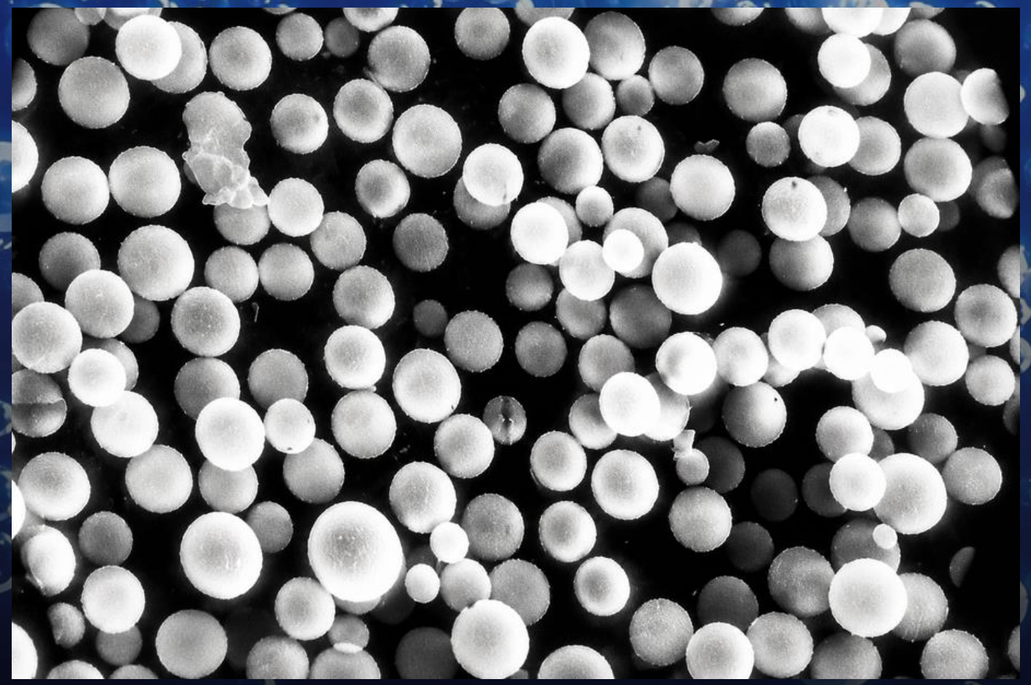
HOLLOW GLASS MICROSPHERES

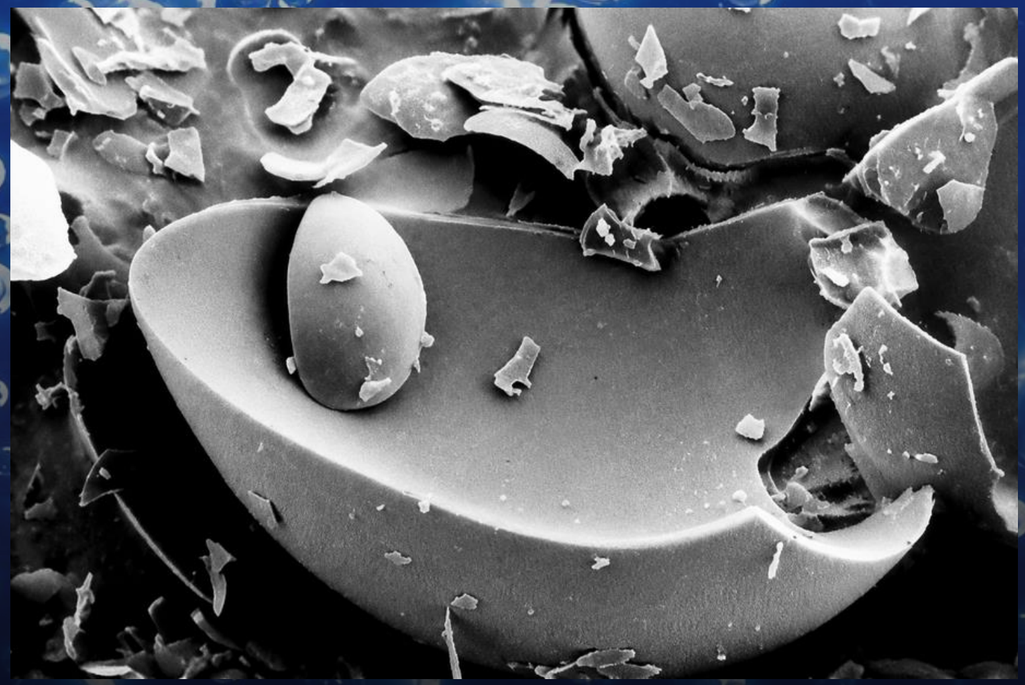
Rapid growth in the field of research of the World Ocean in the middle of the past century was one of the basic incentives for development of the production of hollow glass microsphere(HGM).

