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Organisation internationale de normalisation
International Organization for Standardization
Международная Организация по Стандартизации

Our ref. TS/P 234

TO THE ISO MEMBER BODIES

Date 2013-02-11

ISO/TS/P 234 – *Fine bubble technology*

Dear Sir or Madam,

Please find attached a proposal for a new field of technical activity on *Fine bubble technology* submitted by JISC (Japan).

According to subclause 1.5.6 of Part 1 of the ISO/IEC Directives, you are kindly invited to complete the ballot form (Form 02) which can be downloaded at www.iso.org/forms – *please note that Form 2 has been recently updated and that, from now on, votes that do not provide a justifying statement will not be registered.* Forms should be sent (preferably in Word format) to the Secretariat of the ISO Technical Management Board at *tmb@iso.org* before **11 May 2013.**

As is the usual procedure, this TS/P vote is only to determine whether the content of the attached proposal justifies the establishment of a new field of technical activity by ISO. The eventual structure of any new body will be decided and approved by the TMB once this vote is closed.

Yours faithfully,

Sophie Clivio,
Secretary of the Technical Management Board

Encl.: TS/P 234

PROPOSAL FOR A NEW FIELD OF TECHNICAL ACTIVITY	
Circulation date: Closing date for voting:	Reference number (to be given by Central Secretariat)
Proposer JISC, Japan	**ISO/TS/P**

A proposal for a new field of technical activity shall be submitted to the Central Secretariat, which will assign it a reference number and process the proposal in accordance with the ISO/IEC Directives (part 1, subclause 1.5). The proposer may be a member body of ISO, a technical committee or subcommittee, the Technical Management Board or a General Assembly committee, the Secretary-General, a body responsible for managing a certification system operating under the auspices of ISO, or another international organization with national body membership. Guidelines for proposing and justifying a new field of technical activity are given in the ISO/IEC Directives (part 1, Annex C).

The proposal (to be completed by the proposer)

Title of the proposed new committee (The title shall indicate clearly yet concisely the new field of technical activity which the proposal is intended to cover.)

Fine Bubble Technology

Scope statement of the proposed new committee (The scope shall precisely define the limits of the field of activity. Scopes shall not repeat general aims and principles governing the work of the organization but shall indicate the specific area concerned.)

Standardization of terms and definitions, classifications in sizes and characteristics, and other aspects related to measurements, functions and applications in the field of "fine bubbles."

According to known behaviour of fine bubbles, there are so-called "ultrafine bubbles" which is better to be defined differently. For example, ultrafine bubbles may be determined as the inside pressure increase by the surface tension effect to be larger than 1 atm for the air bubble in water, which would have the equivalent diameter smaller than about 3 μm . This is to be discussed and defined later by the new TC. The new TC deals with both "fine bubbles" and "ultrafine bubbles."

(Refer to descriptions and powerpoint presentation materials in Annex1 and Annex2, respectively.)

Proposed initial programme of work (The proposed programme of work shall correspond to and clearly reflect the aims of the standardization activities and shall, therefore, show the relationship between the subject proposed. Each item on the programme of work shall be defined by both the subject aspect(s) to be standardized (for products, for example, the items would be the types of products, characteristics, other requirements, data to be supplied, test methods, etc.). Supplementary justification may be combined with particular items in the programme of work. The proposed programme of work shall also suggest priorities and target dates.

The proposer plans to use a three-layer standards system for standardization of fine bubble technology. A good example of a three-layer standard is ISO 12100 for the safety of machinery and risk assessment, which proved to have a significant impact to the users of ISO 12100 by preventing industrial accidents and also by ensuring system safety. In order to effectively develop a standard of the technology, e.g. fine bubble technology, a layered standard system which includes a broad concept from high through low layers is better to be adopted. The three-layer standards system in this case consists of (1) terms and definition at the top, (2) measurement methods at the middle, and (3) other aspects related to functions and specific industrial applications at the bottom. The three-layer standards system is considered to be effective for a systematic standardization of new technology. Accordingly, we propose initial programmes of work in a three-layer structure shown below.

1. Top layer standards for basics
   - Terms and definitions
   - Classifications in sizes and characteristics

2. Middle layer standards for measurement methods
   - Laser diffraction scattering method
   - Dynamic light scattering method
   - Electrical sensing zone method
   - Particle tracking analysis method (Brownian motion tracking analysis method)
   - Resonance mass measurement method
   - Zeta-potential measurement method(Particle tracking/Dynamic light scattering)
   - Other candidate methods if proposed.

3. Bottom layer standards for functions applicable to industry
   - Cleaning Effect
   - Separation Effect
   - Lubrication Effect
   - Electrostatic Charge Separation Effect
   - Control Effect of Physical Properties (Density, Diffusivity, and so on)
   - Other candidates functions if proposed

Priorities of standardization work are given to the items listed in the top and middle layers over the others those listed in the bottom layer for the reason that the definition and measurement methods are essential to develop the standards of related applications that provide technical solutions for users. The proposer would like to use the new TC, when approved, as a work model of ISO/TC where an ideal systematic standardization process for new technology, which is not device dependent, is made.

