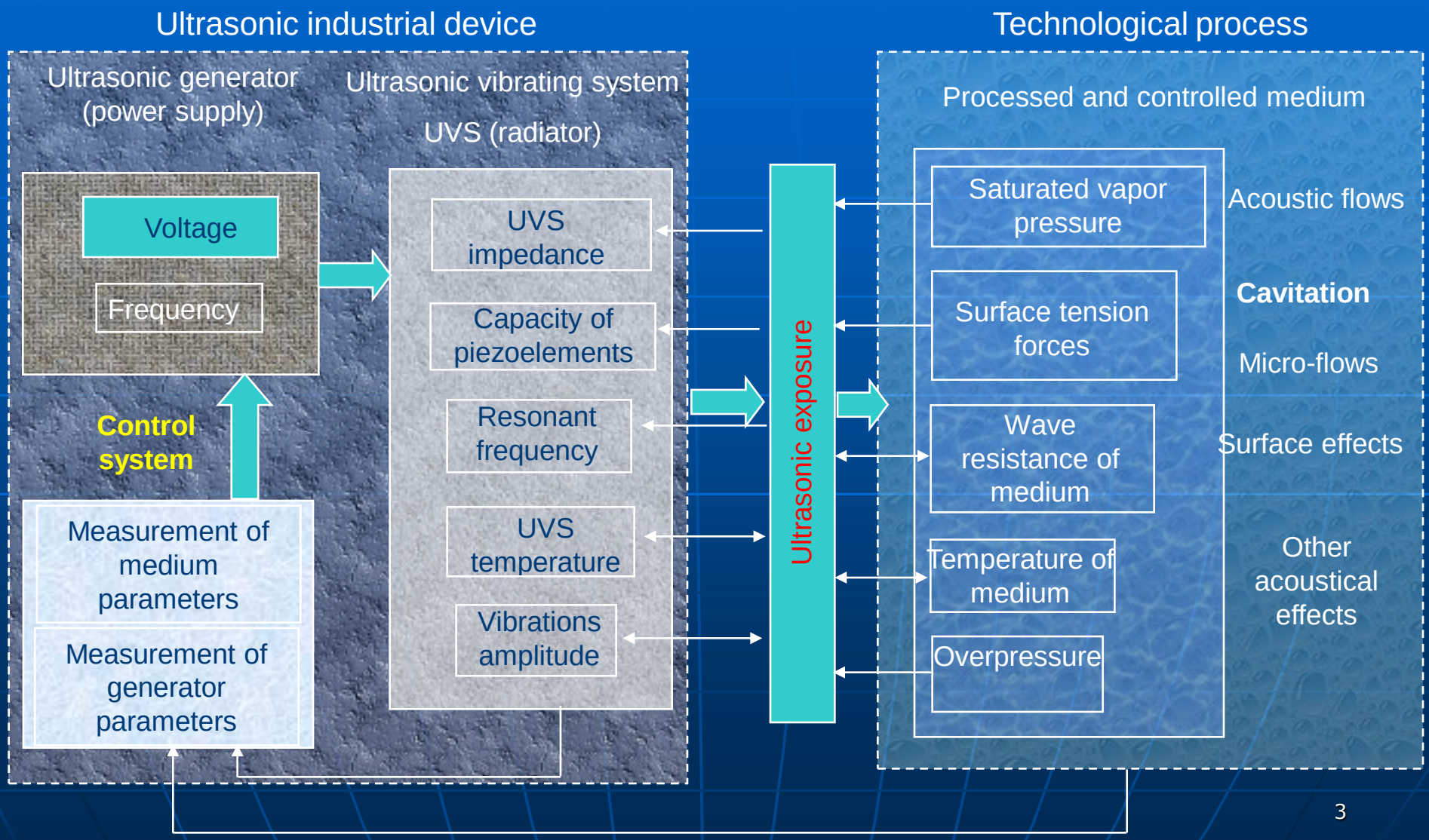
# Features of ultrasonic devices for various purposes

# Khmelev Vladimir Nikolaevich

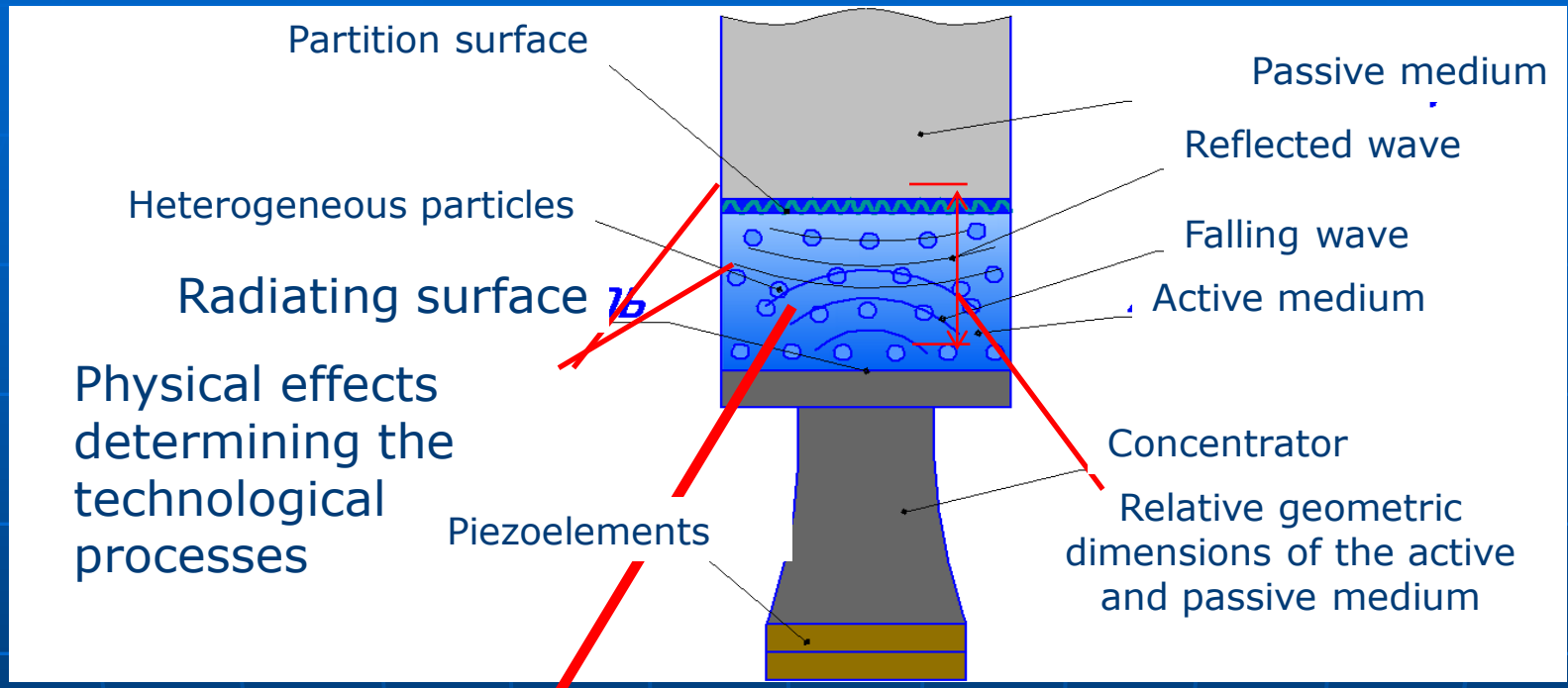
***Doctor of Technical Sciences, Professor, Honored Inventor of the Russian Federation, Senior Member IEEE. Laureate of the Russian Government Award in the field of science and technology, author of more than 900 scientific publications (including more than 100 patents, more than 20 monographs and textbooks), Deputy Director for Scientific Work of the Biysk Technological Institute of the Altai State Technical University.***

+7 9039925120
vnh@u-sonic.ru

# Ultrasonic exposure



# Common scheme of ultrasonic device operating




Frequency and intensity of ultrasonic exposure

$$R = F(f, A, P_1, P_2, L)$$

**Optimization problem**

**Find functional dependency**

**R is the vector of optimal criteria,** P1 is the vector of properties and characteristics of the active medium, P2 is the vector of properties and characteristics of the passive medium, L is the vector of relative geometric dimensions of the active and passive medium, f is the vibration frequency of the radiator, A is the vibration amplitude of the radiator.