The Developers of the deep-submergence vehicles required state-of-art light-weight strong and water-resistence materials. Composites based on the HGM could, to a great extent, meet requirements.

Hollow Glass Microspheres are white color dry powder consisting of tiny bubbles with a diameter of 20-160 µm. The glass composition and almost requlars hperical shape of microspheres provide a very high compressive strength, low water absorption, low heat conductivity, high chemical resistance and radio-transparency. Good adhesion of the HGM towards polymer binders makes it possible to create composites (syntactic) on their basis with a unique complex of properties. All the above factors defined a wide variety of applications for the HGM.



Hollow glass microspheres (x 100)

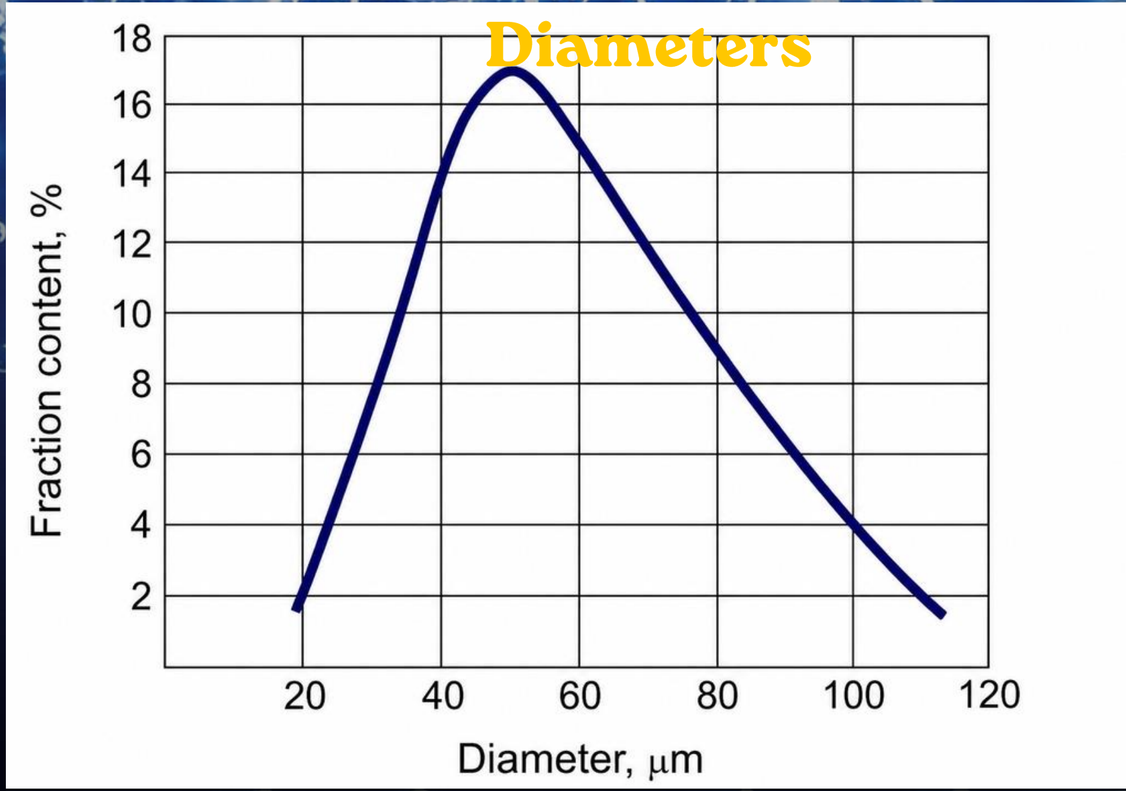


The fragment of broken microsphere

Technology for the HGM manufacture is a combination of complex hydrodynamic, physical and chemical processes taking place in the course of forming of hollow bubbles from micro- particles of glass melt by blowing. For realization of these processes, the scientists have developed special fine-dispersion multi-component glass powders capable to form micro-particles of predetermined volume in melted state. An exact dosage of gas generating component into the powder provides blowing of microspheres with required wall thickness from the melted particles.