The proposer would like to set the target dates of the NPs by the end of 2016 provided that the establishment of new TC is approved timely and then the first TC meeting is held in December 2013. Standardization for functions and applications will start when the definition and measurement methods are outlined, i.e. within a year or so after the first meeting of the TC.

Indication(s) of the preferred type or types of deliverable(s) to be produced under the proposal (This may be combined with the "Proposed initial programme of work" if more convenient.)

Deliverables preferred are all ISO International Standards (ISs).

ISO Standard "Terminology of Fine Bubbles", which may be a multi-part series, including definition of fine/ultrafine bubbles, diameter, density, and life duration in pure water, distilled water, tap water, etc.

ISO Standard "Measurement Methods of Fine Bubbles" which will be a multi-part series, including measurement methods described as programme of work in the box above.

ISO Standards for various fine bubble functions and applications, which will be independent documents from one another.

A listing of relevant existing documents at the international, regional and national levels. (Any known relevant document (such as standards and regulations) shall be listed, regardless of their source and should be accompanied by an indication of their significance.)

There is no ISO documents at any levels that describe fine bubble technology.

As for the measurement methods, which can be applied for fine bubbles are standardized for powder/particles, which are solid particle and liquid droplet, as follows. These published standards would be referred to as normative references in the planned ISO documents for measurement of fine bubbles which include the descriptions about sample preparation, calibration and test reports for fine bubbles.

1 ISO 13099-1 Colloidal systems -- Methods for zeta-potential determination -- Part 1: Electroacoustic and electrokinetic phenomena
2 ISO 13099-2 Colloidal systems -- Methods for zeta-potential determination -- Part 2: Optical methods
3 ISO 13319/JIS Z 8832 Determination of particle size distributions -- Electrical sensing zone method
4 ISO 13320/JIS Z 8825-1 Particle size analysis -- Laser diffraction methods
5 ISO 13321/JIS Z 8826 Particle size analysis -- Photon correlation spectroscopy
6 ISO 20998-1 Measurementand characterization of particles by acoustic methods -- Part1: Concepts and procedures in ultrasonic attenuation spectroscopy
7 ISO 21501-2/JIS B 9921-2 Determination of particle size distribution -- Single particle light interaction methods -- Part 1: Light scattering liquid-borne particle counter
8 ISO 21501-3/JIS B 9921-3 Determination of particle size distribution -- Single particle light inteaction methods -- Part 3: Light extinction liquid-borne particle counter
9 ISO 22412/JIS Z 8828 Particle size analysis -- Dynamic light scattering (DLS)
10 ASTM E2834-12 Standard guide for measurement of particle size distribution of nanomaterials in suspension by nanoparticle tracking analysis (NTA)

A statement from the proposer as to how the proposed work may relate to or impact on existing work, especially existing ISO and IEC deliverables. (The proposer should explain how the work differs from apparently similar work, or explain how duplication and conflict will be minimized. If seemingly similar or related work is already in the scope of other committees of the organization or in other organizations, the proposed scope shall distinguish between the proposed work and the other work. The proposer shall indicate whether his or her proposal could be dealt with by widening the scope of an existing committee or by establishing a new committee.)

1. The proposal can only be dealt with by establishing a new TC.
There is no ISO Technical Committee (TC) which covers fine bubble technology. No particular ISO Technical Committee would be able to cover a wide range of potential phenomena created by fine bubbles, or to develop a number of application standards such as for cleaning effect, separation effect, lubrication effect, electrostatic charge separation effect, control effect of physical properties (density, diffusivity), and so on. For this reason, the proposal cannot be dealt with by widening the scope of an existing committee.

2. A liaison with ISO TC24/SC4 (Particle characterization including sieving/Particle characterization)
However, in order to develop the measurement standards of fine bubbles, a liaison with ISO TC24/SC4, as a joint working group, is necessary. SC4 systematically develops particle measurement standards which can be referred to for standardization of fine bubble measurement. Note that the scope of SC4 is "particle characterization" and the work of the new TC we propose cannot be dealt with by TC24/SC4 by itself even if its scope is widened.

3. Consideration of ISO/TC229 (Nanotechnology)
TC229 covers the matter and process that have the dimension of less than 100 nm. On the other hand, fine bubble technology covers the larger bubbles which have the diameter in micrometers. Furthermore, it would not be possible to distinguish the difference in characteristics of the bubbles between those 100 nm or less and those more than 100 nm. In this sense, TC229 is not a suitable TC for standardization of fine bubble technology. Please refer to the scope of TC229 below.

Scope of TC229: Standardization in the field of nanotechnologies that includes either or both of the following:
(1) Understanding and control of matter and processes at the nanoscale, typically, but not exclusively, below 100 nanometres in one or more dimensions where the onset of size-dependent phenomena usually enables novel applications,
(2) Utilizing the properties of nanoscale materials that differ from the properties of individual atoms, molecules, and bulk matter, to create improved materials, devices, and systems that exploit these new properties.

A listing of relevant countries where the subject of the proposal is important to their national commercial interests.