# Processing of liquid-disperse mediums

***Intensification of processes and forming of new materials in liquids***

Physical and chemical processes

1.Extraction of plant raw materials
- faster in 100...10000 times;
- increasing the output;
- sterilization;

2. Separation of multicomponent systems
3. Demulsification
4. Coagulation of hydrosols
5. Degassing
6. Crystallization
7. Preventing crystallization

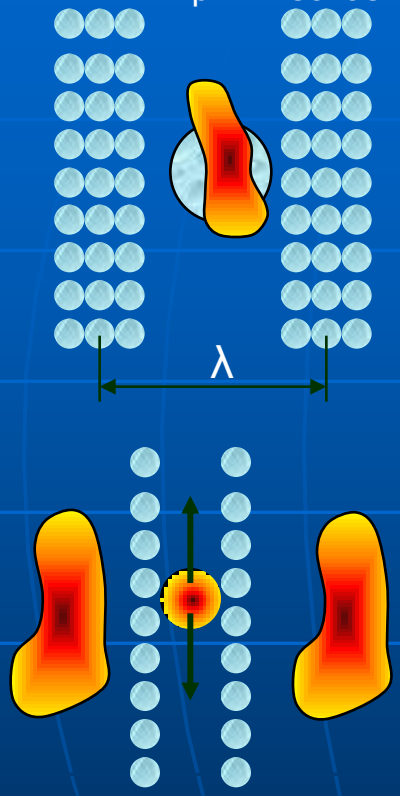
Chemical reactions

Breaking of chemical bonds of substances in a cavitation bubble and on its surface
Redox reactions
Depolymerization
Polymerization

# Cavitation

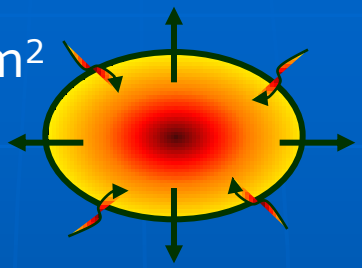
*Initiation*

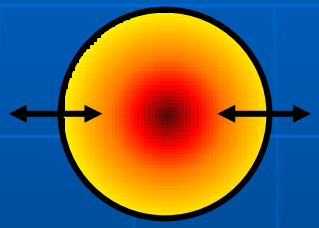
$P<P_{критическое}$



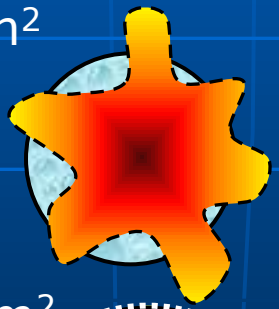

*Stages of progress*

$I \sim 1\ W/cm^2$

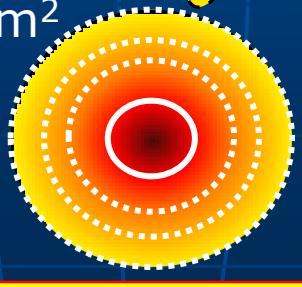




$I > 1{,}5\ W/cm^2$



$I > 2{,}5\ W/cm^2$

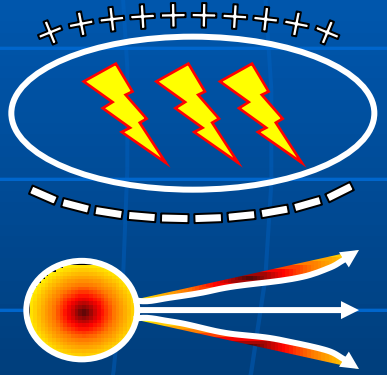


*Active forces*

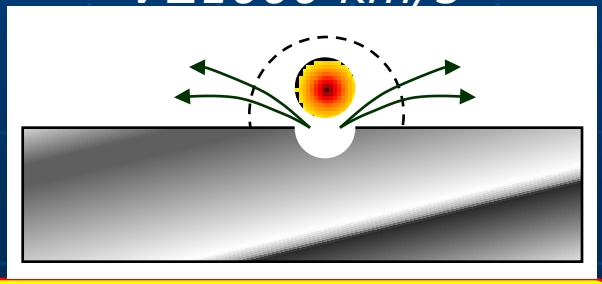
P≥500 MPa

T≥10 000 K

U>1 000 000 V



*V≥1000 km/s*

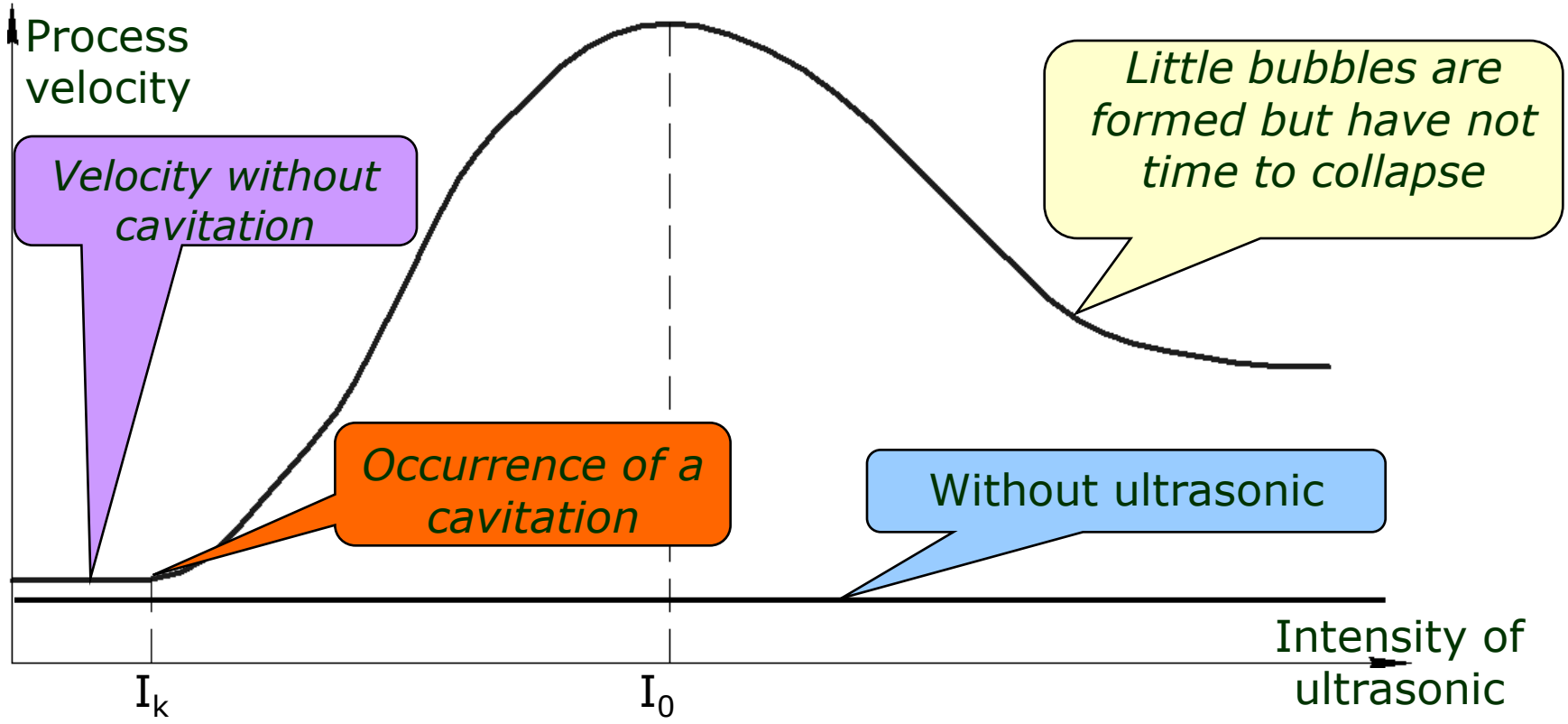


$P_{critical}$=150 MPa

Domains of a cavitation (microscopic gas bubbles)

