

STRATEGIC BUSINESS PLAN

ISO/TC 281

EXECUTIVE SUMMARY

ISO/TC 281 is established to develop international standards focusing on fine bubble technology. We believe that it is the time to prepare for the fine bubble industry in order to create a healthy global market. Fine bubble technology is quite new and it will become applicable to an increasing range of industries. These already include the environment, engineering and construction, foods, medical and agriculture.

Large bubbles in a liquid can be readily observed with the naked eye. High concentrations of smaller bubbles around 10 microns can make a liquid appear opaque by their presence. Ultrafine bubbles of about 100 to 200nm can only be detected from the light scattered by them when illuminated by a short wavelength (green) laser beam. They are invisible to the naked eye.

Recent developments in measurement technology, has revealed that the ultrafine bubble generators, being supplied to the market, are able to generate a large quantity of ultrafine bubbles in defined liquids. It has also become possible to detect those bubbles quite accurately and quantitatively, revealing that billions of ultrafine bubbles per ml exist in the liquid. They have also been shown to have an extended life time.

Examples of the measurement methods are Particle Tracking, which measures the positional change per unit time, following the Brownian motion of the particles., Dynamic light scattering also examines Brownian motion, by analyzing the spectra of laser backscattered light. Gas particles (bubbles) can be distinguished from solid particles using a resonant MEMS device. These measurement methods have been developed by private companies and universities in the UK, Germany, the USA, and Japan. This means that the development of measurement equipment is about to create a new industry. These new measurement techniques have both confirmed the presence of Ultra Fine Bubbles and contributed to the design and optimization of bubble generators.

Adding to the progress of developing the measurement methods and the generators, research and development on ultrafine bubbles uses based on scientific findings have also been pursued to explore the possibility of industrial applications. Such research has started to bring about interesting and useful achievements that indicate a high potential for ultrafine bubble applications. In particular, a significant achievement is made in the field of cleaning. For example, the anti-freezing agent, used on the highways in winter needs to be cleaned away in the spring. Ultrafine bubble water has been found to have a very high cleaning efficiency, when compared with ordinary tap water. Ultrafine bubble water is used also used in the toilets installed in service areas of highways because it deodorizes and removes effectively, urinary calcium deposits. Fine bubbles have found application in the food industry. Using fine bubbles, a mayonnaise product with smooth texture and lowered calories is now being marketed.

Because ultrafine bubbles are extremely small, they exhibit neutral buoyancy. This property combined with Brownian motion and a stabilizing surface charge, enables long life times, with life times of over 6 months having been recorded. This has generated interest in the foods, beverage, cosmetic, chemical, and medical industries.

The application of Fine Bubble Technology has advanced, however, the terms and definitions of fine or ultrafine bubbles have not been made clear. In order for the stakeholders to work together with a common interest, bubble sizes, bubble density, types of liquid or gas, and bubble life times need to be defined in international standards. Many measurement techniques already have International Standards that validate the instruments correct operation (ISO TC24 / SC4). However, the application of these measurement techniques to fine bubble measurements requires specific attention in terms of how the fine bubbles are presented for measurement. Fine and ultrafine bubbles have a potential to bring benefits to a wide range of industrial applications. In order for the users of fine or ultrafine bubbles, to reap the rewards of the new technology, specific conditions and influences to be considered within each application need to be clearly defined.

We believe that both international standardization and R&D are essential tools to create a new healthy market of fine or ultrafine bubble technology. ISO/TC 281 is, therefore, to promote international standardization activity in order to contribute to the needs of global industry.

1. INTRODUCTION

1.1 ISO technical committees and business planning

The extension of formal business planning to ISO Technical Committees (ISO/TCs) is an important measure which forms part of a major review of business. The aim is to align the ISO work programme with expressed business environment needs and trends and to allow ISO/TCs to prioritize among different projects, to identify the benefits expected from the availability of International Standards, and to ensure adequate resources for projects throughout their development.

1.2 International standardization and the role of ISO

The foremost aim of international standardization is to facilitate the exchange of goods and services through the elimination of technical barriers to trade.

Three bodies are responsible for the planning, development and adoption of International Standards: [ISO](#) (International Organization for Standardization) is responsible for all sectors excluding Electrotechnical, which is the responsibility of [IEC](#) (International Electrotechnical Committee), and most of the Telecommunications Technologies, which are largely the responsibility of [ITU](#) (International Telecommunication Union).