Japan, Germany, France, the USA, the UK, China, Australia, Korea, and other countries

A listing of relevant external international organizations or internal parties (other ISO and/or IEC committees) to be engaged as liaisons in the development of the deliverable(s). (In order to avoid conflict with, or duplication of efforts of, other bodies, it is important to indicate all points of possible conflict or overlap. The result of any communication with other interested bodies shall also be included.)

Information exchange and references should be reviewed especially for the measurement methods of fine bubbles with ISO/TC24 Particle characterization including sieving/SC4 Particle characterization.
Information exchange should also be made, if necessary, with ISO/TC229 Nanotechnology.

A simple and concise statement identifying and describing relevant affected stakeholder categories (including small and medium sized enterprises) and how they will each benefit from or be impacted by the proposed deliverable(s).

Regarding fine bubbles, stakeholders are manufactures of generators, of measurement equipment, and of application equipment, including those of machine cleaning industry, food industry, construction and civil engineering industry, semi conductor manufacturing industry for the cleaning effect. Furthermore, many application fields would be expected for various useful effects of fine bubbles to produce large scale of industrial growth.
Fine bubbles or ultrafine bubbles have a potential to bring enormous benefits to a wide range of applications, and for the users of the applications to reap the benefits of the new technology; therefore, specific conditions and positive effects of each application need to be defined clearly. Cleaning, for instance, covers a broad range of applications, such as road, lavatory, plumbing for food processing, semiconductor wafers, and so on.
Only after the necessary ISO standards are developed, a healthy market for the new technology can be fostered, and then the world can enjoy the benefits by referring to the standards developed. Setting international standards and creating a market by way of new research and development have a significant importance as factors closely related to each other, which cannot be promoted separately. In addition, the proposer would like to ask national standards bodies and regional standards bodies for participating actively in the development of fine bubble standards under the name of ISO.

An expression of commitment from the proposer to provide the committee secretariat if the proposal succeeds.

JISC is willingly to undertake Secretariat of new TC when the proposal is accepted by ISO.

Purpose and justification for the proposal. (The purpose and justification of the standard to be prepared shall be made clear and the need for standardization of each aspect (such as characteristics) to be included in the standard shall be justified. Clause C.4.12.1 through C.4.12.10 of Annex C of the ISO/IEC Directives, Part 1 contain a menu of suggestions or ideas for possible documentation to support and purpose and justification of proposals. Proposers should consider these suggestions, but they are not limited to them, nor are they required to comply strictly with them. What is most important is that proposers develop and provide purpose and justification information that is most relevant to their proposals and that makes a substantial business case for the market relevance and the need for their proposals. Thorough, well-developed and robust purpose and justification documentation will lead to more informed consideration of proposals and ultimately their possible success in the ISO IEC system.)

Purpose and Justification:

1. What are fine bubbles or ultrafine bubbles?
Bubbles contained in a liquid are visible to the eyes when their sizes are large enough to see, as we can see the bubbles in carbonated drinks or those coming from the air diffuser in a water tank. Bubbles with the size of a few millimetrs in diameter show visible surfacing action in a liquid, and the presence of fine bubbles of dozens of microns in diameter can be observed with white turbidity. Bubbles in diameter smaller than the wavelength (the diffraction limit of visual ray is 900 nm) of light are often called ultrafine bubbles, and they are too small to see. Recent development in measuring technology proved that ultrafine bubble generators are capable of producing a large amount of ultrafine bubbles of 100 nm to 200 nm in diameter. The technology can also measure bubbles quantitatively, and reveals that, as many as a billion/ml ultra-fine bubbles exist in a liquid and can stay there for a long time.

2. Measuring technique of ultrafine bubbles and advancement of bubble generating technology
Ultrafine bubbles in diameter of less than the wavelength of light cannot be measured by a usual optical microscope. Neither can a scanning electron microscope measure ultrafine bubbles in a liquid. With the recent technological breakthrough, however, various revolutionary methods have been developed to measure ultrafine bubbles in a liquid. Such methods developed by companies and universities in the UK, Germany, and the USA include: tracking Brownian motion of bubbles, measuring the change in laser frequency caused by Brownian motion, analysing the spectrum of laser backscattered light, and distinguishing gas particles from solid ones using a MEMS resonance device. These methods have lately been put into practical uses, and detect a great amount of ultrafine bubbles of 100 nm to 200 nm in diameter contained in a liquid.
Along with the advancement of measurement technology, ultrafine bubble generation technology, such as pressure dissolving method, swirling liquid flow method, ejecting method, as well as several other methods, has progressed in the past few years, and the generators have already been commercialized as products. As quantitative data and new diverse applications are reported steadily, ground-breaking progress in this field is expected.

