Development of Silica Aerogel with Any Density

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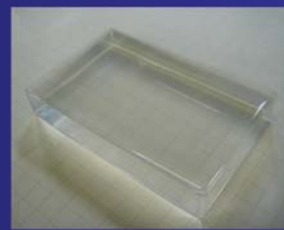
Introduction

Silica aerogel is widely used in high energy experiments mainly for the Cherenkov radiator. Production method of aerogel with the refractive index from 1.01 to 1.07 was developed in the previous studies [Ref.1]. We have improved it and obtained more transparent aerogel with above index range. Further, we have developed the production method of aerogel with lower or higher index. Among them, R&D works for RICH radiator in the upgrade program of KEK Belle detector has reported [Ref.2]. Other works are reported here.



Higher Refractive Index sample

Refractive Index : 1.2206±0.0009
Transmission Length : 18.1±0.5mm
Size : 57×36×9mm
Shrinkage : 86ml → 18ml (21%)
Initial Refractive Index : 1.057

Lower Density sample

Frame Structure

Density : 0.0088±0.0008g/cm³
Corresponding Refractive Index : 1.002
Size : 7×7×1cm

Production Methods

Pinhole Drying Method

Aerogel with Higher Refractive Index

It was known that the anneal of aerogel with more than 900ºC decrease the volume and aerogel with n>1.07 was thus obtained. There were uneven index in the annealed aerogel and transmittance became worse. We found that the volume of alcogel decreased very slowly with no crack when alcogel were kept in the closed vessel with pinhole. The volume of alcogel with methanol solvent decreased to 20% after a month of aging period. Thus, aerogel with the refractive index from 1.070 to 1.265 has been produced. There is almost no decrease of transmittance from the original aerogel with n=1.025~1.060. For the aerogels with n=1.05, aerogels produced in the pinhole method from n=1.025 alcogels have higher transparency than aerogels produced directly.

alcogel → 3 weeks later

Standard Method (KEK Method)

Mix solutions
- Methyl Silicate 51
- Distilled Water
- Methanol, Ethanol, DMF
- Ammonia

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Alcogel (~1 month)

- Put into Ethanol vapor
- ↓ Sink into Ethanol
- ↓ Add hydrophobic agent (Hexamethyldisilazane)
- ↓ Sink into Ethanol
- ↓ Supercritical Drying

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Aerogel

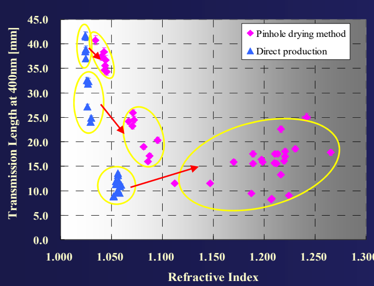
Frame Structure Method

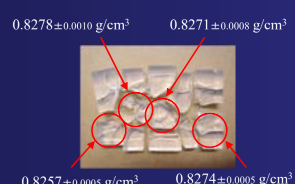
Aerogel with Lower Density

If we try to produce aerogel with n<1.005, heavy shrinkage occurred in the supercritical drying duration. To produce aerogel with low density, alcogel must be attracted at all outer surface. In case a glass mod is used and a thin glass plate is put on the alcogel in the supercritical drying stage, more transparent aerogels is produced. Thus aerogels with n=1.007 were used in KEK-PS E248 experiment [Ref.3]. Further, aerogels with n<1.005 can be produced by the following method.

As the low n aerogels are not so transparent, it is difficult to measure the refractive index and not n but ρ is useful for the discussion of low density aerogel.

Since two aerogels with different density attract hardly in the evaporating duration [Ref.2], an alcogel with lower density completely surrounded by middle density alcogels does not shrink in the drying stage. Outside aerogels are easily removed by a diamond cutter knife. The aerogel with 0.009g/cm³ was produced in the first trial and it is expected that lower density such as 0.005g/cm³ can be achieved. We are planning the study to detect the cosmic dust at Japan Aerospace Exploration Agency. Not powder but solid will be need and material with as low density as possible is suitable because of low frictional heat. Silica aerogel with lowest density is the best candidate for this study.





Even density

Frame Structure (alcogel)

2-layer Structure

Lower density 0.0123±0.0011g/cm³

Middle density

Conclusion

We have succeeded developing silica aerogel with a wide range of density.

New methods
- Pinhole Drying Method → Higher density : ρ≤ 1.02 g/cm³ (n ≤ 1.273)
- Frame Structure Method → Lower density : ρ≥ 0.009 g/cm³ (n ≥ 1.002)

Standard method
- KEK Method → Middle density : 0.04 <ρ< 0.28 g/cm³ (1.01< n < 1.07)

References

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