ISO is a legal association, the members of which are the National Standards Bodies (NSBs) of some 164 countries (organizations representing social and economic interests at the international level), supported by a Central Secretariat based in Geneva, Switzerland.

The principal deliverable of ISO is the [International Standard](#).

An International Standard embodies the essential principles of global openness and transparency, consensus and technical coherence. These are safeguarded through its development in an ISO Technical Committee (ISO/TC), representative of all interested parties, supported by a public comment phase (the ISO Technical Enquiry). ISO and its [Technical Committees](#) are also able to offer the ISO Technical Specification (ISO/TS), the ISO Public Available Specification (ISO/PAS) and the ISO Technical Report (ISO/TR) as solutions to market needs. These ISO products represent lower levels of consensus and have therefore not the same status as an International Standard.

ISO offers also the International Workshop Agreement (IWA) as a deliverable which aims to bridge the gap between the activities of consortia and the formal process of standardization represented by ISO and its national members. An important distinction is that the IWA is developed by ISO workshops and fora, comprising only participants with direct interest, and so it is not accorded the status of an International Standard.

2. BUSINESS ENVIRONMENT OF THE ISO/TC

2.1 Description of the Business Environment

The following political, economic, technical, regulatory, legal and social dynamics describe the business environment of the industry sector, products, materials, disciplines or practices related to the scope of this ISO/TC, and they may significantly influence how the relevant standards development processes are conducted and the content of the resulting standards:

With the progress of development in ultrafine bubble generators and measurement technology, it was established that a number of ultrafine bubbles whose diameter is typically 100 nm to 200 nm can be generated in liquid. Further more, it became possible to measure such bubbles more accurately and quantitatively, and it is known today that billions of ultrafine bubbles exist in liquid and that they have a significant life time.

At the first plenary meeting of ISO/TC 281 held on 11th and 12th December 2013 in Kyoto, it was agreed that, compared with general bubbles, we needed to define fine bubbles as the ones whose diameter is 100 micron meters or less, and ultrafine bubbles as the ones whose diameter is 1 micron meter or less as noted in the resolution of the meeting. This is the first step to have the common international concept of fine bubbles (see Figure 2-1-1). The reason for setting the diameter as one of the parameters of fine bubbles is that fine or ultrafine bubbles are different in characteristics from the general large bubbles whose diameter is measured in millimeters (see Figure 2-2-2). A distinguishing property is that ultrafine bubbles exhibit a significant life time.

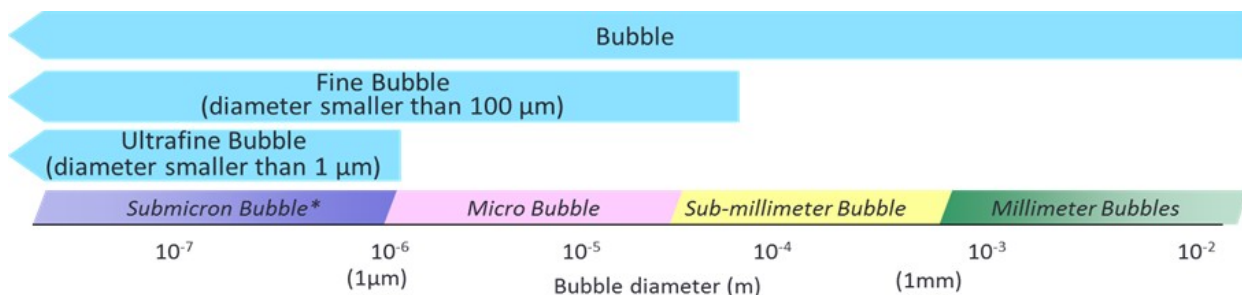


Figure 2-1-1 Classification of bubbles in diameter



Figure 2-1-2 Bubble's behavior

The epoch-making discovery, that ultrafine bubbles can have a substantial life time was discovered due to the innovative development of measurement equipment.

It is impossible to measure ultrafine bubbles using an ordinary optical microscope because the bubbles are smaller in diameter than the wavelength of light. It is also impossible to measure them using an electron microscope because they exist in liquid. However progress in recent measurement technology makes it possible. Examples of the measurement methods are particle tracking, observing the Brownian motion of bubbles; by measuring the interference fluctuations of coherent laser light intensity caused by the Brownian motion; and by distinguishing gas particles (bubbles) from solid particles using a resonant beam MEMS device. Those measurement methods are developed by the private companies and universities in the UK, Germany, the USA, and Japan. Using several different measurement methods, each having different in principles, it is confirmed that a number of ultrafine bubbles whose diameter is 100 nm to 200 nm exist in liquid (see Figure 2-1-3).