3. Advantageous effects and applications of fine bubbles
As the measurement and generation technology have progressed, the possibility of using ultrafine bubbles in industrial applications has also been studied. Scientific research and development of ultrafine bubbles have brought about positive results that encourage researchers that ultrafine bubbles have high potentials in industrial applications.
Use of ultrafine bubbles in cleaning applications has remarkable benefits among other applications. Cleaning antifreezing agent on highways using ultrafine bubble water is much more effective than cleaning using just tap water. Ultrafine bubble water has also been used on a trial basis to clean lavatories in highway rest stops, which shows excellent cleaning effect on urinary calculus removal.
Ultrafine bubbles are used in semiconductor and photovoltaic manufacturing process, too. Specifically, ultrafine bubble technology is adopted in the separation process of photovoltaic wafers. Also for cleaning of silicon semiconductor wafers, using the ultrapure water that contains ultrafine bubbles has a greater cleaning effect than using the only ultrapure water applied in conventional cleaning method.
As the function of control effect of various physical properties such as density and diffusivity, the following technology would be utilized. Fine bubble technology would find another promising application in food processing. For people who wish to control calorie intake, low-calorie mayonnaise was made by incorporating fine bubbles into it, which has received good response in the market. Because ultrafine bubbles are extremely small, they do not surface with buoyance as usual large bubbles do so, and it was confirmed that Brownian motion holds ultrafine bubbles in a liquid for over six months. Various kinds of flavour can be added to the bubbles, or many types of gas can be trapped in the bubbles, either of which raise expectations of potential applications in food, beverage, cosmetics, chemicals, medical care, etc.
Furthermore, in agriculture, ultrafine bubbles are used to accelerate the growth of vegetables. Shorter growing season was observed when using ultrafine bubbles on lettuce growth, and there is a strong probability that ultrafine bubble technology would greatly improve the production efficiency on a global scale.

4. Necessity for developing international standards for fine bubble technology
As described above, measurement and generation technologies of ultrafine bubbles have advanced and the uses in applications are increasing steadily. However, the terminology and meaning of fine bubbles or ultrafine bubbles are not clearly defined yet. Bubble size, bubble density, types of liquid and gas, and bubble holding time need to be defined in international standards so that those concerned can work toward further development using a "common language." As a variety of measuring methods have been developed, measuring conditions and methods must be specified, too.

Signature of the proposer

Tamotsu Nomakuchi

President of JISC

Further information to assist with understanding the requirements for the items above can be found in the Directives, Part 1, Annex C.

Comments of the Secretary-General (to be completed by the Central Secretariat)

Signature

Annex 1

Explanatory document of fine bubble technology and its development to be proposed to ISO as international standards

JISC (Japanese Industrial Standards Committee)

1. What are fine bubbles or ultrafine bubbles?

Bubbles contained in a liquid are visible to the eyes when the bubble sizes are large enough to see, as we can see bubbles in carbonated drinks or those coming from the air diffuser in a water tank. Bubbles with the size of a few millimeters in diameter show visible surfacing action in a liquid, and the presence of fine bubbles of dozens of microns in diameter can be confirmed with white turbidity in a liquid. Bubbles in diameter smaller than the wavelength of light are called ultrafine bubbles, and they are too small to see. Recent development in measuring technology confirms that ultrafine bubble generators are capable of producing a large amount of ultrafine bubbles of 100 nm to 200 nm in diameter. The technology can also measure bubbles quantitatively, and reveals that as many as a billion/ml ultrafine bubbles exist in a liquid and can stay for a long time. (see Annex 2 Page1-3)

2. Measuring technique of ultrafine bubbles and advancement of bubble generating technology

Ultrafine bubbles in diameter of less than the wavelength of light cannot be measured by a usual optical microscope. Neither can a scanning electron microscope measure ultrafine bubbles, as bubbles are contained in a liquid. With the recent technological breakthrough, however, various revolutionary methods have been developed to measure ultrafine bubbles in a liquid. Such methods developed by companies and universities in the UK, Germany, and the USA include: tracking Brownian motion of bubbles, measuring the change in laser frequency caused by Brownian motion, analyzing the spectra of laser backscattered light, distinguishing gas particles from solid particles using a MEMS resonance device, etc. These methods have lately been put into practical uses, and detect a great amount of ultrafine bubbles of 100 nm to 200 nm in diameter contained in a liquid.

Along with the advancement of measurement technology, the ultrafine bubble generation technology, such as pressure dissolving method, swirling liquid flow method, ejecting method, as well as several other methods, has progressed rapidly in the past few years, and the generators have already been commercialized as products. As Japanese companies and universities report quantitative data and new diverse applications steadily, groundbreaking progress in this field is expected to be made soon. (see Annex 2 Page4-5)

3. Advantageous effects of fine bubbles and its applications

As the measurement and generation technologies have progressed, the possibility of using ultrafine bubbles in practical applications has also been studied. Scientific research and development, and also industrial application development of ultrafine bubbles have brought about positive results that encourage researches that ultrafine bubbles have high potentials in applications.

