Impact of polishing on the light scattering at aerogel surface

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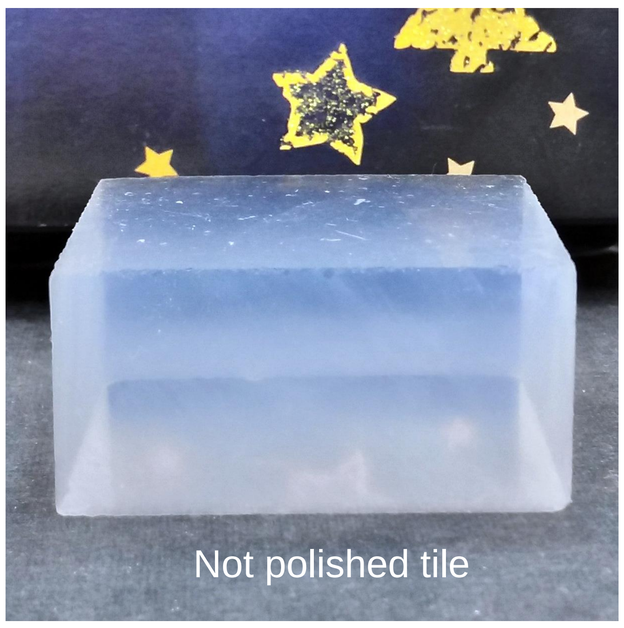
Particle identification power of modern aerogel RICH detectors strongly depends on optical quality of radiators. It was shown that wavelength dependence of aerogel tile transparency after polishing can not be described by the standard Hunt formula. The Hunt formula has been modified to describe scattering in a thin layer of silica dust on the surface of aerogel tile. Several procedures of polishing of aerogel tile have been tested. The best result has been achieved while using natural silk tissue. The resulting block has optical smooth surfaces. The measured decrease of aerogel transparency due to surface scattering is about few percent. This result could be used for production of radiators for the Focusing Aerogel RICH detectors.

Introduction

Particle identification power of modern aerogel RICH detectors strongly depends on optical quality of radiators. The development of multilayer focusing aerogel radiators for RICH detectors[1,2] requires to have flat optical clean entrance and exit surfaces. This task becomes the most important if one needs to have 3-4 layer radiator consisting of separate tiles.



The aerogel RICH detector for CLAS12 experiment (Jefferson lab., USA) has complicated light collection system with two mirrors [3]. Cherenkov light from outer aerogel tiles passes twice through the central tiles. Such a scheme puts additional requirements on the quality of entrance and exit surfaces of central aerogel tiles.

The main aim of this research was the search for a polishing method of aerogel. The current technology of aerogel synthesis used in the Boreskov Institute of Catalysis in Novosibirsk can not produce aerogel tiles with optical clean, flat bottom (entrance) surface. To prevent gel adhesion to the stainless steel molds during the production they are covered with paraffin. After the contact with paraffin aerogel surface becomes slightly mat.

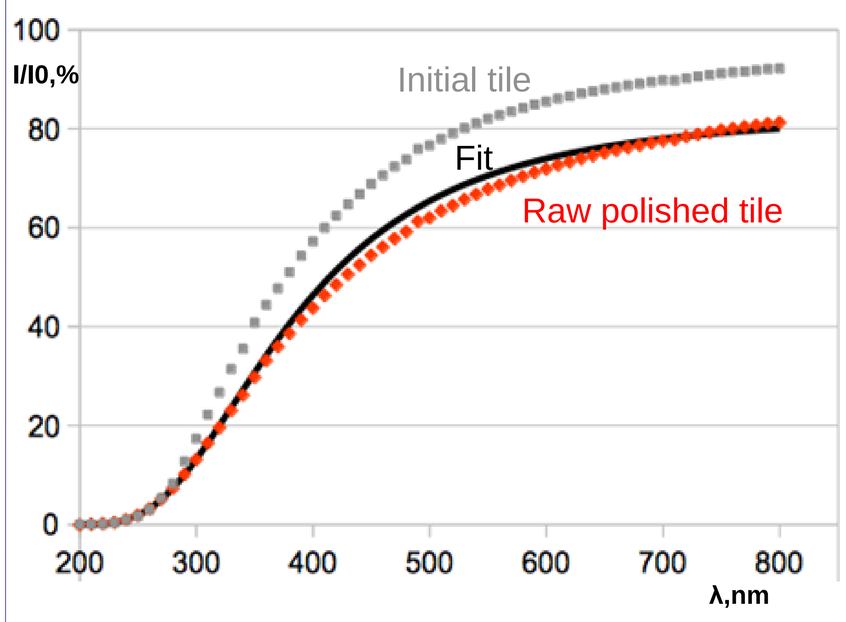
The existing technologies of optical polishing of materials use liquids. This liquid must wet the polished material in order to remove fragments from processed plane. Aerogel is destroyed by capillary forces during the contact with such liquid. This is the reason why such technology can not be used for aerogel polishing.

