Plasmon-polariton propagation in metallic nano-chains for subdiffraction circuits

W. A. Jacak

Institute of Physics, Wroclaw University of Technology,
Wyb. Wyspianskiego 27, 50-370 Wroclaw, Poland
witold.aleksander.jacak@pwr.wroc.pl

Hybridized states of surface plasmons on metal-dielectric interface with photons result in plasmon-polaritons [1, 2], which are of high interest for applications in photonics and microelectronics [1, 3], in particular, for subdiffraction transportation of converted light energy and information in metallic modified structures in nano-scale [2, 4, 5], for sensors, plasmonic antennas, in electrochemistry, plasmon microscopy, plasmon litography and others. The formation of plasmon-polariton consists in reducing the wave-length of corresponding mode, due to lower group velocity in comparison to light velocity, and related concentration of the e-m field along the interface. The remarkable property is that the ideal surface plasmon-polaritons have ca. 10 times lower wave-length, thus larger momentum in comparison to photons with the same energy (thus they allow to enhance subdiffraction optics critical solutions, eg. in the area of nano-opto-electronic interfaces). On the other hand, it is impossible to excite plasmon-polaritons by enlightening metal surface, as well as the e-m irradiation of plasmon-polaritons is quenched. Inclusion of additional periodicity by grating or folding of the surface or introducing periodic nanostructure allow, however, matching momentum and energy conservation in interaction of plasmon-polaritons with free photons.

In the present paper collective wave type plasmon-polariton self-modes in the metallic (Au, Ag) nano-chain were determined and analyzed with respect to the nano-sphere size and chain-separation parameters in the framework of a previously developed analytical theory [6]. At some regions for parameters the undamped modes were identified when the interaction had been assumed as the near-field-zone dipole coupling [7]. These modes were found on the rim of stability of the linear theory, which indicates artifact of the model of near-field coupling. Inclusion of the medium- and far-field zone contributions to dipole interaction removes, however, instability and allows for fully analytical demonstration of quenching of irradiation losses of plasmon-polaritons in the chain to the level of only Ohmic attenuation (the metallic nano-chain behaves thus like an ideal wave-guide for plasmon-polaritons suitable for arrangement of subdiffraction circuits). The plasmon-polariton dispersion and the group velocity of plasmon-polariton wave packets were examined with respect to nano-sphere and chain parameters and mode polarization. Previous numerical results [8] related to long range plasmon-polariton propagation in the chain were transparently reinterpreted within the analytical approach.

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