Use of ultrafine bubbles in cleaning applications has remarkable benefits among other applications. Cleaning antifreezing agent on highways using ultrafine bubble water is much more effective than cleaning using just tap water. Also, ultrafine bubble water has been adopted on a trial basis to clean lavatories in highway rest stops, which shows excellent cleaning effect on urinary calculus removal. (see Annex 2 Page6-7)

Ultrafine bubbles are also used in semiconductor and photovoltaic manufacturing processes. Specifically, ultrafine bubble technology is adopted in the difficult process of separating a pile of photovoltaic wafers. Also for cleaning of silicon semiconductor wafers, using the ultrapure water which contains ultrafine bubbles has a greater cleaning effect than using the only ultrapure water applied in conventional cleaning method. (see Annex 2 Page8-9)

Fine bubble technology has found another promising application in food processing. For people who wish to control calorie intake, low-calorie mayonnaise is made by incorporating fine bubbles into it, which has received good response in the market.

Because ultrafine bubbles are extremely small, they do not surface with buoyancy as usual large bubbles do so, and it was confirmed that Brownian motion holds ultrafine bubbles in a liquid for over six months. Various kinds of flavor can be added to the bubbles, or many types of gas can be trapped in the bubbles, either of which raise expectations of potential applications in food, beverage, cosmetics, chemicals, medical care, and so on.

Furthermore, in agriculture, ultrafine bubbles are used to accelerate the growth of vegetables. Shorter growing season was observed when using ultrafine bubbles on lettuce growth, and there is a strong probability that ultrafine bubble technology would greatly improve the production efficiency on a global scale.

4. Necessity for developing international standards for fine bubble technology

As described above, measurement and generation technologies of ultrafine bubbles have advanced and the uses in actual applications are increasing steadily. However, the terminology and meaning of fine bubbles or ultrafine bubbles are not clearly defined yet. Bubble size, bubble density, types of liquid and gas, and bubble holding time need to be defined in international standards so that those concerned can work toward further development using a "common language." Also as various measuring methods have been developed, measuring conditions and methods must be specified.

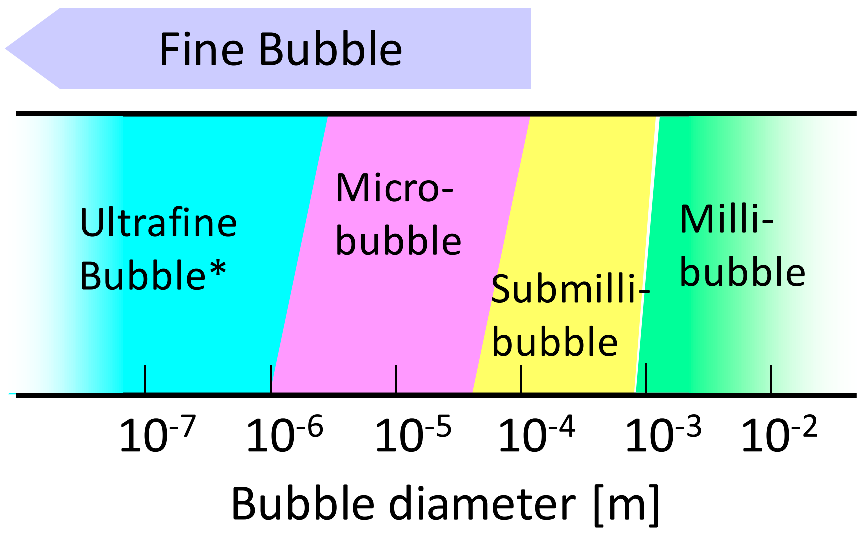
Fine bubbles or ultrafine bubbles have a potential to bring enormous benefits to a wide range of applications, and to reap the benefits of the new technology for the users of these applications; therefore, specific conditions and positive effects of each application need to be defined clearly. Because cleaning, for instance, covers a broad range of applications, such as road, lavatory, plumbing for food processing, semiconductor wafers, and a lot others, conditions and measuring parameters specific to each application need to be defined explicitly.

Only after the necessary ISO standards are developed, a healthy market for the new technology can be fostered, and then the world can enjoy the benefits by referring to the standards developed. For the reasons mentioned here, setting a three-layer standard system for the fine bubble technology is under study. The standard system will consist of the definition and terminology as the first-tier standard, measuring method as the second-layer group of standards, and specific industrial applications as the third-layer group of standards. The three-layer standard system is modeled after the A-B-C three-layer standards system (see Annex 2 Page10), i.e. ISO 12100 for the safety of machinery and risk assessment. The A-B-C three-layer standards system had a significant positive impact on the world by preventing industrial accidents and also by ensuring system safety.

Setting international standards and creating a market by way of new research and development have a significant importance as factors closely related to each other, which cannot be promoted separately. We hereby propose the new ISO activity, i.e. development of new ISO standards for fine/ultrafine bubble technology, which we believe to contribute to the world.

