Self pulsation behavior of a ring resonator based on nonlinear plasmonic waveguides

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In the last years, nonlinear plasmonic waveguides have been intensively investigated both numerically and theoretically mainly due to the high confinement degree of the propagating electromagnetic field as well as their interesting modal properties. Numerically it has been shown by Davoyan et al. that MDM waveguides presenting Kerr nonlinearity possess symmetry breaking bifurcation points leading to a power dependent complex modal structure [1, 2]. Also, in the case of small Kerr nonlinearities, the dispersion of MDM waveguides has been determined to quadratures for cases when the fundamental mode is symmetric and antisymmetric, respectively [3]. It has also been shown numerically, that the modification of the modal structure will lead to the power switching in nonlinear directional couplers [4].

Here we demonstrate theoretically and numerically, using FDTD algorithm, the possibility to employ plasmonic nonlinear waveguides for microring resonators, systems which exhibits self – pulsation behavior. Essentially, the system consists in a nonlinear MDM waveguide with geometric and material parameters chosen such that for wavelengths below 500 nm, this waveguide presents an antisymmetric, backward propagating slow mode. The nature of the slow modes character of this waveguide is structural [6] such that an enhancement of nonlinearities occurs, and high phase sensitivity can be attained for lower values of electromagnetic fields. This waveguide is coupled counter – directionally with a feedback loop consisting in an MDM waveguide supporting symmetric fast modes as it is shown in Fig 1.

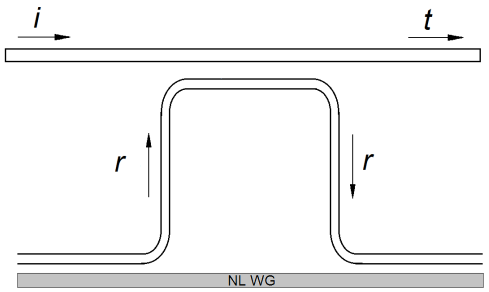

Fig. 1 The schematic diagram of a the proposed plasmonic microring resonator showing self-pulsation.

We have investigated the temporal behavior of the field in these systems for various geometrical and material parameters, and we show that the self – pulsating behavior can be attained for low values of the electromagnetic fields. The time scale of the pulses generated by the investigated self-pulsating microring resonators are of the order of hundreds of femtoseconds. Moreover, due to the fact that the plasmonic waveguides operating in the slow mode regime present a high sensitivity of the group velocity with respect to the wavelength, a broad tunability of these can be achieved. The self-pulsating systems presented in this work can have applications in sub-picoseconds optical clocks [7].

References

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