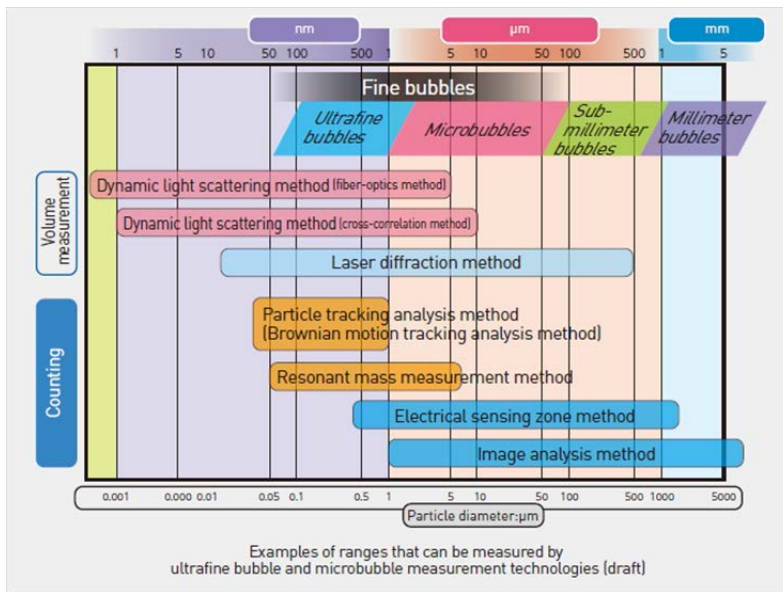


Figure 2-1-3 Example of bubble ranges

Figure 2-1-4 shows the measurable ranges of bubbles with the name and principle of measurement equipment developed. The figure also shows the measurement data of ultrafine bubbles using the described measurement methods. It is confirmed by all measurement methods that the diameter of the bubbles is in an approximate range of 100 nm to 200 nm.

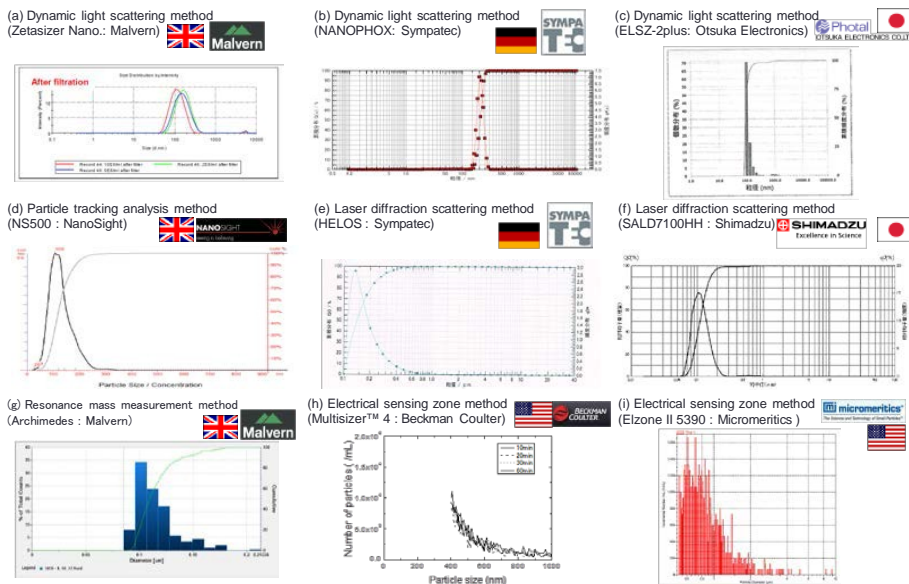


Figure 2-1-4 Example of measurement

In response to the progress of measurement and generator technology, industrial applications exploiting the research and development of ultrafine bubbles, has commenced. Applications in the fields of cleaning, sterilization, semiconductors, solar batteries, foods, beverages, chemical, medical, agriculture, cultivations etc., have evolved over the past few years. Figure 2-1-5 shows the overall view of the application of fine bubble technology.



Figure 2-1-5 Application fields of fine bubble technology

One of the most significant applications of fine bubble technology is in cleaning where substantial trials data has been obtained.