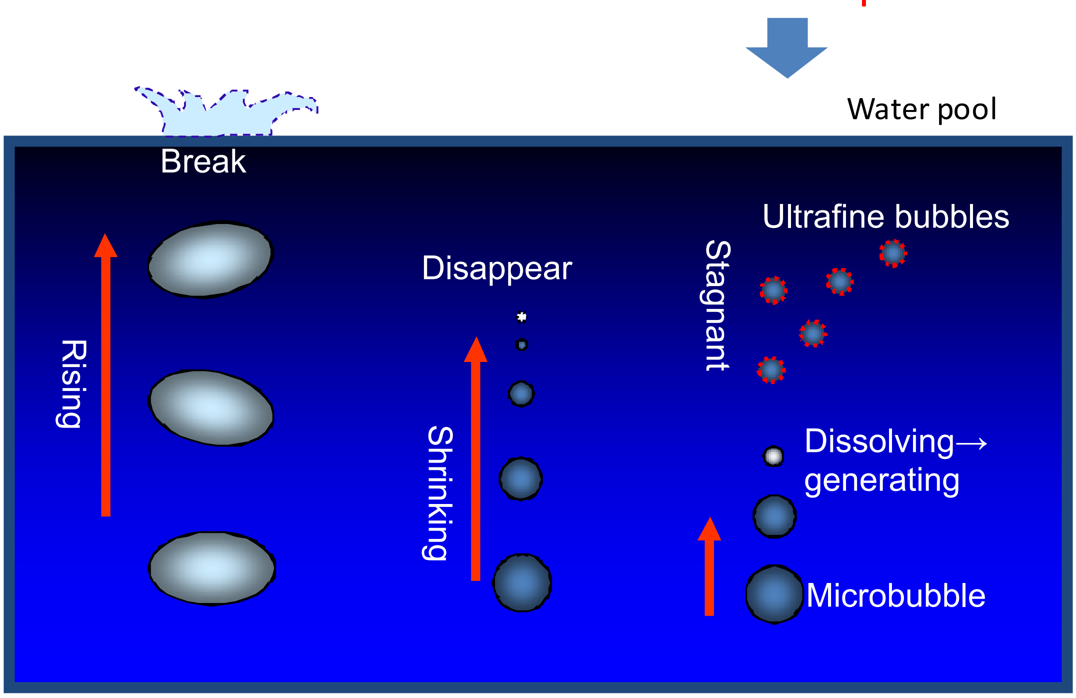
What are fine bubbles or ultrafine bubbles? Annex 2

Bubbles are tentatively classified as



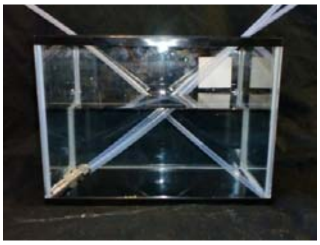
Behavior of milli-, micro- and ultrafine-bubble

Fine bubble has unique behavior !!

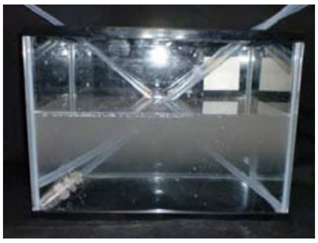


Milli-bubble Microbubble Ultrafine bubble

Observation from microbubble water to ultrafine bubble water

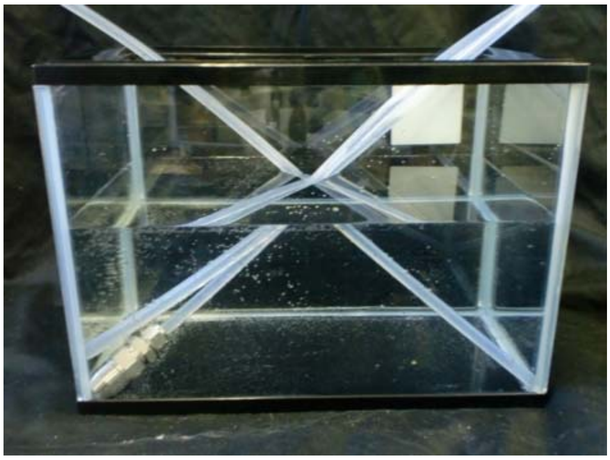


Ultrapure water



Waiting with no aeration (during microbubble surfacing separation)

Microbubble water (looks cloudy)

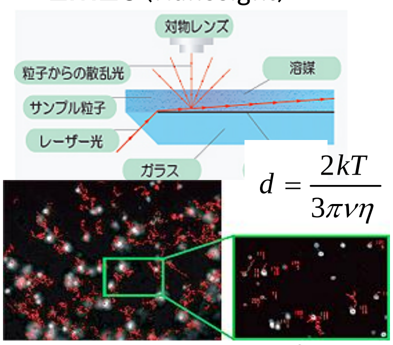


Ultrafine bubble water（looks clear)

The latest measuring method of size of ultrafine bubbles

Particle tracking analysis method (Brownian motion tracking analysis method)