***Conditions for thermonuclear reactions realization are provided***

# Dependence of processes velocity from cavitation parameters




$I_k$=1 W/cm² – Water

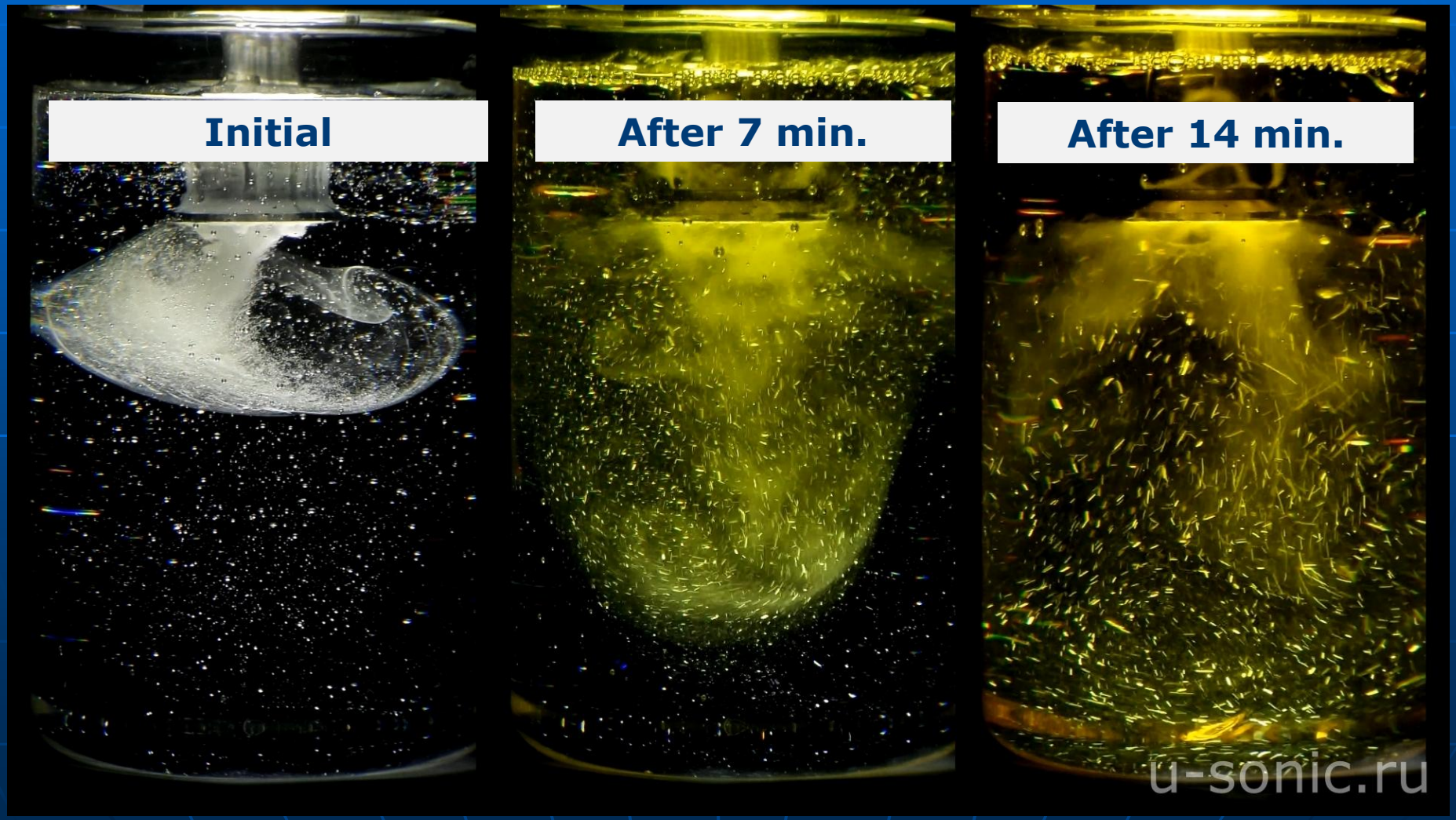
$I_k$=4 W/cm² - Oil

$I_k \sim f(\omega)$

$I_0 = f(P, \rho c, \eta)$

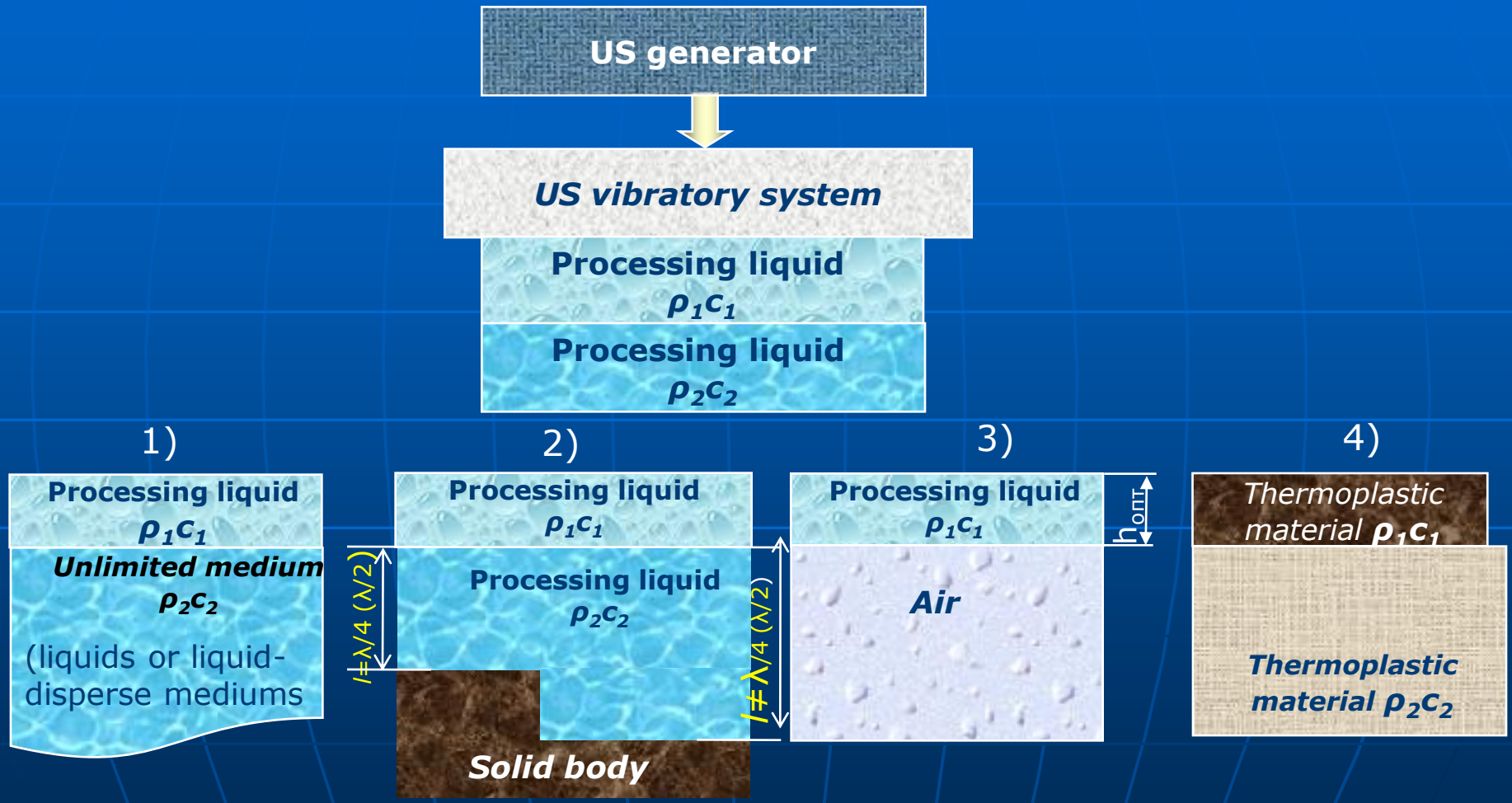
*Process velocity* = *Generation rate of radicals*

# Cavitation into viscous liquid



# *Ultrasonic processing of non-Newtonian liquids*

# Features of ultrasonic exposure




**The absence of the optimality criteria of ultrasonic exposure due to the impossibility of continuous monitoring of the processing mediums parameters**

