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Extract from the annual report 2017
To the website: www.ist.fraunhofer.de/en.html

DEFECT-FREE SILICON OXIDE FILMS FOR THE AVOGADRO PROJECT

The prototype kilogram to which all scales are calibrated is losing weight. Consequently, in an international project the basic unit of mass will be redefined and in the future based on natural constants. To do this, in the so-called Avogadro experiment scientists will determine how many atoms are contained in virtually perfect silicon spheres. At the Fraunhofer IST film processes will be executed for homogeneous and uniform silicon oxide film (SiO_2) of the sphere surface to reduce the degree of measurement uncertainty.

Redetermination of the Avogadro constant

The kilogram is the last unit of measure in the international measurement system that is defined through a macroscopic body – the prototype kilogram. All other units are already based on atomic processes, molecular properties or natural constants. If scientists succeed in counting the number of atoms in a silicon crystal with the mass of 1 kg with the utmost precision, then in the future the material kilogram can also be replaced through a physical constant.

The Avogadro constant is being worked on in a worldwide project. In this regard, several metrological institutes are conducting the individual measurements: From determination of the mass of the sphere, the volume of the sphere or the molar mass via analysis of the lattice parameters and density differentials, and extending to investigations of oxide layer properties, water layer and impurities.

ALD-SiO_2 minimizes measurement uncertainties

There is always a natural layer SiO_2 on the surface of the silicon spheres, which likewise has an influence on mass and volume. This native layer grows slowly, however to some extent it also grows quite unevenly. This means that the actual weight of the oxide layer and the actual weight of the sphere are very difficult to measure. Consequently, to redetermine the Avogadro constant an alternative, homogeneous SiO_2 film is being investigated to reduce measurement uncertainties and to enable precise determination of volume and mass of the sphere.

With the aid of the atomic layer deposition (ALD) available at the Fraunhofer IST, stoichiometric SiO_2 films can be deposited with a defined roughness and adjustable layer thickness; the condition of these films satisfies the rigorous requirements: They are reproducible and can be applied as an extremely thin oxide layer with homogeneous thickness on the sphere. Potential impurities, such as carbon or nitrogen, are below the detection limits, the roughness of the films remains under one nanometer.

The deposition processes of the silicon spheres were performed in 2017. The results within the Avogadro consortium will be presented in 2018 at the Conference for Weights and Measures. By this time at the latest the prototype kilogram

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1 *A look into the silicon sphere.*

2 *Preparation and holding arrangement of the silicon sphere for the coating process .*

will be replaced as the standard. At the Fraunhofer IST, at the end of 2017 additional films of silicon spheres took place to investigate the influence of different SiO_2 layer thicknesses.

Outlook

The SiO_2 films developed at the Fraunhofer IST do not only enable application on spherical systems, but rather on any complex structured services desired. Thus, the possible future areas of implementation are varied and extend from optical applications to the semiconductor and electronics sector and to medical technology.

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