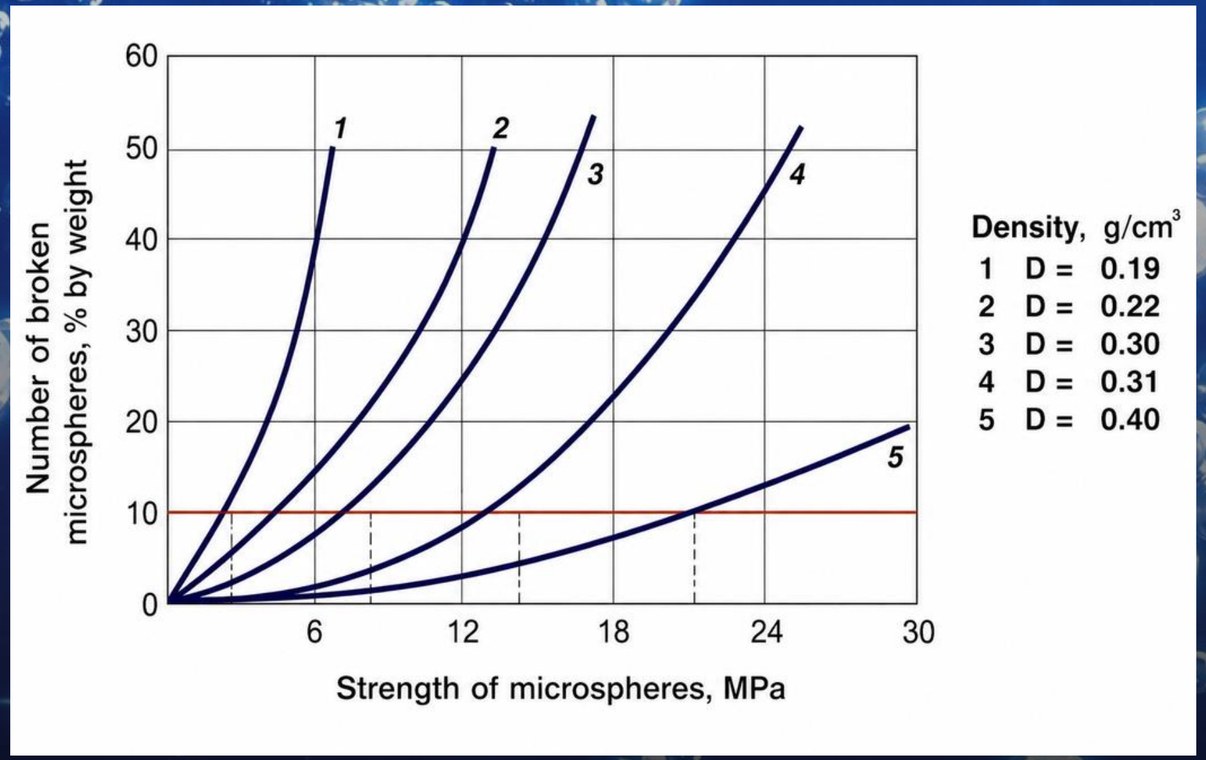
It is obvious that with such a complex technological process it is impossible to make microspheres with a strictly identical predetermined diameter. Therefore, if necessary, calibration of microspheres according to their dimensions is performed.

Distribution of Microspheres According to Their Diameters



Strength of microspheres is estimated the value of hydrostatic pressure at which not more than 10% HGM are broken. It is natural that microspheres with a greater weight, and thus with thicker walls, are stronger.

Dependence of Microsphere Failure Degree on Pressure



Hollow glass microspheres

Microspheres designation	Density, g/cm^3	Strength (10 % level of failure in water), MPa no less than	Volume ratio, %	Humidity, % no more than	Content of size, % by weight
МСВП-30 МСВПА9-30	0.21-0.25	3.0	60	0.3	0.15-0.35
МСВП-50 МСВПА9-50	0.21-0.25	5.0	60	0.3	0.15-0.35
МСВП-60 МСВПА9-60	0.26-0.32	6.0	60	0.3	0.15-0.35
МСВП-80 МСВПА9-80	0.26-0.31	8.0	60	0.3	0.15-0.35
МСВП-120 МСВПА9-120	0.28-0.32	12.0	60	0.3	0.15-0.35
МСВП-150 МСВПА9-150	0.35-0.41	15.0	60	0.3	0.15-0.35
МСВ-1	0.18-0.22	–	–	–	–
МСВ-2	0.23-0.27	–	–	–	–
МСВ-3	0.28-0.30	–	–	–	–