# Cavitational exposure areas

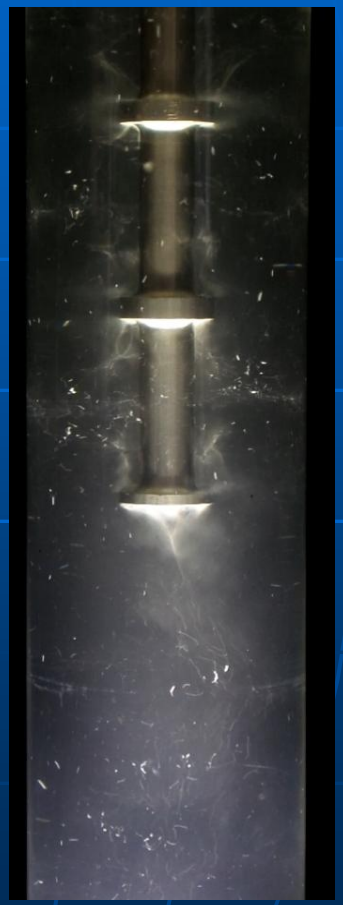
Volna-M UZTA-1/22-OM

water

oil


Bulava UZTA-2/18-O

water



oil

# Cavitational area (LUK-0.125/50-O)

Output power

100%

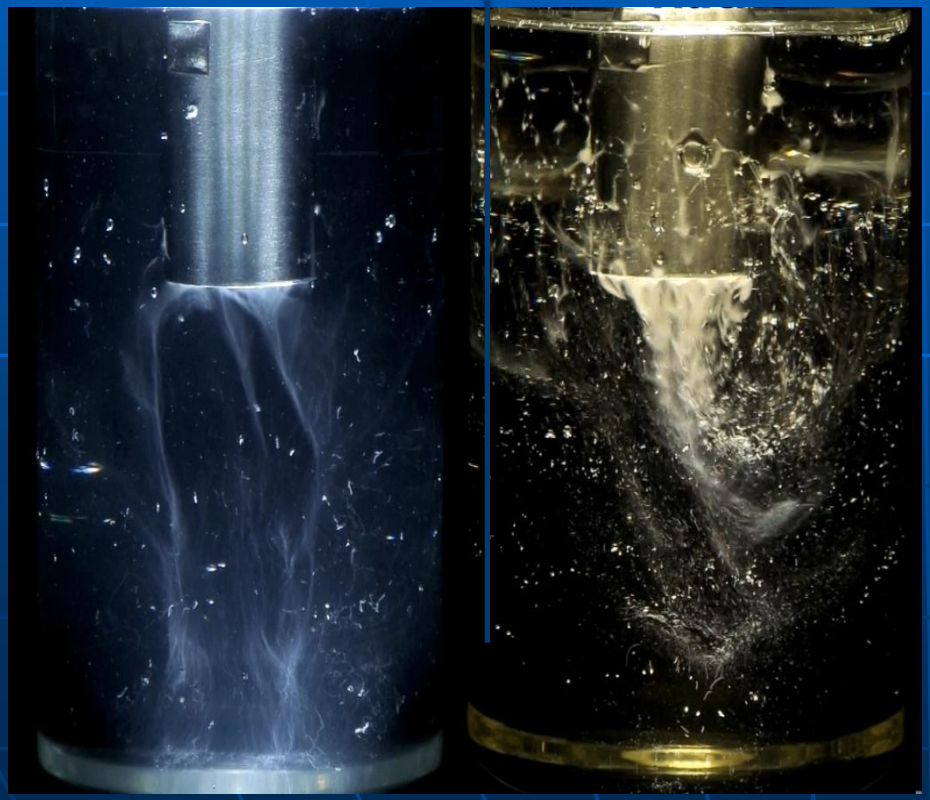
80%

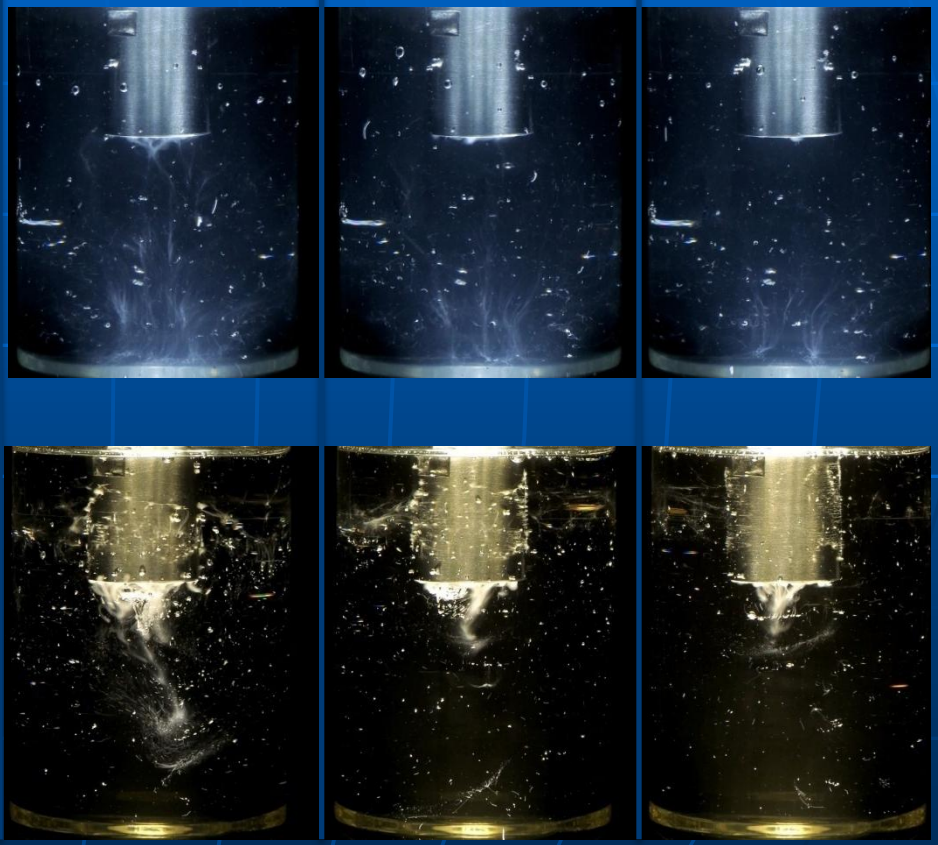
60%

40%

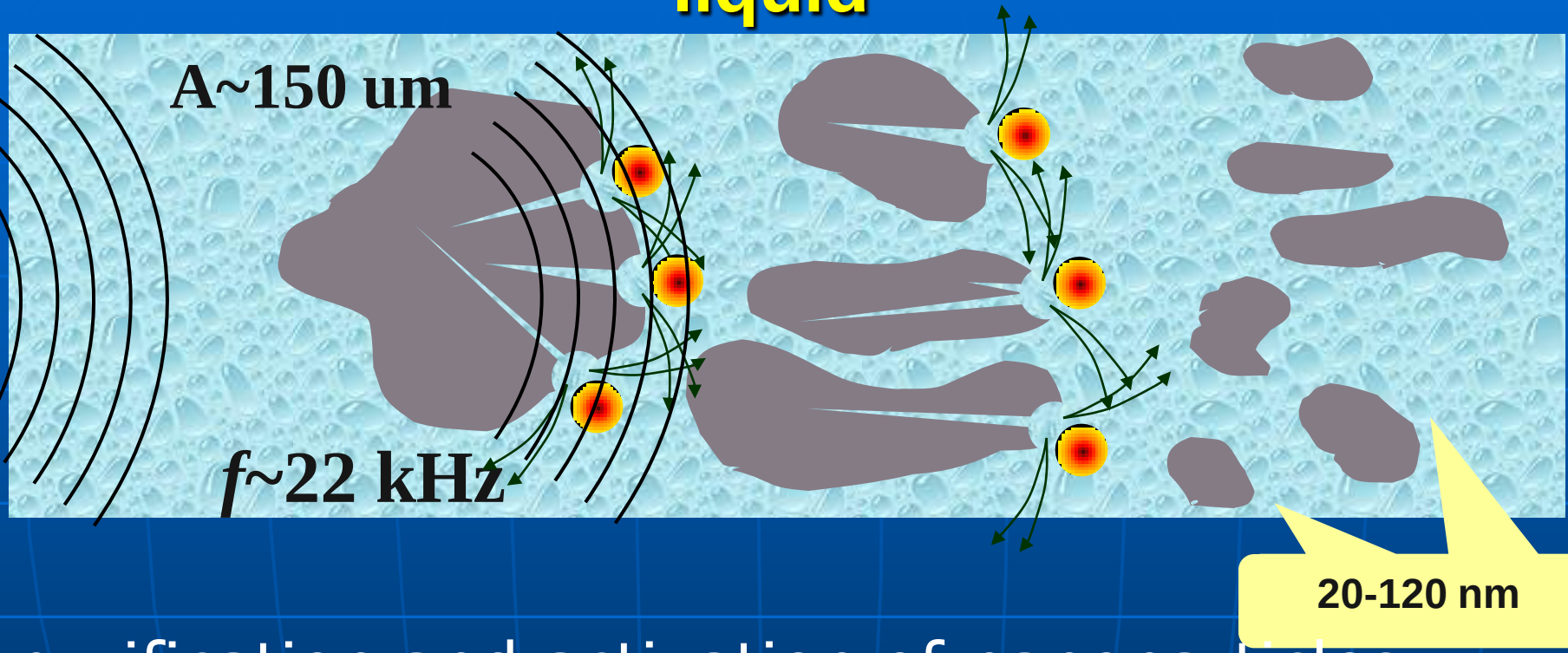
