(Invited)

Planar waveguide devices on an Si-compatible technology platform

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Research and development in the field of integrated optics devices for communication application and sensing purposes has been extremely speeded up over the last decade [1]. The main motivation beyond this development arises from the rapidly increased need of today's information society for fast data transfer. In principle, the integrated optics devices can be realized in various materials systems and technologies, e.g. $LiNbO_3$, doped silica, III-V materials, polymers, silicon oxynitride, etc. For each of them advantages and drawbacks can be pointed out. For the majority of our integrated optics devices, an Si-compatible technology platform is applied. Mostly, a silicon oxynitride (SiON) waveguide forms the basic building block [2]. This material is highly attractive for integrated optics due to the following properties:

- Large refractive index range (1.45 for SiO_2 up to 2.01 for Si_3N_4 or 3.5 for silicon) allowing for low- and high contrast application
- Low optical loss (< 0.2 dB/cm for visible light, for 3rd telecommunication window losses increased due to N-H and Si-H overtones, however losses are decreased to below 0.2 dB/cm by annealing, Fig. 1)
- High uniformity, homogeneity and reproducibility of layer thickness (within 1%) and refractive index (better than 0.05%)
- Access to reliable technology (PECVD, LPCVD, RIE, etc.) for fabrication of various waveguiding structures, Fig. 2 and 3

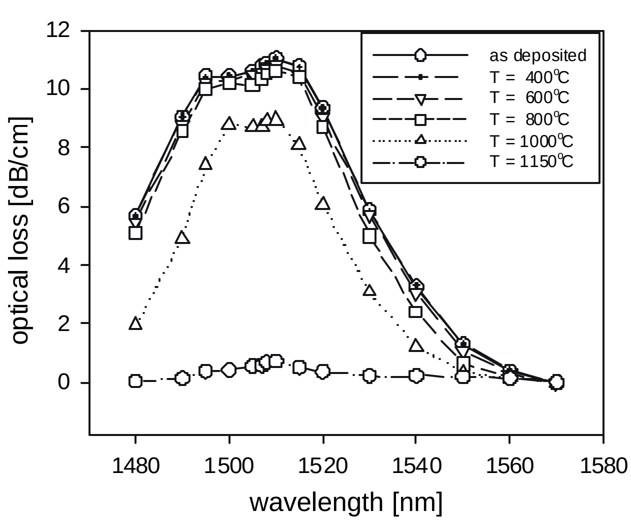

Figure 1: Optical loss of PECVD grown silicon oxynitride with n ~ 1.53 upon heat treatment at various temperatures

The major drawback of silicon-based technology is given by the lack of active functionality. Nevertheless, this drawback can be overcome when combining the SiON-based waveguide platform with materials yielding special properties. In recent research, this hybrid approach has been successfully applied, e.g.:

- Er doped Al_2O_3 and Y_2O_3 [3], allowing for light generation in the 3rd telecommunication window
- Polymers [4], exploiting the high thermo-optic coefficient of this material
- ZnO [5], implementing electro-optic activity at desired positions of the integrated optics circuit

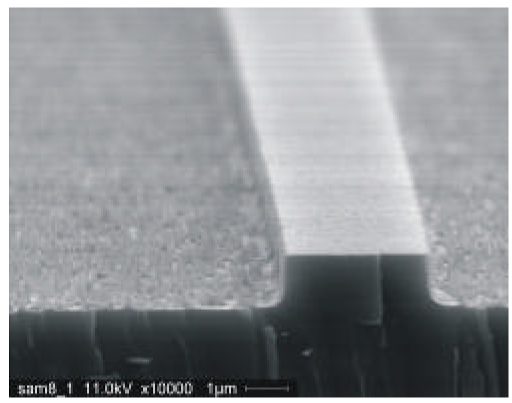

Figure 2: SEM micrograph of waveguide channel in SiON technology for WDM application, channel definition by standard lithography and reactive ion etching

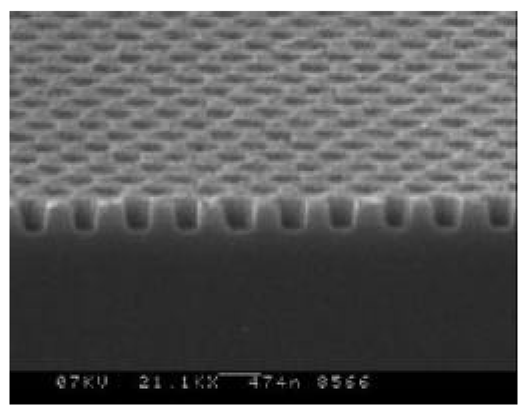

Figure 3: SEM micrograph of lattice of holes in silicon for photonic bandgap application, pattern definition by laser interference lithography and reactive ion etching

References

[1] L. Eldada, *Opt. Eng.*, **40** (7), 1165 (2001).

[2] K. Wörhoff, L.T.H. Hilderink, A. Driessen and P.V. Lambeck, in, *Silicon nitride and silicon dioxide thin insulating films*, K.B. Sundaram, M.J. Deen, D. Landheer, W.D. Brown, D. Misra, R.E. Sah, ECS Proc. Vol. 2001-7, 191 (2001).

[3] S. Musa, H.J. van Weerden, T.H. Yau and P.V. Lambeck, *IEEE J. Quant. Electr.*, **63**, 1089 (2000).

[4] A. Driessen, H.J.W.M. Hoekstra, F. Horst, G.J.M. Krijnen, B.J. Offrein, J.B.P. van Schoot, P.V. Lambeck and Th.J.A. Popma, *IEE Proc. Optoelectron*., **145**, 227 (1998).

[5] R.G. Heideman and P.V. Lambeck, *Sensors and Actuators B*, **61**, 100 (1999).