Microspheres marked as МСВПА9 are coated with γ - aminopropyltriethoxysilane

Hollow glass microspheres for Composites Applcation

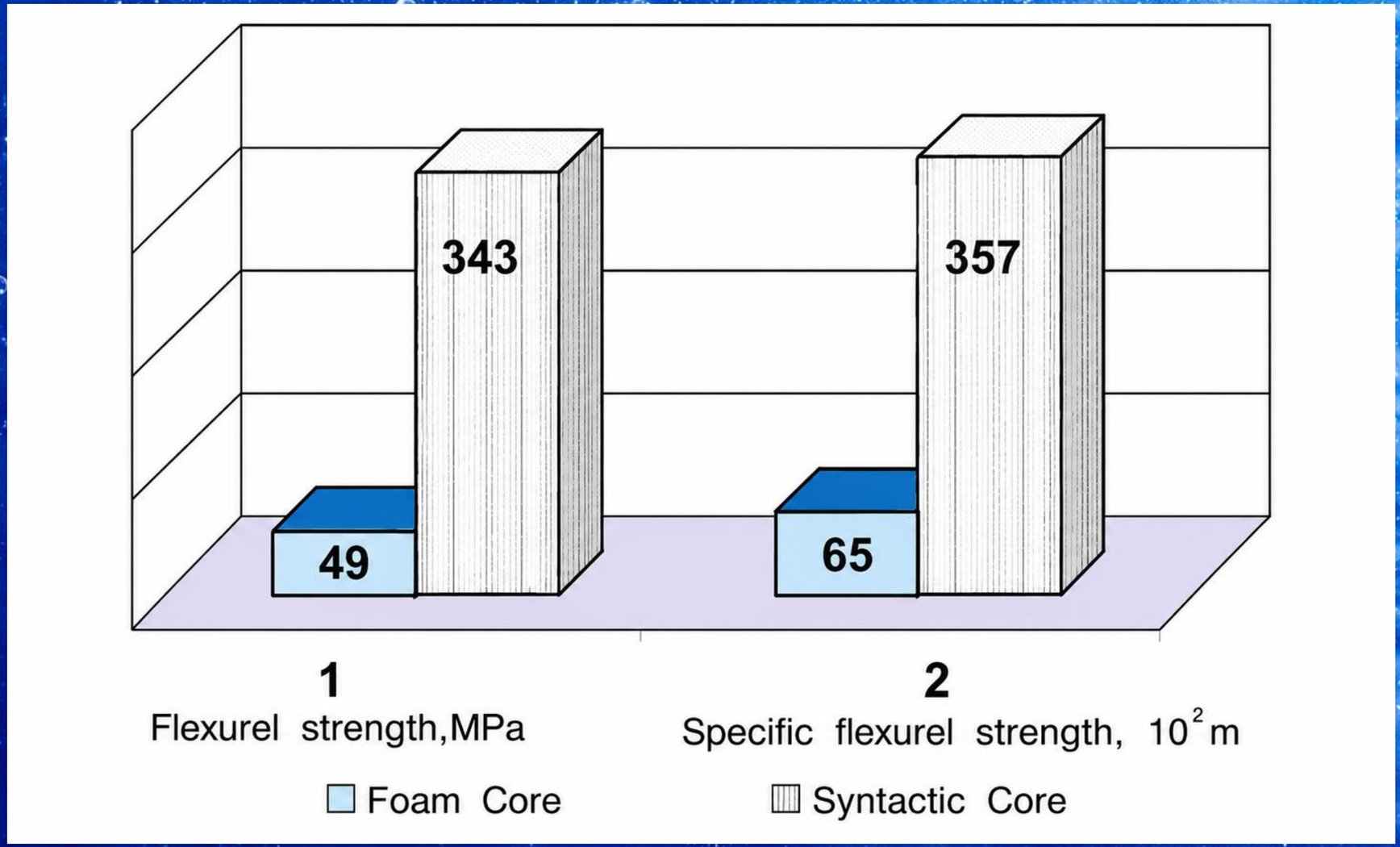
Development of sandwich composites is not a simple technological task especially when manufacturing multilayer items of complicated geometric shapes, variable thickness and with local reinforcements. Composites based on HGM have opened new possibilities for designers and industrial engineers developing sandwich structures. Breakthrough in this field became possible owing to creation of highly workable sheet half-finished product based on HGM for manufacturing sandwich composites.