Water

Oil



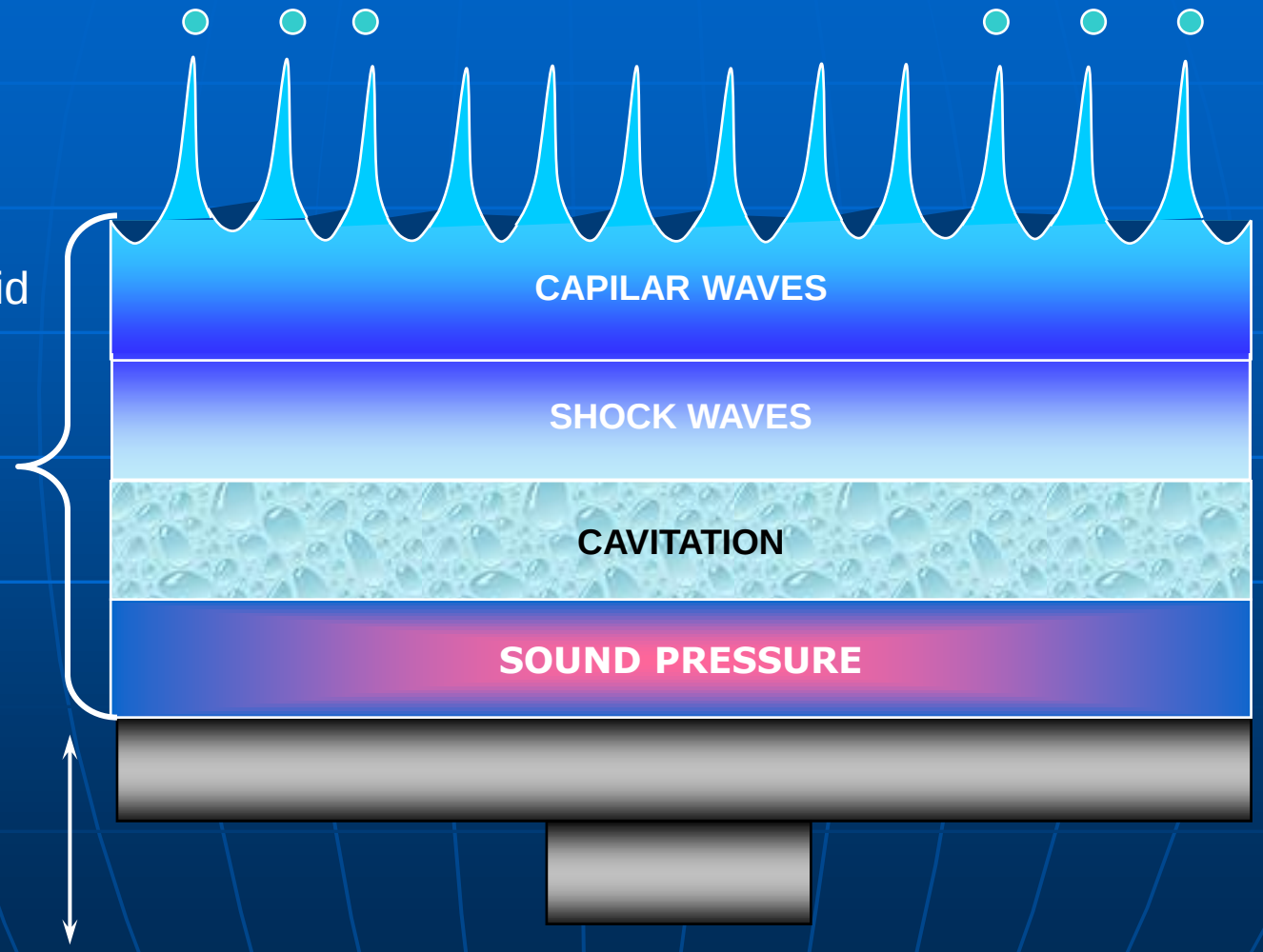


# Cavitational exposure of solid particles into liquid

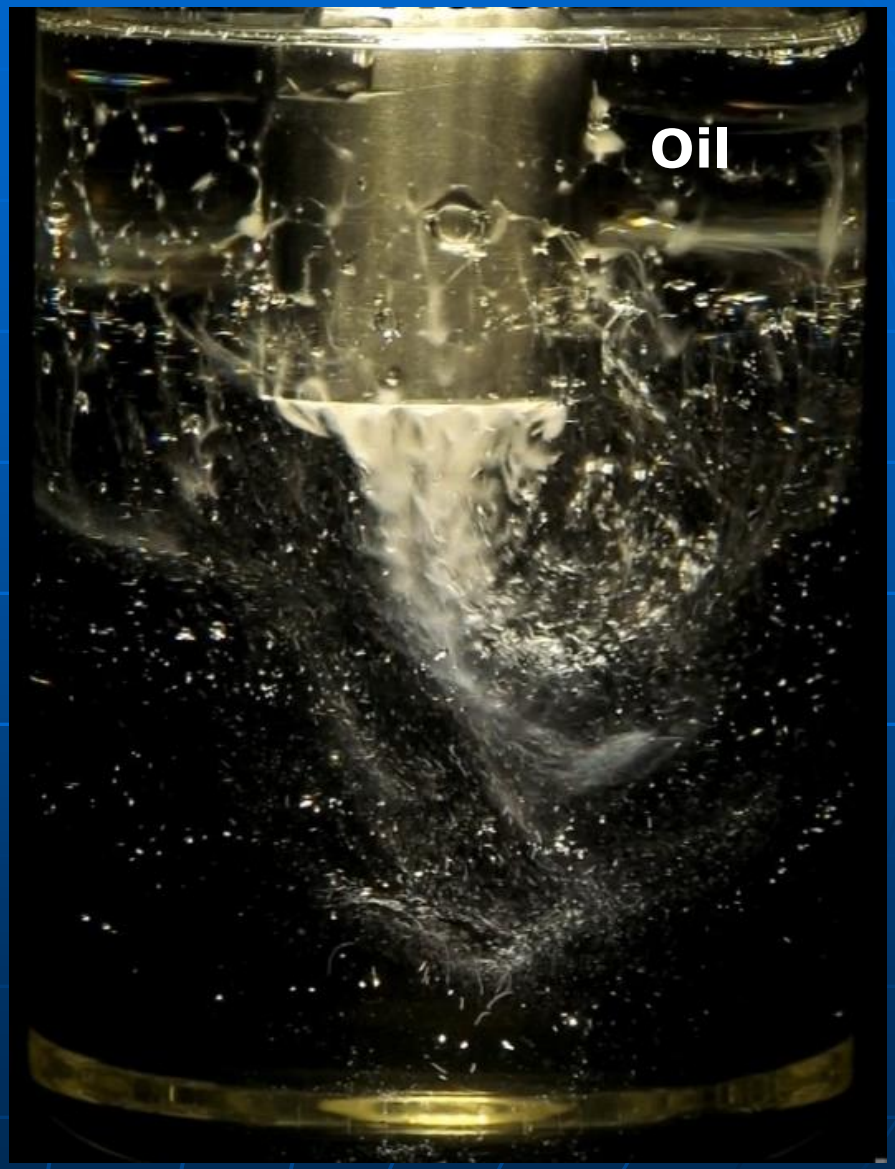



- purification and activation of nanoparticles;
- uniform distribution in viscous media;
- cluster destruction;
- deposition of nanoparticles in a liquid.