The first example is for road cleaning. It was demonstrated, in an initiative taken by NEXCO-West Japan, that the anti-freezing agent was more efficiently removed from road and bridges if ultrafine bubbles were present. It was also demonstrated that ultrafine bubbles removed effectively, urinary calcium deposits from toilets in the service areas of highways. This cleaning system is adopted by NEXCO-West (see Figure 2-1-6) though it is on a trial basis.



Cleaning position	Tap water			Ultrafine Bubble water		
	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 [°C]	22	20		22	20	

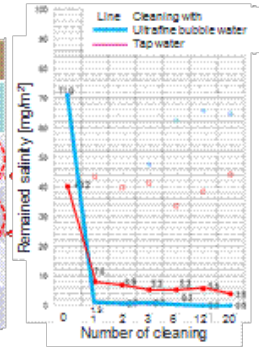


Figure 2-1-6 Example of application

The second example, is from semiconductor wafers. Studies conducted by the National Institute of Advanced Industrial Science and Technology (AIST) of Japan demonstrated that using ultrapure water containing ultrafine bubbles has a greater cleaning effect than using ultrapure water alone (see Figure 2-1-7).

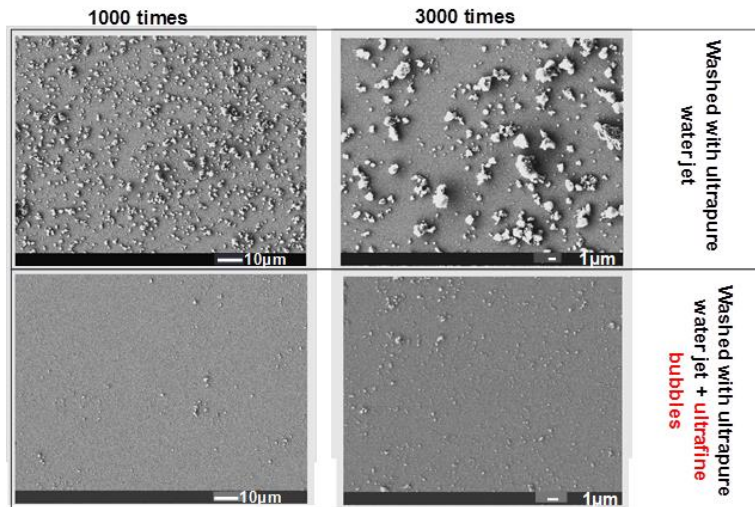


Figure 2-1-7 Example of applications

The third example, is from photovoltaic wafer separation. IDEC uses ultrafine bubbles to safely separate one sheet of photovoltaic wafer from another within a pile of the wafers (see Figure 2-1-8.).

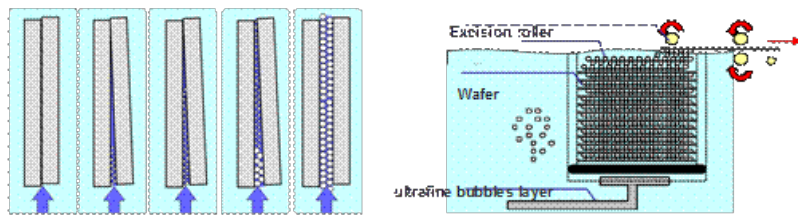


Figure 2-1-8 Example of applications

The fourth example, is from a food application. Fine bubble technology has already been applied as a new method in the food industry. A mayonnaise product with smooth texture and lowered calories has been developed through a joint development project carried out by Keio University and Kewpie Corporation and it is already on the market (see Figure 2-1-9).



Figure 2-1-9 Example of applications

In addition to the four application examples above, Kyoto University has succeeded in adding various kinds of aroma to the ultrafine bubbles because they are extremely small and they do not surface by buoyance as larger bubbles do. It is known that the Brownian motion and surface charge of ultrafine bubbles can retain them within liquid for over six months. This means that the technology can also be used to trap various types of gas in the ultrafine bubbles, which raise expectations of potential applications in food flavors, beverage, cosmetics, chemicals, medical care. In the field of agriculture, ultrafine bubbles may be used to speed the growth of plants, which made earlier harvesting of lettuce, possible. There is, therefore, a strong probability that ultrafine bubble technology would realize great improvements in efficiency of agricultural production, which is becoming today, a global focus of interest.

