RADIATING OPTICAL STABILITY OF GLASS FIBER WAVEGUIDES

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ABSTRACT

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In connection of importance of application vitreous SiO2 (v-SiO2) in the nuclear industry do not weaken attempts to receive this material with high stability to influence of radiation. The description of a method of reception of the preliminary form of glass possessing optical stability to action of radiation for manufacturing a glass fiber waveguides is submitted in work.

On the basis of glass fiber waveguides various types of the gauges – acoustic, magnetic, temperature, gauges of pressure and etc., are developed. Optical fiber waveguides are used for transfer of a signal both on short and on a long distance. Transfer of a signal on short distances is carried out with use of fiber waveguides with losses much exceeding losses in waveguides on a long distance. If to accept reguirement showed to optical material for optical fibre communication lines that loss of light on working length of a wave should be less than 10 db/km for long lines and less than 50 db/km for short lines which length makes 100-300 m [1]. However, if fiber glass is maintained in conditions of radiating influence that it results in essential change of its optical characteristics and causes the raised losses of an information signal. So for example fiber glass with a core from v-SiO2 and an environment from v-SiO2 + v-B2O3 at λ=0,82μm, value absorption coefficient $\alpha \sim 11$ db/km and at a dose of an irradiation $\sim 10^3$ rad $\alpha \sim 1000$ db/km [2]. From these data follows that in a zone of an irradiation it is possible to maintain only fiber glasses subjected by rather low doses of radiations.

1.INTRODUCTION

It is known that in process work of a nuclear reactor or at its stop on routine inspection in some cases there is a necessity to carry out the control as parameters of a active zone of a reactor and on presence of cracks, etc. The big doses of an irradiation can lead to to losses of light in glass waveguides that practically will bring to nothing monitoring procedure. Our purpose was development of method of preparation of the preliminary form of glass for manufacturing an optical fiber waveguides possessing optical stability to action of radiation. The given purpose was reached by reaction of interaction of hydrogen and oxygen with products of high cleanliness – $SiCl_4$, BCl_3 and etc., with their subsequent joint sedimentation as particles and fusion. Researches of optical characteristics of various quartz glasses under action of radiation have led to to revealing of that fact that optical stability of materials depends on presence in them of hydrogen. Introduction of hydrogen in quartz glass can be carried out by various ways. One of such technical decisions on introduction of hydrogen in glass it was offered the author of article. "Way of reception of a glass steady against influence of radiation". On the given invention the copyright certificate is received.

There are various methods of preparation of preform glass for manufacturing from them optical fiber waveguides; a) a method of external vapour-phase oxidation, b) the modified chemical vapour-phase sedimentation, c) plasma chemical vapour-phase sedimentation, d) vapour-phase axial sedimentation [3] . The way of reception of the preliminary form of a glass for manifacturing an optical fiber waveguides suggested by us is carried out as follows. In an internal cavity of a basic quartz tube (fig.1) submit a gas mix consisting from halogens and oxygalogens ($SiCl_4$, BCl_3, etc.), and necessary amounts of oxygen and hydrogen.

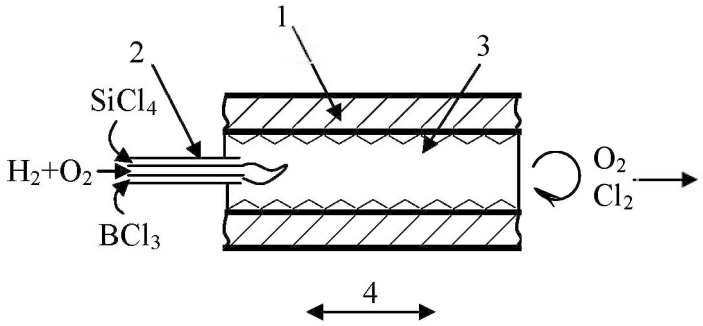

Fig. 1. Scematic illustration the way of reception of the preliminary form a glass; 1 – quartz tube, 2- gas torch, 3- a besieged layer oxides, 4-moving of quartz tube.