# Cavitation into thin layer



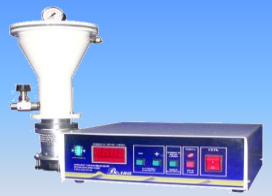
# Cavitation process

# Formation sequence stages 1 (pre-cavitational)

120 W

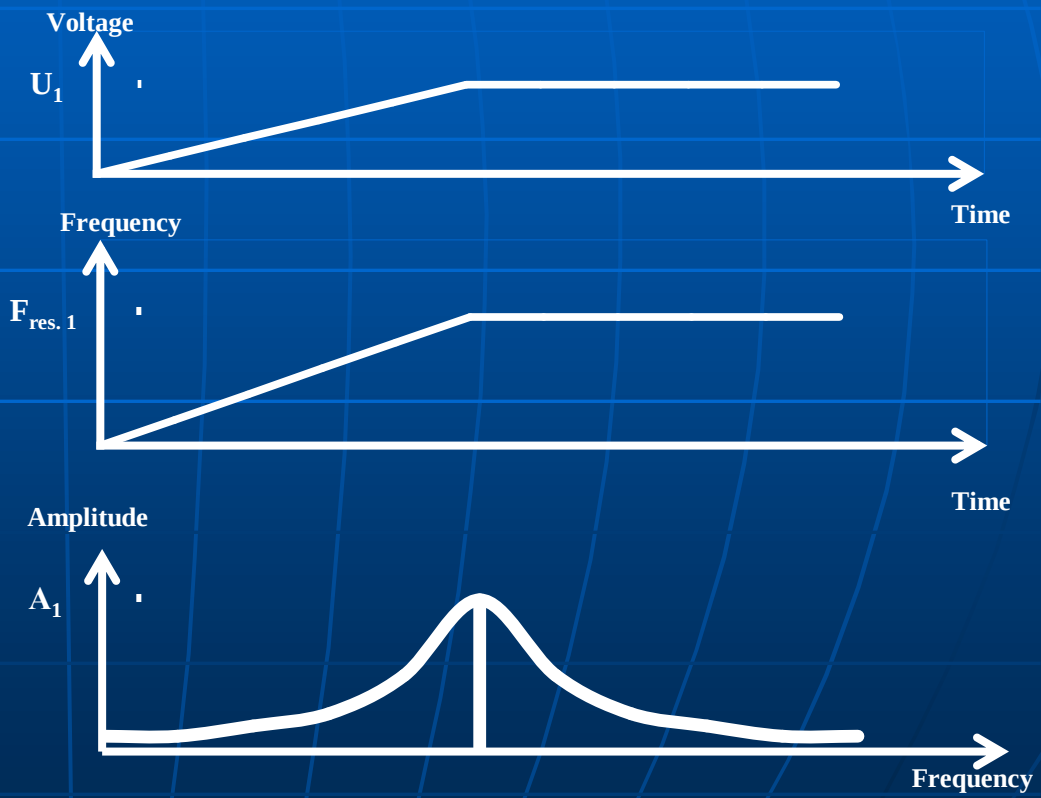
200 W



400 W

1000 W

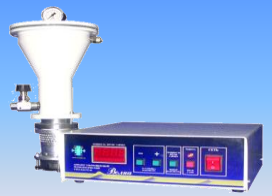
3000 W



# Formation sequence stages 2 (cavitational)

120 W

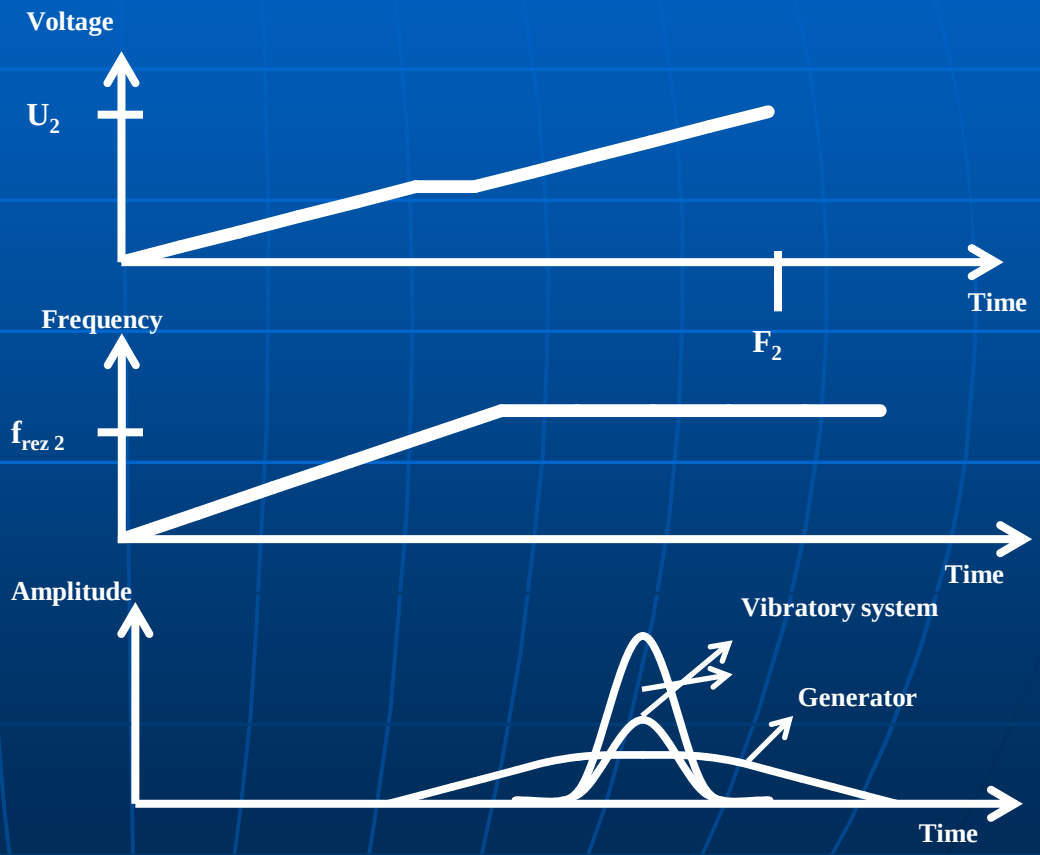
200 W



400 W

1000 W

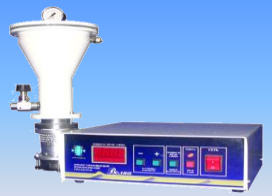
3000 W



# Formation sequence stages 3 (gas)

120 W

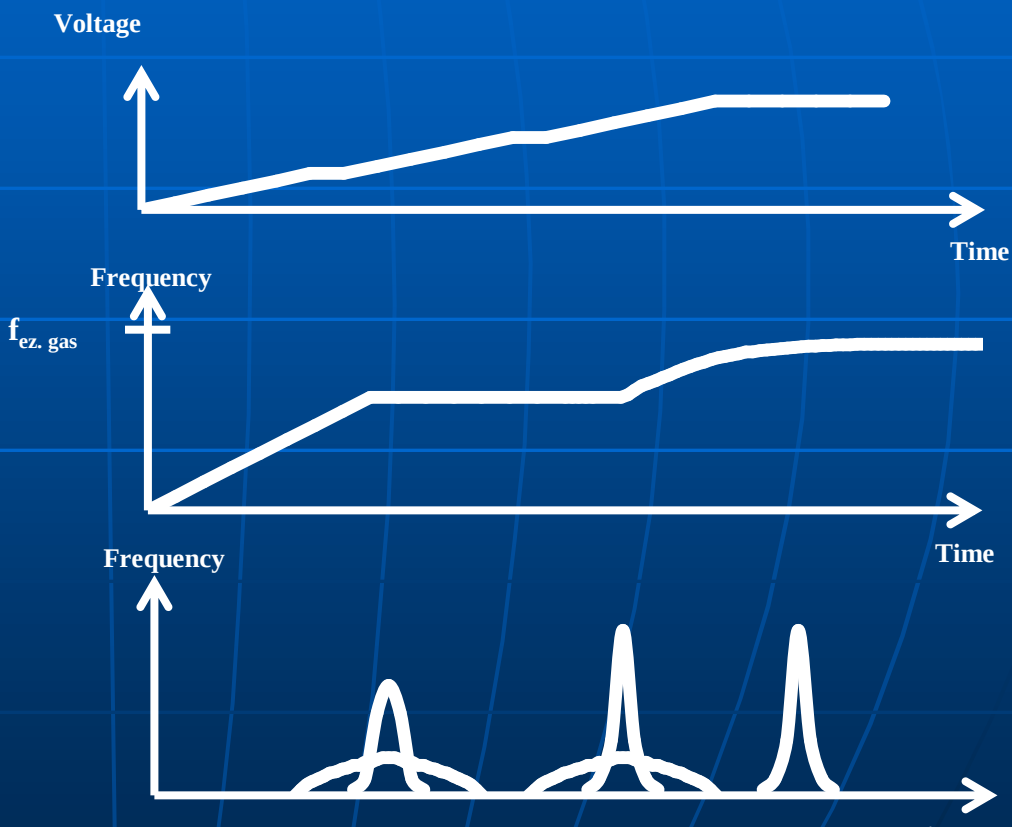