LM20（NanoSight）

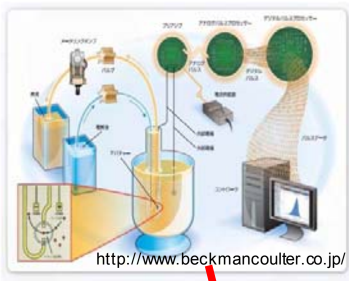


$$d = \frac{2kT}{3\pi\nu\eta}$$

http://www.qd-japan.com/product/lifescience/

Electrical sensing zone method

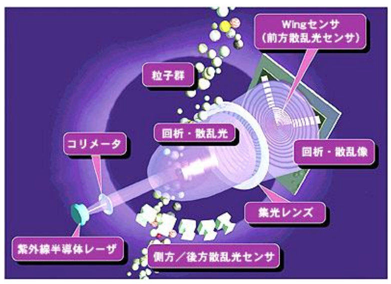
Multisizer 4（Beckman Coulter）



http://www.beckmancoulter.co.jp/

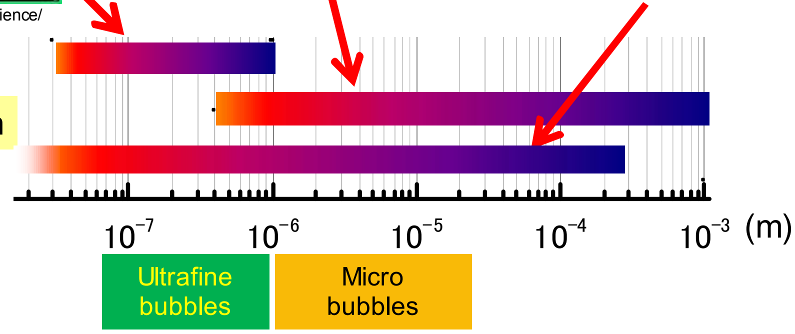
Laser diffraction / scattering method

SALD-7100H
（SHIMADZU）



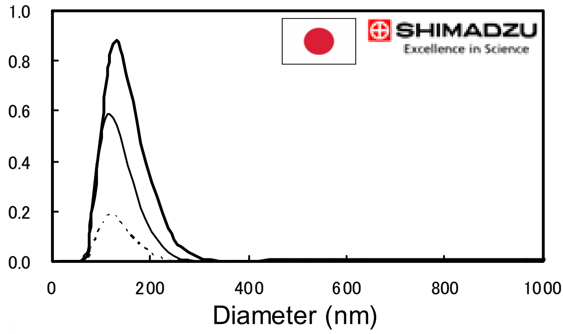
http://www.shimadzu.co.jp/powder/products/01s7100/index.html

Measurement region

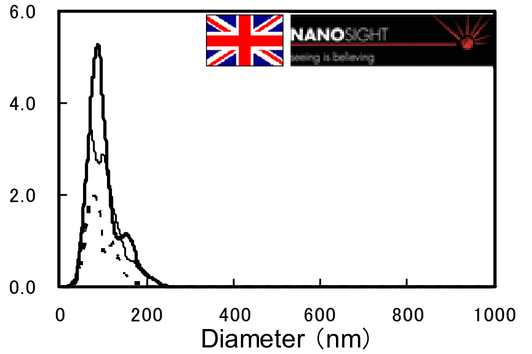


Various technologies show measurement results of ultrafine bubble diameter around 100-200 nm

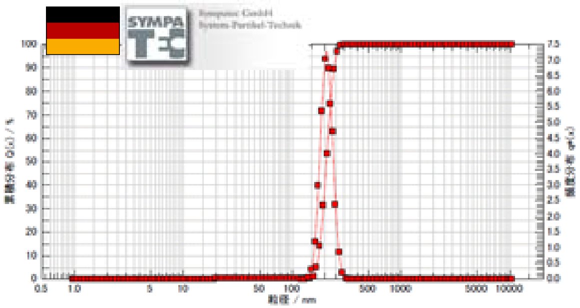
Laser diffraction / scattering method



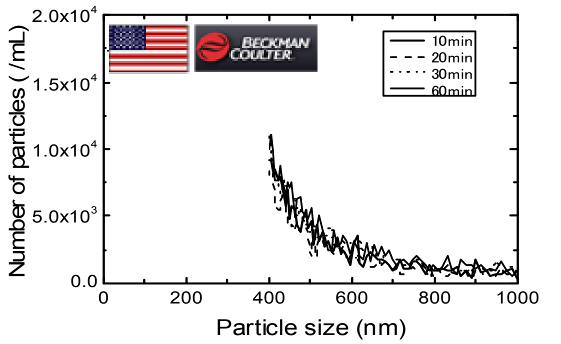
Particle tracking analysis method
(Brownian motion tracking analysis method)



Dynamic light scattering method



Electrical sensing zone method



Application of ultrafine bubble water for cleaning of steel bridges(1/2)

The outline of cleaning test

（1） Research purposes

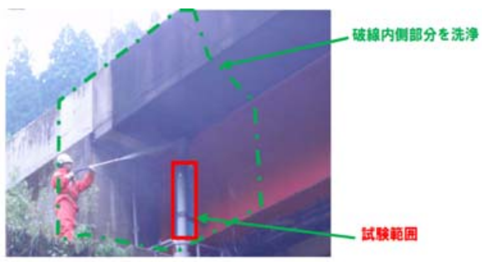
The effect and validity to an antifreeze in case of utilizing the ultrafine bubble water and tap water to steel bridge washing work are investigated.

（2） Measuring method

By using a portable surface chloride meter (SSM-21P manufactured by TOA DKK-21P), the salinity on the surface of water was measured before and after cleaning.