2.2 Quantitative Indicators of the Business Environment

The following list of quantitative indicators describes the business environment in order to provide adequate information to support actions of the ISO/TC:

The expected market demand

The confirmed effects of fine bubbles are purification, separation, lubrication, electrification separation, control of physical characteristic, growth, sterilization, etc., and a wide range of cross industrial applications such as for mining and manufacturing, foods, agriculture, forestry, fisheries, health-care, environment, etc. are expected.

Cleaning of semiconductor wafers, bathroom, soil, plumbing in a plant, cleaning services, etc. are concrete examples of the introduction of ultrafine bubbles. The semiconductor industry continues to grow along with the sensor network of devices that are to be built into facilities and social infrastructures. For small size and high performance, technology for minute construction with high accuracy, cleanliness is essential. In this area, the application of fine bubble technology is expected to grow (see Figures 2-2-1 and 2-2-2).

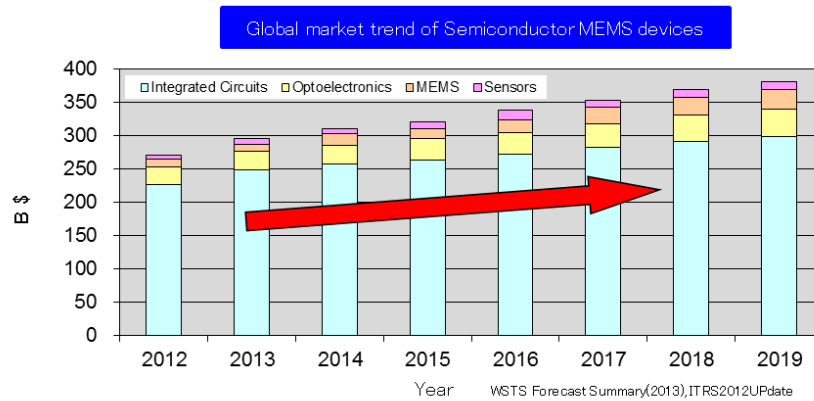


Figure 2-2-1 Global market of semiconductors

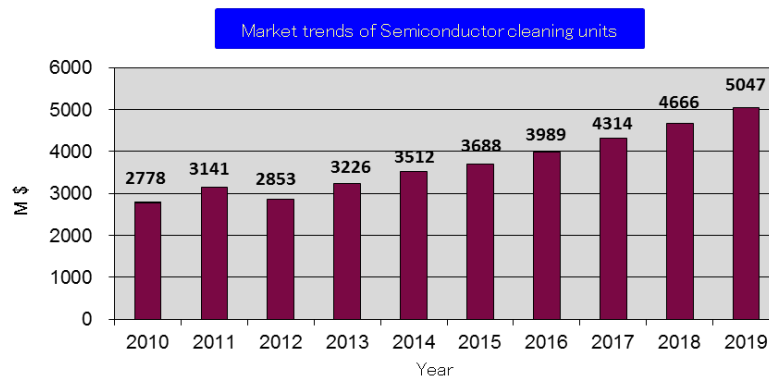


Figure 2-2-2 Global market of semiconductor cleaning units

In the field of environment, to construct a recycled society with less environmental load, the technology of on-site and recycled sewage processing is required. There is growing worldwide crisis of water resources and earth environment problems. Therefore, the multi-layered sewage processing, to remove the contaminant, including COD, BOD, nitrogen, etc. has to be improved so that the waste water can be returned to water courses without problem. Physical and chemical process such as cohesion, etc. and biochemistry processes are needed, and fine bubble technology may be able to contribute significantly to the decomposition and cost reduction.

As described here, the potential market for fine bubble technology is large, as it can contribute to the solution of the global problems of industries. Because the technology is of fine and ultrafine bubbles of gas and a liquid, the relevant market is not only for the bubble generators and measurement equipment but also for many public products. Potential applications are in washing equipment (shower); machines for industrial use and environment improvement; maintenance related services and in system assembly operations. Accordingly, The size of the global market for fine bubble technology including the application fields is expected to change as shown in Figure 2-2-3. 44 billion dollars are expected in the physical year 2020. A business activity level in this field is expected to be worth some 44 billion dollars by 2020.

