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FORMATION OF A DIELECTRIC MATERIAL DERIVED FROM OXIDIZED POROUS SILICON AND TITANIUM OXIDE FOR INTEGRATED OPTICAL WAVEGUIDES

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Feasibility is demonstrated for obtaining a dielectric material derived from oxidized porous silicon and titanium oxide by depositing the latter onto porous silicon using a sol-gel method followed by high-temperature oxidation. The resulting dielectric material has an enhanced refractive index, making it promising for creating low-loss integrated optical channel waveguides in bulk microassemblies of electronic circuits with optical interconnects.

Keywords: *porous silicon, silicon oxide, titanium oxide, sol-gel method, thermal oxidation, refractive index, optical waveguide.*

Introduction. Unprecedented high demands are now being placed on the transmission capacity of data treatment devices and fast-action communication channels for the widespread introduction of fifth- and sixth-generation mobile telecommunication networks and autonomous systems. One solution to this problem is the creation of complex electronic devices, in which the integrated circuit dice are installed into a 3D construction known as a microassembly. In order to prepare microassemblies, we use connected interposer wafers with metallized through holes and silicon interconnect substrates with metal connections. According to estimates, the further development of 3D microassemblies unavoidably will require replacement of the metal connections in the microassemblies by optical connections, which will involve the development of technological approaches to the formation of integrated optical waveguides [1, 2].

Several types of integrated optical waveguides have now been developed derived from films of silicon, silicon nitride, and aluminum oxide formed on the surface of silicon substrates. Such waveguides have found use in optoelectronics schemes and integrated photonics devices but their use for optical connections in 3D microassemblies has encountered some difficulties. Thus, for such use, the waveguides must be embedded into the silicon interconnect substrates and allow the injection of LED light and its subsequent exit to photodectors through a hole in the interposer wafer. In waveguides derived from the above-mentioned materials, this problem can be solved only using special microprisms or diffraction gratings, which significantly complicates the construction and preparation of the micro-assemblies.

In previous work [3, 4], we demonstrated the feasibility of creating a channel waveguide derived from porous silicon (PS) obtained by electrochemical anodization with subsequent thermal oxidation to give oxidized PS (OPS). Channel waveguides derived from OPS consist of a waveguide layer and barrier layer with different refractive indices. The waveguide layer should have a refractive index higher than for the barrier layer so that the starting PS layers are formed with different porosity: 55–60% for the waveguide layer and 55–60% for the barrier layer. The OPS waveguide layer after high-temperature oxidation has a refractive index of 1.445–1.558, while the barrier layer has a refractive index of 1.380–1.400 in the visible wavelength range at 500–550 nm.

OPS channel waveguides hold special interest for use in chip microassemblies with optical connections due to a characteristic set of properties not found for any other known analogs. Firstly, such waveguides are embedded in silicon substrates, which permits retention of the substrate planarity and provides for a facile connection with the interposer wafers. Secondly, OPS channel waveguides function in a broad spectral range from the visible to the near-infrared. Finally, their

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