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Industrial technology for constructing large-scaled ultra-high-vacuum systems

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Collaboration between laboratories and industries is most necessary concerning choice of materials and process control of machining, heat-treatment, surface finish, electroforming and braze/weld, in order to construct a large-scaled ultra-high-vacuum systems such as J-PARC accelerator, long-baseline interferometer KAGRA of gravitational-wave telescope, and so on. Some of industrial technologies so far applied to those scientific machines are here introduced.

High-purity electroformed copper lining recently developed in a manufacturer has been applied to the J-PARC 200-m long linac of 0.57 m in diameter and 9.9 m of unit cavity length. The lining was formed on the entire inner surface of iron cavity by cyanide copper plating using a periodic current-reversing method, which makes the copper grains small and uniform without any additives of brightener. The electrical breakdown strength and ougtgassing rate measured for the lining surface showed better performance than those formed by other plating methods.

Beam chambers in the J-PARC 3-GeV ring, having a diameter of 200 to 300 mm and 348-m in circumference, require non-electrical conductivity for avoiding any eddy current effect due to rapid varying magnetic filed and further non-magnetism preventing disturbance of fine magnetic filed. An alumina ceramic tube of 3.54 m long is first sintered in a 0.8 m-long short unit with thickness of 8 mm, then precise grinding of both extremities is performed for preparing metalize/braze process. Inside the tube a 15 nm-thick TiN film is coated for suppressing secondary electron emission. After jointing the unit tubes by brazing in a large vacuum furnace, titanium flanges of non-magnetism are welded at the both ends; hydro-formed titanium bellows are also used in the accelerator. These production processes are successively completed by several industries.

500 of stainless steel tubes of 12 m long with a diameter of 0.8 m are necessary for constructing the two arms of 3-km long baseline interferometer of KAGRA. An 8 mm-thick sheet is first ground to the roughness of 8 μm, then rolled by pressing followed by plasma welding. After welding a hydro-formed bellow and rotary-forged flanges to the tube, electro-polishing is preformed, resulting a surface roughness of 2.5 μm. Final treatment of vacuum baking at 22°C for 20h is applied. It takes three years from production start to finishing installation.