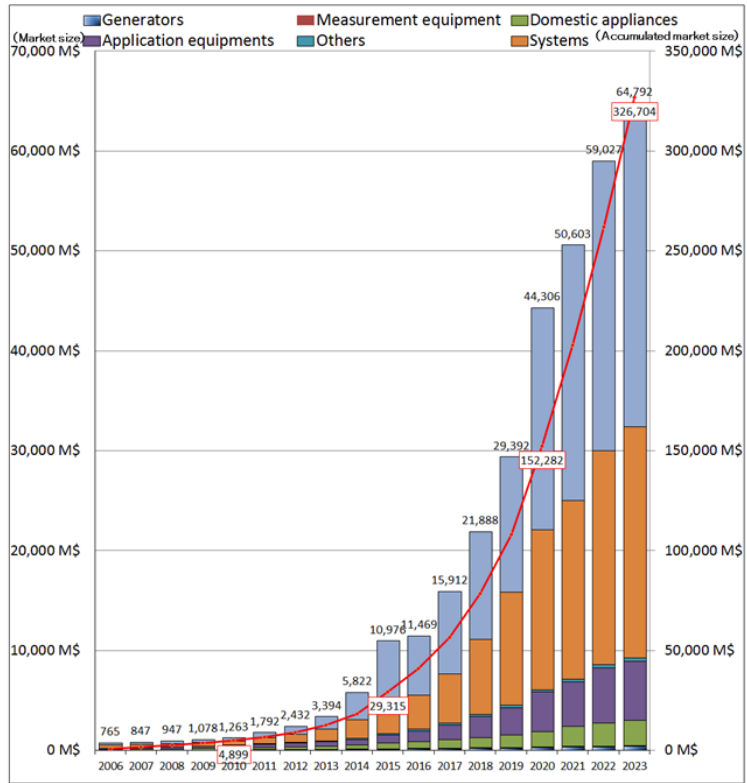


Figure 2-2-3 Estimated Market Growth (Source: FBIA)

3. BENEFITS EXPECTED FROM THE WORK OF THE ISO/TC

Fine bubble technology has made considerable progress, however the terms, definitions and general principles have not been made clear. Without setting international standards of fine bubble related attributes such as bubble sizes, bubble density, types of gas and liquid, life time in liquid, it is difficult for stakeholders to develop a “common language” in order to further fine bubble technology development. International standards setting out the methods of preparation, for measurement in a total system of fine bubble technology, are necessary in order to avoid confusion in the market.

As mentioned before, fine bubble technology has a potential to be used in many application fields, it is necessary for the users to express the conditions and effects particular to each application. For example, cleaning may mean a wide range of applications such as road cleaning, toilet cleaning, food piping cleaning, semiconductor wafer cleaning, each requiring a standardized methodology. Therefore, it is important to specify applications under the specific conditions required for consistent measurement parameters to be achieved.

In order to achieve the goals set forth, a three tier structure of standards is proposed. The top layer, contains common elements including general principles, and terms and definitions. The middle layer, sets out the methodologies for the measurement of particles and various other properties of fine bubbles. In the bottom layer, there are specific industrial applications. With the ISO standards system of this new concept, we believe that a healthy market is realized so that the people in the world can use common, standardized systems (see Figure 3.).