Inside a basic quartz tube burning hydrogen in an atmosphere of oxygen is carried out. The basic quartz tube rotates about the axis. Inside along an axis of a tube makes back and forth motion the gas torch creating inside a tube necessary for course of reaction temperature. Under action of the high temperature developed by an oxygen-hydrogen flame, there is a formation oxides to simultaneous their sedimentation on an internal surface of a basic quartz tube. Sedimentation of oxides occurs in a zone of heating. Simultaneously to sedimentation there is a saturation of formed layers hydrogen. After the ending of process of sedimentation of oxides compression of a basic quartz tube with the put layers of oxides in monolithic preform is made. The contents of hydrogen in glass raises its radiating stability nevertheless its quantity in glass should be in the certain limits. It is connected by that at an irradiation of a glass groups –Si-H, Si-O-H are formed, the last cause fluctuations not only in the range of 2.7 μm, but also at 0.95 μm and 0.72 μm corresponding to the second and third overtones of fluctuations OH-groups. Absorption answering to fluctuations of OH-groups influence on optical losses of a glass. So concentration of water only in 8.3×10^{-5} % in fusion SiO2 raises losses on 1 db/km in a maximum of absorption OH-ions at λ=942 nm [4].

On fig.2 dependence value of attenuation of a signal on concentration OH groups in a material is submitted.

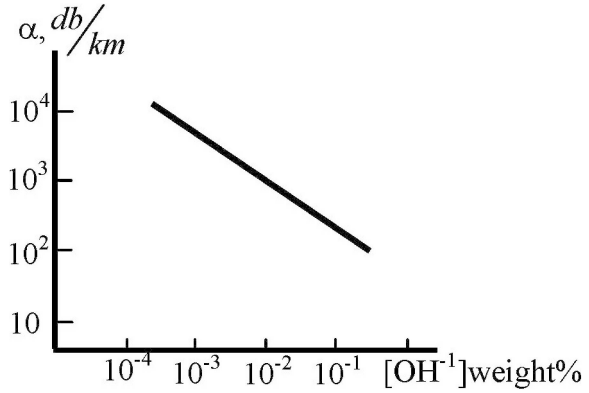

Fig.2. Dependence of attenuation of a signal (at λ=630 nm) on concentration OH groups in a glass fiber optical waveguide

A source radiations γ(^{60}Co). Dependence of a signal on concentration OH groups in a material is a given in weights of %. A dose of an irradiation 10^5 rad, capasity of a dose 330 rad/sec. Measurements are carried out in 1 hour after an irradiation for the fixed length of a wave 630 nm. As follows from the submitted data decrease in attenuation with growth OH groups in a material is observed.

Increase of radiating optical stability v-SiO2 due to hydrogen at its moderate concentration in a matrix of a glass can be explained by two possible reasons[5];

1.Modification of structure of element-oxygen unit with nonbridging oxygen ions being potential hole traps,

$$[MO]^{-}...M^{+} \rightarrow [MO]^{-}...H^{+}, \text{ where M-Li,Na,K,...}$$

The center $[MO]^{-}...H^{+}$ as against $[MO]^{-}...M^{+}$ are not painting.
2. Pue to bloking E'-defects OH-groups decreases absorption in a visible range of a spectrum brought by long-wave wings of stripe of the E'-center.

Optical glass fiber waveguide consist of a core and an environment. The core of waveguide is produced from a glass and an environment can be glass, or it can be metallized or have a polymeric covering. For the control of a radiating zone of a nuclear reactor over high activity of radiation waveguide with a polymeric environment it will be hardly appicable in view of their low radiating stability. Except for that the polymeric covering will not sustain the required temperature annealing an waveguide at its reuse. The limited application will be found with waveguide with a metallized surface.

2. REFERENCES

1. Pearson A.D.,French W.G. Bell.Labs.Rec.,1972,V.50,p.103.
2. Friebele E.J. Optical fiber waveguides in radiation environments.-"Optical Engineering", 1979,V.18,N6,p.552-561.
3. Dj.B.Makchesni. Materialy i prosessy dly izgotovleniya zagotovok metodami modifizirovannogo khimicheskogo parofaznogo osajdeniya i plazmennogo khimicheskogo parofaznogo osajdeniya.TIIER. T.68,N10,1980,s15-18.
4. X.G.Unger.Planarniye i volokonniye opticheskiye volnovodi.Izd.Mir.Moskva,1980,s.578
5. E.K.Mamedov, V.A.Tuylnin. Primesniye defecty v stekloobraznom kremnezeme, ikh vliyaniye na radiazionno-opticheskiye ustoychivost s-SiO2. Dep.rukop. D 06279 Moskva, 1984 god, Referat opubl. v " TTE", seriya T, vip.25, 1984.