Portable salinometer surface計(SSM-21P)

Salinity measurement situation



Washing situation (surrounding washing)

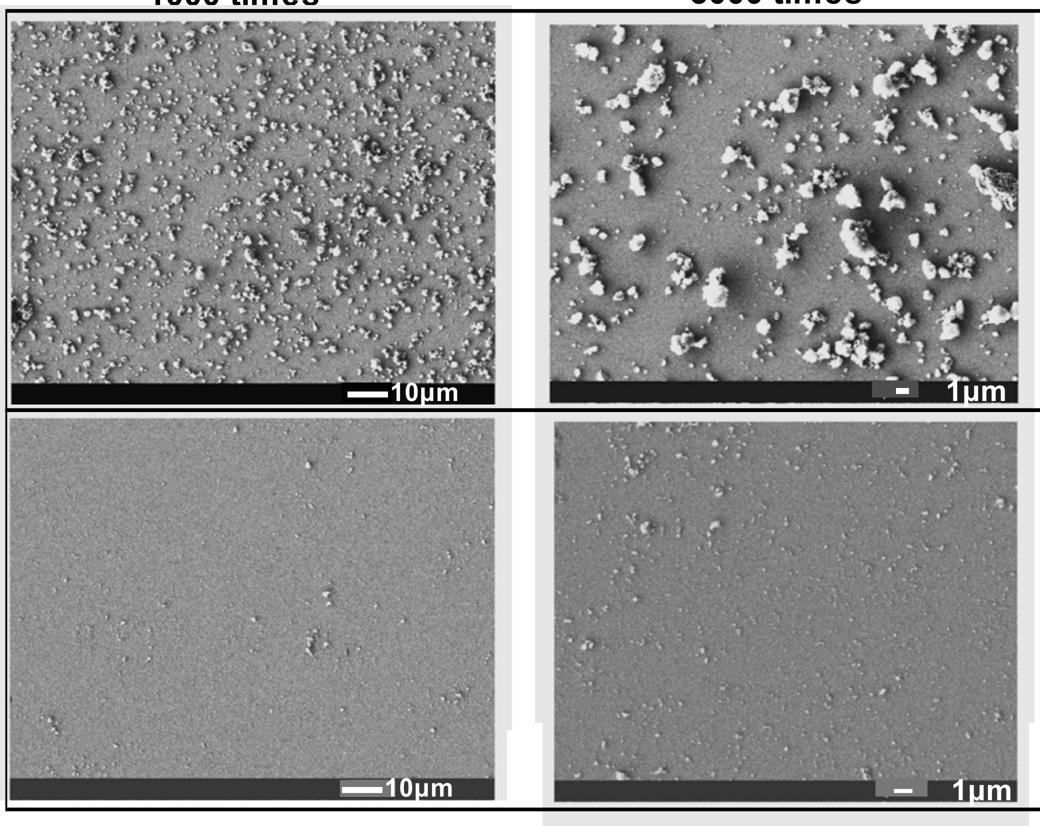
Application of ultrafine bubble water for cleaning of steel bridges(2/2)

Salinity adsorbed on bridge wall before and after cleaning

Cleaning water	Tap water			Ultrafine Bubble water		
Cleaning position	Before cleaning	After cleaning	Cleaning rate [%]	Before cleaning	After cleaning	Cleaning rate [%]
Web face	60.9	10.9	82.1	136.9	1.5	98.2 Highly improved!
Upper face of bottom flange	57.4	4.8	91.6	190.9	0	100 Highly improved!
Weather	Sunny	Sunny		Sunny	Sunny	
Temperature [℃]	22	20		22	20	

Application of ultrafine bubble water for cleaning of semiconductor wafer

1000 times | 3000 times



Washed with ultrapure water jet

Washed with ultrapure water jet + ultrafine bubbles

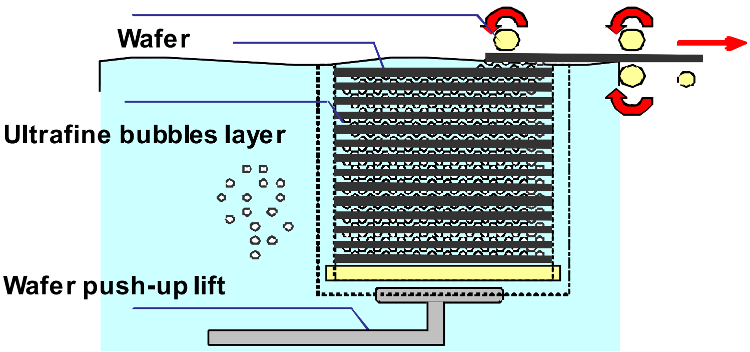
Application of ultrafine bubble water for solar cell wafer separation

IDEC

The more thinning progresses, the wafer will be fragile in peeling sheet.

Ultrafine bubble layer which is formed in the gap of each wafer plays the role of a cushion.

The wafer sheet is peeled off with no load.



Ref : Maeda, S., et al., Proc. 1st Int. Symp. on Multiscale Multiphase Process Engineering, P-19-1, (2011).

Three-layer structure of ISO standards on Fine Bubble Technologies

International standardization