200 W



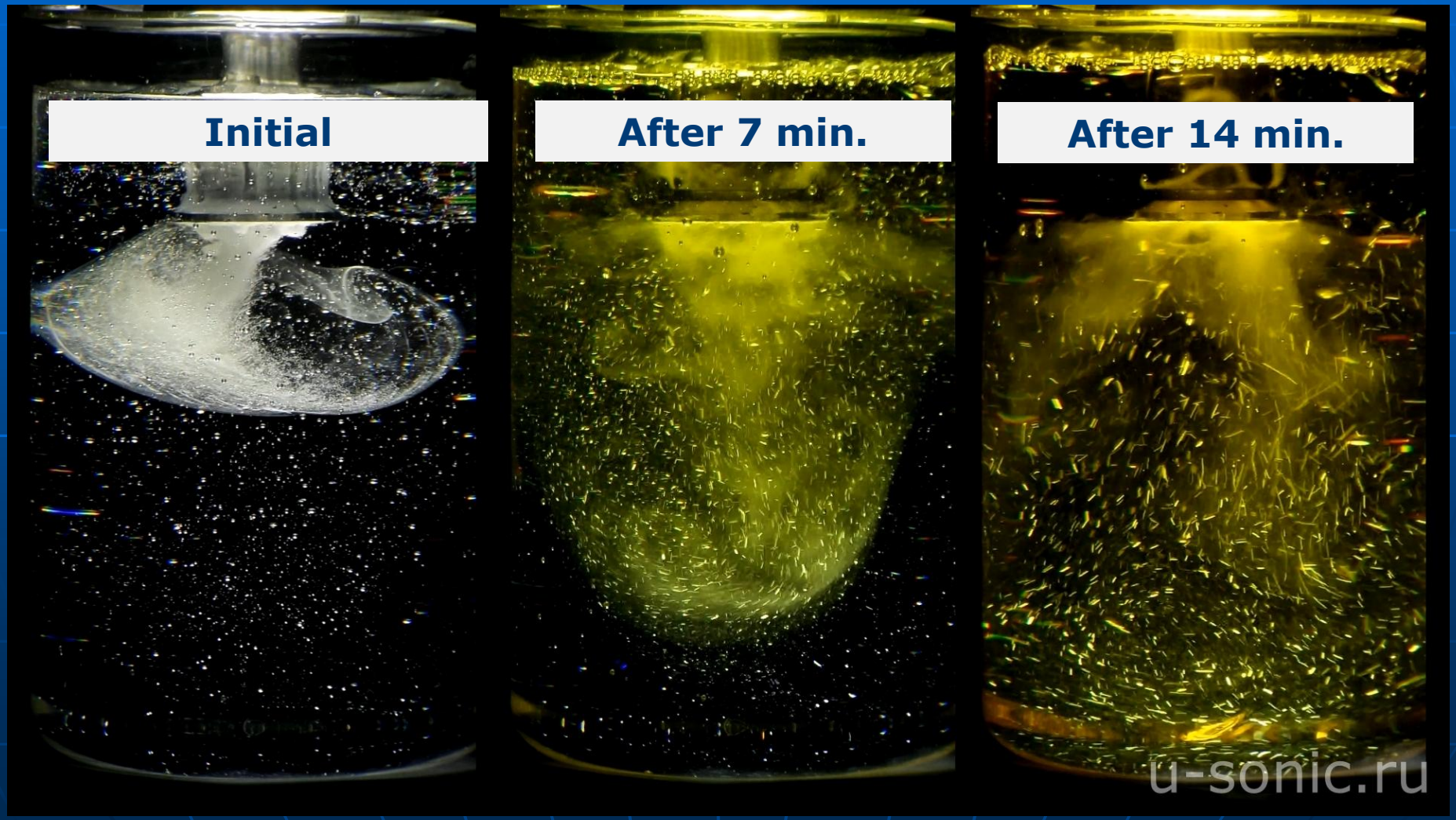
400 W

1000 W

3000 W



# Cavitation in viscous medium



# Ultrasonic exposure on human

Liposuction (removal of subcutaneous fat)

# Ultrasonic exposure in gases

## Intensification of processes in gases

- Acoustic coagulation
- Absorption
- Burning

**Ultrasonic drying**

- Drying without heating the material
- Lower limit of drying acceleration 135-140dB
- There is no significant dependence on the frequency
- Drying of thin layers of material (2-3 cm)