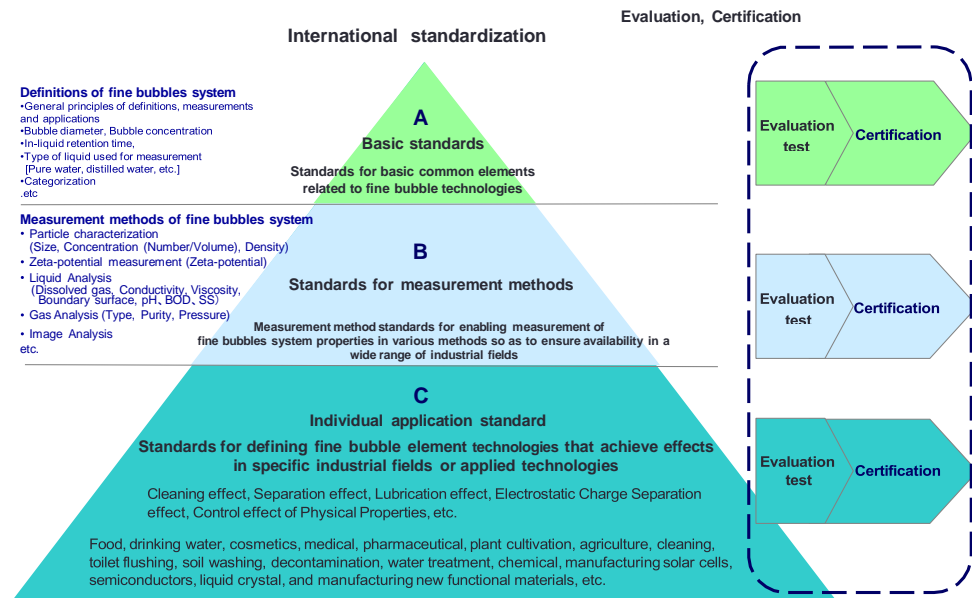


Figure 3 Three layer International standardization

4. REPRESENTATION AND PARTICIPATION IN THE ISO/TC

4.1 Membership

Countries/ISO member bodies that are P and O members of the ISO/TC 281committee

4.2 Analysis of the participation

In the ISO/TC 281 committee there are 7 P-members and 11O-members as of December 2014. At the launch in December 2013 there were 5 P members and 10 O-members.

Fine bubble technology is at a early stage of development. Many O members are active to raise their level of participation to become P members.

There are many conventional technologies using bubbles. For example, the ones for carbonated drinking water, floatation in mineral recovery, fish farming and transportation, where air (oxygen) supply is added into water. Waste water treatment extensively employs bubble technology. We also enjoy bubble baths, etc. These examples have arisen over many years and have a distributed level of control covered by a diverse range of industry regulation and practice.

The erosion properties of cavitation on ships propellers as well in other machines using fluid mechanics has been observed since the 19th century. It was some time before the stress induced by a collapsing bubble was described. This phenomenon is exploited in ultrasonic bath cleaning applications. However fine bubble technology is to be developed not in as an established area but in as a new business and research areas, and this may make fine bubble technology difficult to gain immediate acceptance. Ultrafine with a significant life time, are observed and characterized but as yet are not supported by scientific theory.

In recent years, new possibilities of ultrafine bubbles for cleaning, sterilization, activation of functions of living things, etc. are discovered, and such functions and effects are actively used in the industry. It is recognized that common standards, not a standard per application, are required for evaluation on fine bubbles and the effects. Regarding IPRs of fine bubbles, most applications for patents are made by three countries, Japan, China, and Korea, and the number of patents is increasing today. This reveals that there are stakeholders, including further potential ones, in these countries.

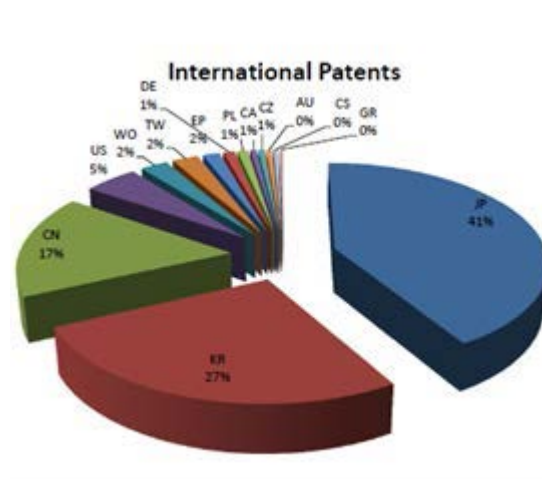


Figure 4 International patents per country

In Europe and the USA, most IPRs of microbubbles are for medical diagnoses as contrast agents in ultrasound examinations. Some drug delivery systems using fine bubbles are in research. In an academia, there are researchers in Europe and Oceania who observe the bubbles attached to the surface of materials using AFM but this has not yet reached a stage of industrialization..

Before establishing TC 281, FBIA-Japan suggested new possibilities for ultrafine bubbles such as for cleaning, sterilization, activation of function of living things, etc., through exhibitions and lectures. It is reported that companies in Europe and Southeast Asia, especially who are concerned about applications, are very interested. By actively calling attention to the merits, these countries where there are stakeholders will be expected to become P members.

The stakeholders of fine bubble technology are very varied. They vary from companies producing bubble generators through measuring instrument suppliers to consultants, researchers and application engineers. The most significant stakeholders in this market is those applying the technology. Fine bubble technology may become the center of public attention in order to solve the problems of diminishing resources, including water, and chemical materials. Increasing agricultural output whilst maintaining fresh fish supplies to market may also become important.

The development of fine bubble technology is expected to be advanced as much by private companies as in national research institutions. Since both will find advantage from having a “common language” set down by the work of TC 281 a steady growth of P membership is anticipated.

