Ultra-high vacuum glass cell

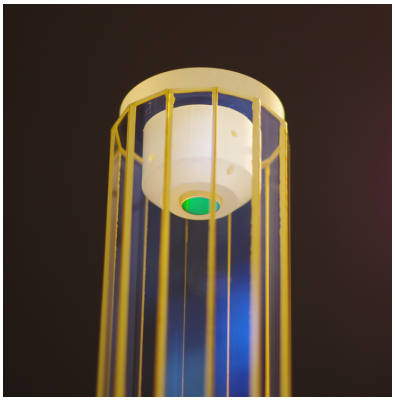
Ultra-low birefringence dodecagonal vacuum glass cell for the investigation of cold atom ensembles.

Invention

The invention consists of a glass cell characterized by an outstanding value of birefringence (around 10^{-8}) with an extensive optical access due to its dodecagonal shape. The cell is ideally suited for experiments in ultra-high vacuum that require the state of polarization to be preserved to the highest degree.

Modern experiments for the investigation of cold atom ensembles require an ultra-high vacuum apparatus with a very large optical access and an accurate preservation of laser beam properties such as the state of polarization and the wave-front quality.

The standard approach consists in using a metal vacuum chamber in combination with viewports. As an alternative to metal chambers, vacuum glass cells are widely used since they generally exhibit less birefringence than conventional vacuum viewports. Furthermore owing to their small volume and the avoidance of metal components, glass cells can be combined with compact electromagnetic coils, which allows one to generate strong magnetic fields and field gradients that can be switched on a short time scale.



Photograph of the vacuum cell holding a large-numerical-aperture objective lens in its interior.

The innovative manufacturing process is based on the bonding of double-side antireflection-coated glass windows with epoxy adhesives that fulfill the NASA low outgassing standard. Surface roughness and small deviations from the ideal geometry are compensated by the glue volume, therefore allowing for relatively large tolerances in the glass cutting process. The epoxy bonding technique is also applicable to complex geometries with different shapes, where optical contacting is difficult.

Only recently, glass cells bonded by optical contact have become commercially available with double-sided antireflection coating and in more versatile geometries. However, this bonding method requires the contact surfaces to be polished to highest precision and the different components to be aligned with very high mechanical accuracy. For that reason, optical contact has been so far applied to vacuum cells with up to eight facets, and furthermore using only standard glass materials.

In the actual market a glass cell for experiments in UHV requiring low birefringence is not available. The process, which defines the true object of this invention, combines the excellent optical access of the dodecagonal geometry with exceptionally low birefringence.

Commercial Opportunities

The extraordinarily low birefringence of this vacuum cell is essential for modern experiments ranging from generation of synthetic gauge fields and artificial spin-orbit coupling to quantum technologies like coherent spin-dependent transport of atoms. Ultra-low birefringence is also crucial for atomic clock experiments and precision measurements of electric dipole moment and vacuum polarizability.

In addition, the cell is well suited for ultra-high vacuum apparatuses in spite of the epoxy adhesive used for the glass bonding.

Current Status

A German patent application has been filed. On behalf of the University of Bonn PROvendis is seeking a partner for licensing the technology

An invention of the University of Bonn.

Competitive Advantages

- **The cell is suitable for applications requiring UHV**
- **The innovative procedure for application of epoxy glue combined with the use of the special SF-57 glass guarantees ultra-low birefringence ($\Delta n \approx 10^{-8}$).**
- **Double-side antireflection-coated vacuum glasses ensures negligible transmission losses.**
- **The manufacturing technique enables the realization of a many-sided glass cell, offering an outstanding optical access.**
- **The inner volume of the glass cell is sufficiently large to host further scientific components (e.g. objective lens, atom chips, optical cavities, etc.)**

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