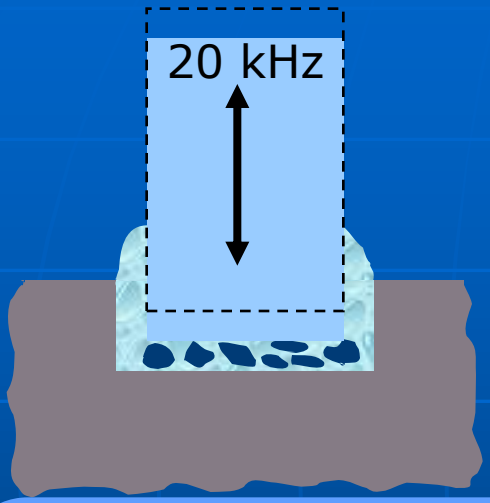
# Radiators into gases

Multi-element UVS with a focusing radiator

Radiator with phase-leveling elements

Single-phase radiation radiator

# Impact on hard materials (sizing of fragile materials)



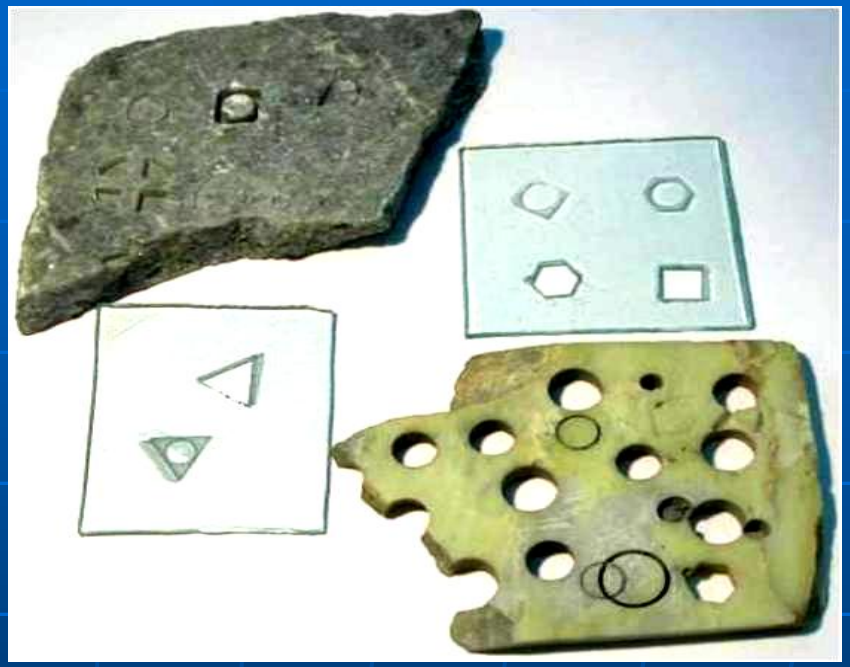

1.Impact of abrasive particles

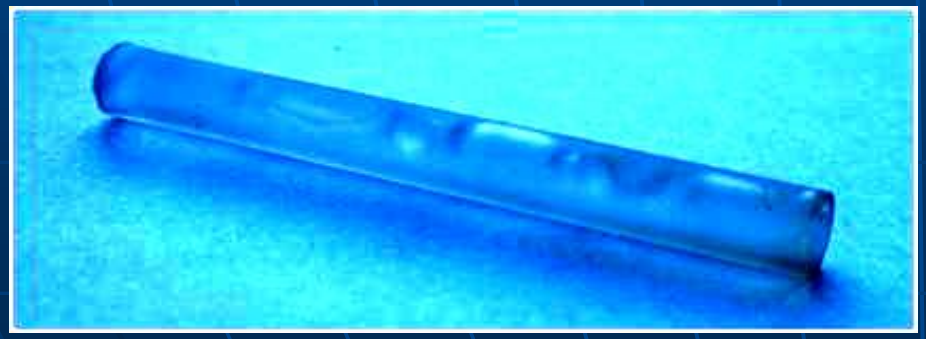
2.Circulation and change of abrasive due to cavitation

**Results**

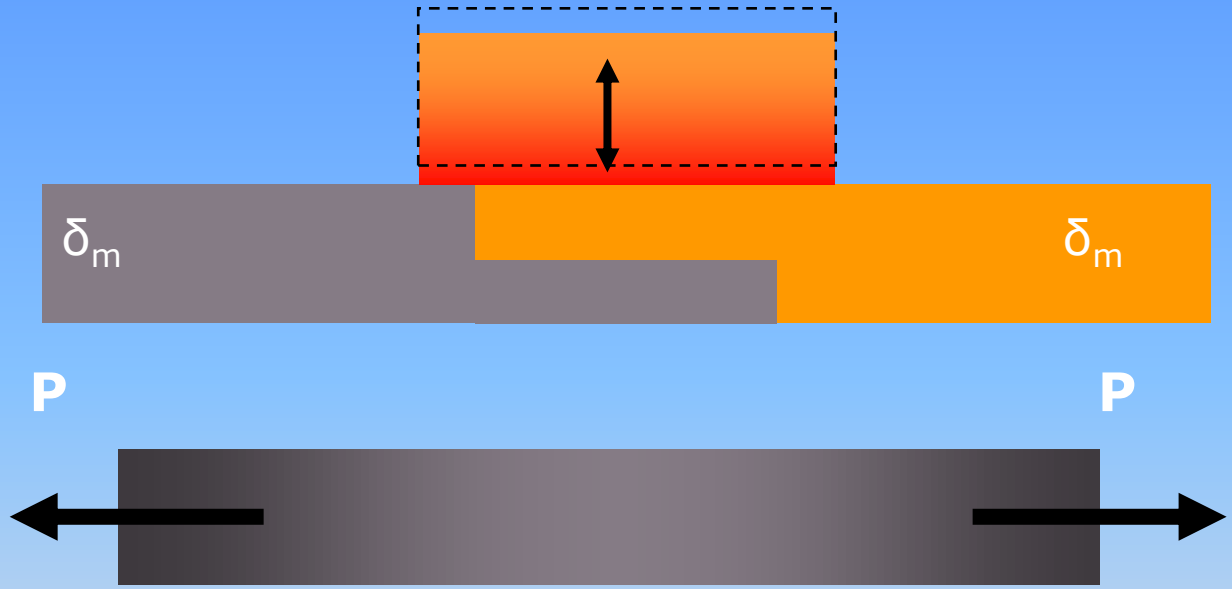
- Energy content < 10J/cm3
- Performance > 10 mm/s
- No cracks
- Diameter from 1 to 120 mm

# Ultrasonic sizing of fragile materials





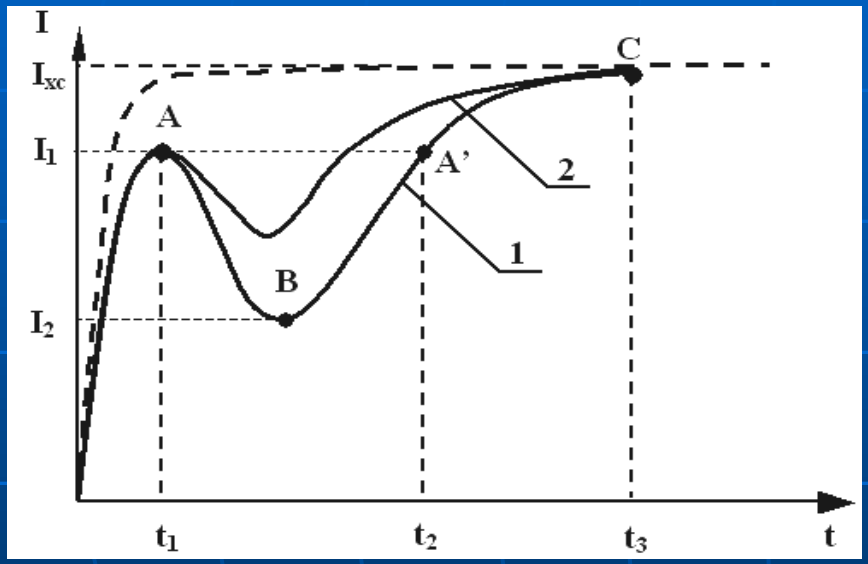
# Weld of polymer materials



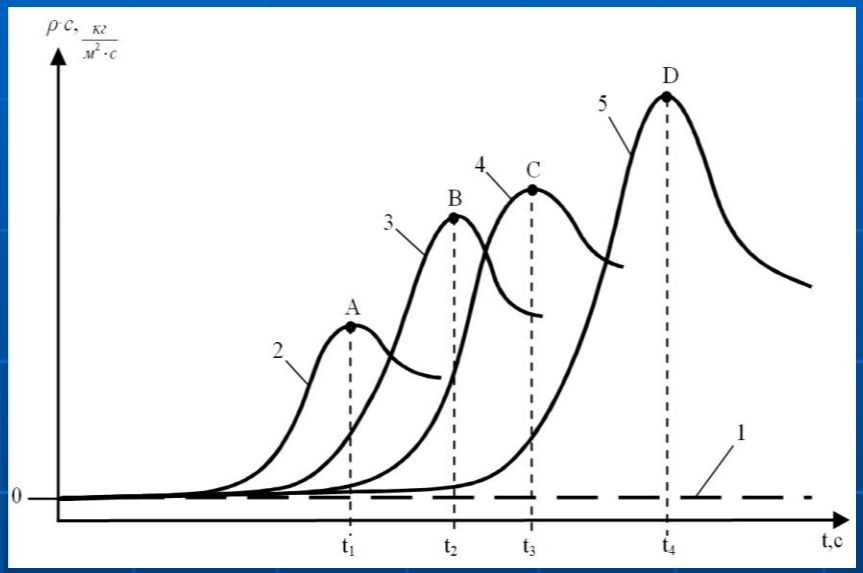

$\delta_{seam} > 70\% \delta_{material}$

Any thermoplastic materials

# Features of ultrasonic effects during welding




Dependence of the current amplitude through the ultrasonic vibrating system when changing the properties of materials during welding




Time dependence of the wave resistance of the materials being welded for various materials:
1 – at the absence of materials;
2-5 - for materials of different properties