5. OBJECTIVES OF THE ISO/TC AND STRATEGIES FOR THEIR ACHIEVEMENT

5.1 Defined objectives of the ISO/TC

ISO/TC 281 is to carry out proactive standardization to lead the wide industrialization of fine bubble technology.

Therefore, we aim to develop a three layered standards system of fine bubble technology (described in Figure 3).

For top layer A, standards for general principles

- General principles
- Terms and definitions
- Classifications in sizes and characteristics

For middle layer B, standards for measurement methods

- Characterization of bubble; size, number concentration, Zeta-potential, gas composition, inside pressure and so on
- Characterization of liquid; chemical composition, dissolved gas, and soon

For bottom layer C, standards for defining fine bubble technologies that achieve effects in specific industrial fields or applied technologies, such as;

- Water treatment and remediation
- Surface cleaning
- Decontamination
- Bio-medical (Drug delivery and imaging)
- Agriculture and Aquaculture applications
- Food processing and manufacture
- Semiconductor processes
- Automobile industry (Fuel injection)

5.2 Identified strategies to achieve the ISO/TC's defined objectives

To achieve its objectives in the best possible way, ISO TC 281 formally establishes Working Groups (WGs) with the following structure and appoints their convenors;

ISO/TC 281/WG 1 General principles including terminology
ISO/TC 281/WG 2 Fine bubble characterization and measurement
ISO/TC 281/WG 3 Applications of Fine Bubble Technology

WG 1, WG 2 and WG 3 will develop standards in the top layer A, middle layer B and bottom layer C, respectively.

The convenor of each working group manages the discussion on standard development considering the scientific background and manages to have a good collaboration with other working groups.

The working groups are planning to have a face-to-face meeting during the TC 281 meeting. In addition, working groups have interim meetings using the Web-Ex and/or telephone conference systems between the TC meetings.

(The first WG 1 and WG 2 meetings were held on March 2014. The first meeting of WG 3 was held on December 2014.)

ISO TC 24/SC 4 is a well established committee covering a broad spectrum of particle characterization techniques. It creates standards for the validation of correct machine operation. It does not focus on how such machines should be applied to specific material applications. The focus of how to apply a measurement technique to characterize fine or ultrafine bubbles will be the task of TC 281/WG 2.

Substantial overlap of expertise between TC 281 and TC 24/SC 4 is expected and to support this, a mutual liaison arrangement to inform each committee has been put in place.
(Considering the convenience of the experts joining both meeting and also for the encouragement of communication between the experts attending at either of one of meetings, TC 281 meeting was held in conjunction with 47th TC 24/SC 4 meeting at Manchester. Similar arrangement will be considered in future meeting.)

6. FACTORS AFFECTING COMPLETION AND IMPLEMENTATION OF THE ISO/TC WORK PROGRAMME

Because fine bubble technology is very new, there are still few countries where there are research and development of generators, measurement methods, and applications, and where its applications are put to practical use. This makes creates a challenge in most countries to promote standardization activity by finding stakeholders.

However, we find that the area of measurement technology is rich in experts. It is important for us to urge the experts working at universities, laboratories and companies in Oceania, South America, South Africa, etc. in addition to those in Europe, North America, and Asia to join into the work of creating standards. Besides the new approach of the three-tiered standards system, we need to promote actively ISO international standardization of fine bubble technology in order to realize to a new industry where the technology contribute to the global market.

The main challenges, which are to be addressed during the work of ISO/TC 281, are as follows:

- 1) The number of the participating countries is limited so far, because the fine bubble technologies are new. Continuous effort to invite other countries worldwide will be expected.
- 2) The bubble technology closely relates to wide area of technologies in both measurement and application. The harmonization with other international standards, which have been and will be developed, is important. Also there is a need to receive an official approval to use the standards of TC281 as a basis for the contents of standards in other TCs and standards-developing bodies such as ASTM, etc.

7. STRUCTURE, CURRENT PROJECTS AND PUBLICATIONS OF THE ISO/TC

Information on ISO online

The link below is to the TC's page on ISO's website:

[ISO/TC 281 on ISO Online](#)

Click on the tabs and links on this page to find the following information:

- About (Secretariat, Secretary, Chair, Date of creation, Scope, etc.)
- Contact details
- Structure (Subcommittees and working groups)
- Liaisons
- Meetings
- Tools
- Work programme (published standards and standards under development)

Reference information

[Glossary of terms and abbreviations used in ISO/TC Business Plans](#)

[General information on the principles of ISO's technical work](#)