Ge-Sb-S-Se-Te amorphous chalcogenide thin films for nonlinear optics in the Mid-Infrared

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Abstract

Chalcogenide materials exhibit a unique portfolio of properties which has led to their wide use for non-volatile memory applications such as optical data storage or more recently Phase-Change Random Access Memory. Some chalcogenide glasses (CGs) are showing a high transparency window in the infrared range and large optical nonlinearities offering also opportunities for elaboration of innovative mid-infrared (MIR) components such as MIR supercontinuum (SC) sources. Up to now, state-of-the-art MIR SC sources have been mainly demonstrated with CGs containing Arsenic. However, the REACH European recommendation and the World Health Organization have both identified Arsenic as one of the ten most harmful chemicals for human health. In that context, we study here the linear and nonlinear optical properties of As-free amorphous chalcogenide thin films with a particular emphasis on their compatibility with CMOS technologies for future realization of on-chip MIR components. Magnetron co-sputtering of chalcogenide compounds targets in an industrial 200 mm deposition tool allowed us to tailor the composition of the amorphous GeSbwSxSeyTez films aiming at finding the best compromise between good glass stability of S-based chalcogenide and the huge nonlinear refractive index of Te-based compositions. Modeling of spectroscopic ellipsometry measurements on the films allowed to determine their linear optical constants and to approximate their optical band gap energy. Optical attenuation at 1548 nm was obtained using M-line technique. FTIR and Raman allowed to get information on the amorphous structure of the films. Advanced optical characterizations of nonlinearities in rib and ridge waveguides with a tailored group velocity dispersion were performed and compared to the nonlinear refractive Kerr index of each CGs calculated by means of analytical and

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empirical models. Finally, the origin of the enhanced optical nonlinearities observed in some of the amorphous GeSbwSxSeyTez chalcogenide compositions will be probed by means of ab initio simulations.

Keywords: Chalcogenide Glasses, Nonlinear Optics, Physical Vapor Deposition, SuperContinuum Generation, Mid InfraRed