Light scattering at the surface

At the beginning of our research we try to find some quantitative method of characterizing the light scattering on the surface. The well known Hunt formula does not describe well the transparency of polished tiles:

$$\frac{I}{I_0} = A \cdot \exp\left(-\left(\frac{t}{L_{sc}\left(\frac{\lambda}{400}\right)^4}\right)\right),$$

where A is the surface scattering coefficient, t is the thickness of the tile in mm, L_{sc} is the light scattering length in mm at 400 nm, λ is the light wavelength in nm.



	A, %	Lsc, mm
Initial tile	94.85±0.4	51.3±1.5
Raw polished tile	91.15±0.9	56.8±1.7

While using standard fit one could assume that L_{sc} is changed after polishing procedure. That is not correct because L_{sc} is the characteristic of aerogel volume, not suface.

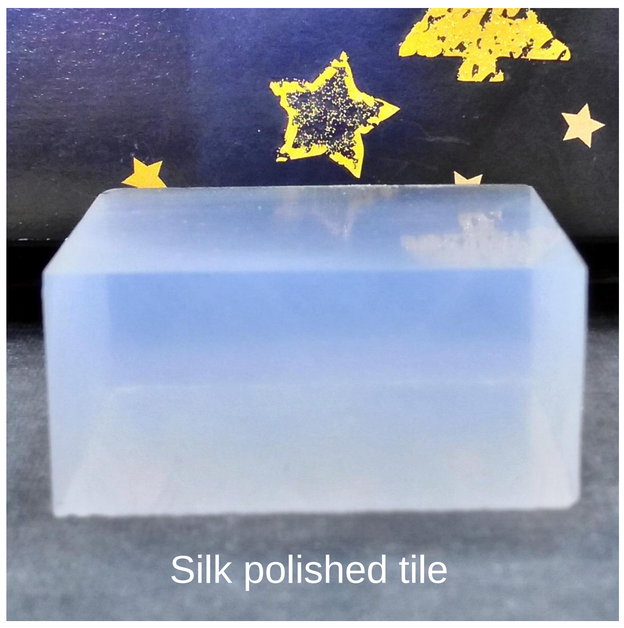
The Hunt formula has been modified to describe scattering in a thin layer of silica dust on the surface of aerogel tile. An additional term with inverse square dependence on the wavelength was added:

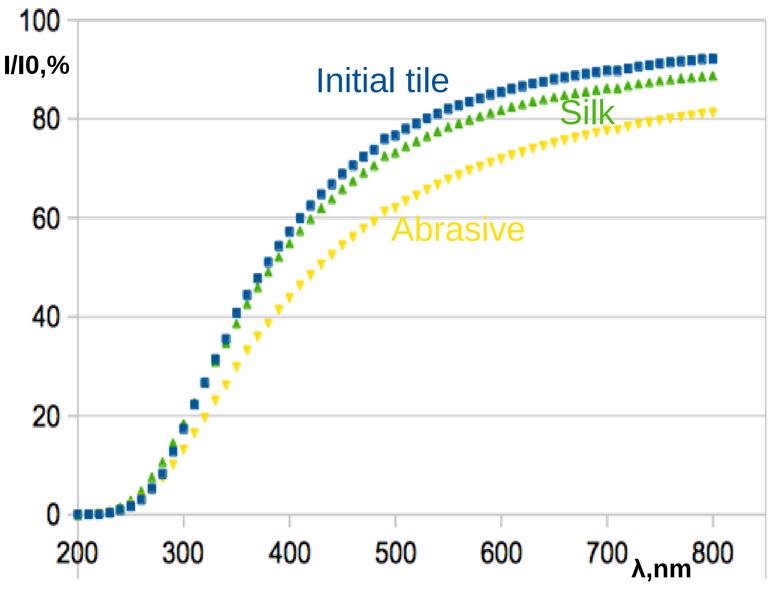
$$\frac{I}{I_0} = A \cdot \exp\left(-\left(\frac{t}{L_{sc}\left(\frac{\lambda}{400}\right)^4}\right) - \frac{M}{\left(\frac{\lambda}{400}\right)^2}\right).$$

The subsequent tests show that M and A coefficients describe well the quality of polishing. L_{sc} from the fit does not differ significantly after different polishing procedures.

Polishing with the silk

Different polishing tests with a fine abrasive paper did not give positive results. We concluded that during dry polishing with abrasive there is no possibility to remove aerogel fragments from the surface. These fragments remains inside the aerogel pores. We decided to use some pore material – tissue. We try several tissues: wool, natural silk, synthetic silk. The best result we have got with natural silk.





	Initial tile	Abrasive	Silk
A, %	94.9±0.8	91.2±1.7	92.4±1.2
L_{sc}	51.3±0.9	56.8±2.2	50.3±1.5
M	0.01±0.01	0.36±0.03	0.05±0.02

Conclusion

We have succeeded to obtain aerogel tiles with optical smooth surfaces by polishing with the silk tissue. The measured decrease of aerogel transparency due to surface scattering is about few percent. This result could be used for production of radiators for Focusing Aerogel RICH detectors.

REFERENCES:

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