Geometry-Dependent Two-Photon Absorption in AlGaAs Waveguides

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Aluminium gallium arsenide (AlGaAs) is an established material platform for photonic integrated circuits. In particular, AlGaAs waveguides have been used to generate new frequency components through the nonlinear optical processes of sum- and difference-frequency generation, second-harmonic generation, frequency comb generation, and four-wave mixing. However, the efficiency of such processes may be limited by nonlinear losses as the power of the input pump laser gets higher. A proper characterization of a photonic device's nonlinear absorption is imperative to understand its limits. Nonlinear absorption can also be of interest for optical limiting or optical switching applications. Besides the material nonlinear optical property, the cross-sectional geometry of the waveguides plays an essential role in the strength of the nonlinear interaction, as the irradiance is inversely proportional to the effective mode area. In this work, the nonlinear transmittance technique was used to measure the two-photon absorption coefficients (figure 1) and free-carrier absorption cross-sections of AlGaAs waveguides in the nanowire, strip-loaded, and half-core geometries in the wavelength range from 1480 to 1560 nm. The output power is measured as a function of the input power of a 3 ps pulsed beam at the repetition rate of 76.6 MHz. The data are fitted by a model that describes a two-photon absorption followed by a free-carrier absorption mechanism. We discuss how the irradiance distribution in the different heterostructure layers can contribute to geometry-dependent two-photon absorption coefficients and examine the results in terms of the third-order nonlinear confinement factor.

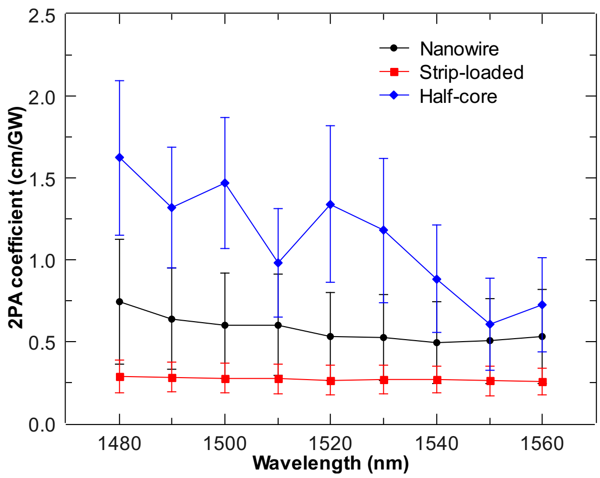

Figure 1: Two-photon absorption coefficient spectra for 2-μm-wide waveguides in each geometry