In outward appearance SYNLAY looks as rolled pastry which does not stick to the skin. Depending upon requirements content of the microspheres in the material can theoretically achieve probable limit equal to 70% of the whole volume. For all that, owing to specially designed formulation of the polymer binder, the material will be elastic even with such a high percentage of the filler. SYNLAY sthickness is from 0.7 to 30 mm. Shelf time of the material with epoxy resin can make up 3months at +20 °C and up to two years at -5 °C.

Comparable properties of the foam plastics and composites based on HGM

Quality	Foam	SYNLAY
Density (γ), kg/m^3	30 — 400	400 — 650
Compressive strength (σ), MPa	0.2 — 12	25 — 95
Specific compressive strength,(σ / γ),10^{3}m	0.8 — 3.0	6.2 — 15
Compressive modulus (E), MPa	20 — 600	1000 — 3000
Specific compressive modulus (E / γ),10^{4}m	0.7 — 15	25 — 46
Shear strength (τ), MPa	0.3 — 6.5	6 — 22
Specific shear strength (τ / γ),10^{3}m	1.0 — 1.6	1.5 — 3.3
Shear modulus (G), MPa	11 — 200	500 — 1300
Specific shear modulus (G / γ),10^{4}m	3.7 — 5	12 — 20

Comparative characterstics of sandwich samples with syntactic and foam core



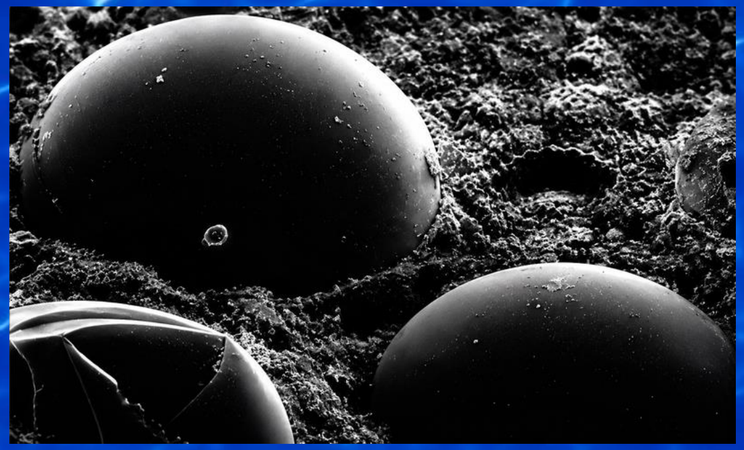
The basic technological advantage of SYNLAY is its high elasticity what allows to mould items of any shape with use of many well-known technological techniques (press method, vacuum and autoclave molding, winding, blow-molding etc.).

Thanks to good flow of the material, manufacture of the sandwich structures of various thickness does not create technological problems either. One more advantage of the material is that as a core for sandwich structuresit does not need glues, as amount of polymer binder is quite enough in the material to be bonded to the faces. Thus, multilayer structure technology with use of SYNLAY is practically identical to that well mastered mould technology from prepreg. Sheet half- finished product based on HGM allows to make very thin (up to 1 mm) sandwich structures, production of which with use of foam plastics or honeycombs is not possible from technological point of view and, above all, it is senseless from the point of view of realization of strength capabilities of the faces, thickness of which is comparable with thickness of the core in thin sandwiches.

Not only the volumes of application of glass microspheres are increasing year by year, but also fields of application of this material with unique properties are considerably expanding.

Low-density composites based on hollow glass microshperes are traditionally widely used for deep-submergence vessels, and not only for manufacture of buoyancy elements, but for molding of high strength structures for such apparatus as well.

In petro-gas industry, addition of microspheres to drilling mud does not only intensify the drilling process, but also considerably increases the life cycle of the drilling equipment. Besides, filling the cement mortar with HGM makes it possible to produce a shrinkage-free heat-insulating quick- hardening material providing a reliable bond between the casing pipes and the seam.



Microstructure of light-weight oil-well cement filled with glass microspheres.

Glass microspheres are more and more widely used in paint and varnish industry as well as in the manufacture of various sealants and mastics.

The incorporation of hollow glass microspheres into explosives considerably increases the velocity of detonation, which results in an increase of efficiency of the explosion process.

Application of compounds, based on glass microspheres, as a light-weight intermediate filler for sandwich composites has considerably expanded the application of them not only in the airspace industry, but in automobile, shipbuilding and construction industry as well.

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