Properties of annealed silicon oxynitride layers for optical applications

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Silicon oxynitride (SiON) is an amorphous material, which is highly transparent over a wide wavelength range. The most commonly applied fabrication processes for this material, such as Plasma Enhanced Chemical Vapor Deposition (PECVD) and Low Pressure Chemical Vapor Deposition (LPCVD) have, besides being low-cost, the potential for reliably depositing SiON thin films with excellent thickness uniformity (< 1%) and refractive index homogeneity (~ 10^{-4}) [1], [2], [3]. Therefore, SiON became a highly attractive material for a broad range of integrated optics devices. In order to optimize the properties of silicon oxynitride thin films for the highly demanding integrated optical waveguide applications, the research effort in this field has been significantly increased over the last years. Next to improvements in uniformity, reproducibility and reliability, the optical loss, which occurs in the third telecommunication window, has been studied and decreased. The optical loss in this wavelength range is due to vibrational overtones of Si-H and N-H bonds, which are inherently to the fabrication processes, incorporated in the as-deposited layers. The exact amount of the Si-H and N-H, which depends mainly on the composition of the silicon oxynitride material, determines the optical loss quantity around 1510 nm wavelength (Figure 1). Due to the tail of the loss peak, the optical loss in the third telecommunication window (λ > 1530 nm) becomes unacceptably high. Applying thermal treatment, the hydrogen bonds can be broken and the optical loss can be decreased to acceptable values (< 0.2 dB/cm). In this paper we will study the anneal behavior of optical SiON waveguides with various compositions. Next to the effect of the thermal treatment on the hydrogen bonds and the optical loss, the impact on important waveguide parameters, such as refractive index, layer thickness and material birefringence will be discussed.

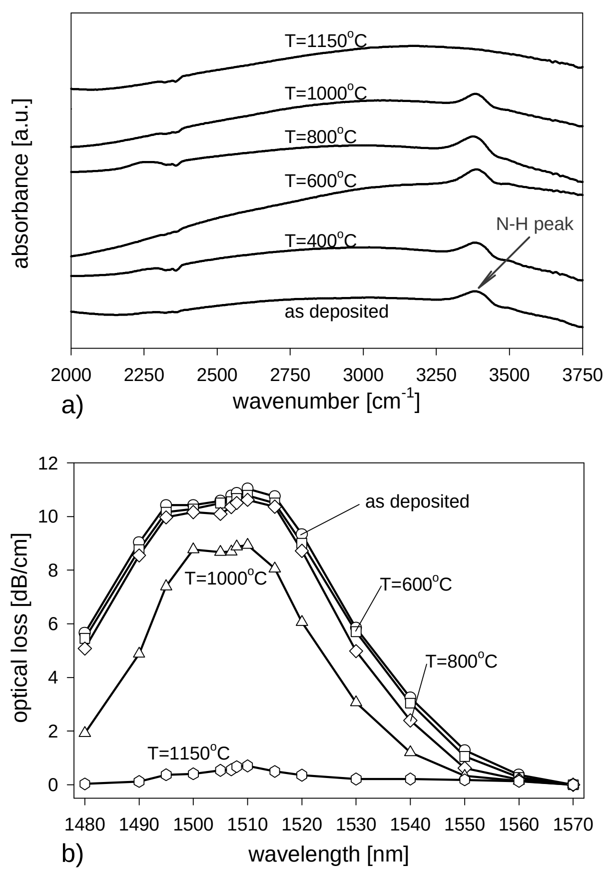

Figure 1: Properties of annealed PECVD silicon oxynitride (n ~ 1.53): IR absorption spectrum (a) and optical loss (b)

References

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