Plasmon Modes on Laminated Nanomembrane-based Waveguides

Slobodan M. Vuković[1], **Zoran Jakšić**[2,*] Katarina Radulović[2] and Jovan Matović[3]

[1]*Institute of Physics,University of Belgrade, Zemun, Serbia*
[2] *Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Belgrade, Serbia,*
[3] *Institute for Sensor and Actuator Systems (ISAS), Vienna University of Technology, Vienna, Austria*
[*] *jaksa@nanosys.ihtm.bg.ac.rs*

We studied the propagation of electromagnetic Bloch modes along planar multilayer metal-dielectric structures with finite number of layers. Our investigated platforms were symmetric self-supported freestanding sheets with nanometer-scale thickness – the nanomembranes, presented in Fig. 1. We determined analytically the dispersion relation for the investigated structures [1, 2] and applied the finite element method to determine the field distribution. Experimentally, our nanomembranes were fabricated utilizing radiofrequent sputtering on sacrificial silicon substrates. We have found additional surface-bound TE-polarized modes on nanomembranes, besides the conventional TM-polarized modes. Our analysis shows that there are N such TE-polarized modes in total, where N is the number of metal strata within the laminated structure; all of them appear within the light cone. In contrast, there are $2N$ modes that are TM-polarized and that are divided in two branches: N in the upper and N in the lower branch (see Fig. 2). An important observation is that negative group velocity (left-handed modes) appears among the TM-modes in the upper branch that cross the light line, and thus make it possible to excite those modes directly by the incident light. However, only the lowest TM-mode from the upper branch (the one with the least losses) cross the edge of the Brillouin zone and later-on coalesce with the highest mode of the lower branch (yellow lines in Fig. 2), revealing the dispersion of a surface plasmon polariton on a single metal-dielectric interface. It is worth noting that zero group velocity (i.e. standing light) appears for both TE- and TM-polarized modes (upper branch) for k=0. Such slow and spatially compact states of light are termed Tamm plasmon polaritons [3].

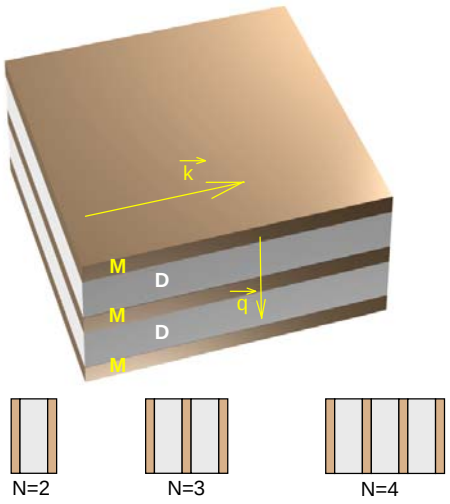

Fig. 1. Geometry of the multilayer structure; M stands for a metal layer, D for a dielectric one. N denotes the number of metal strata.

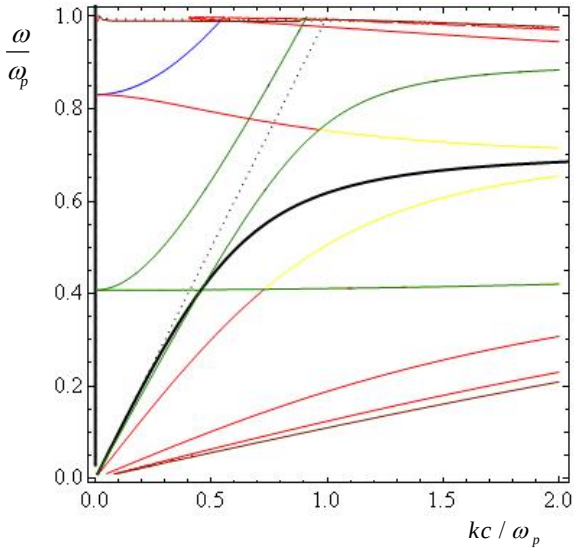

Fig. 2. Dispersion of guided modes for N=3, TE-(blue) and TM-polarized (red) guided modes. Green and brown lines represent the edges of Brillouin zones. Two yellow lines are surface wave type modes that coalesce into a surface wave on a single boundary (black line) for higher values of k. Dotted straight segment is the light line

[1] S. M. Vuković, I. V. Shadrivov and Y. S. Kivshar, *Appl. Phys. Lett.* **95**, 041902 (2009)
[2] J. Matović and Z. Jakšić, *Microel. Eng.*, **86**, 906 (2009).
[3] M. E. Sasin, R. P. Seisyan, M. A. Kalitteevski, S. Brand, R. A. Abram, J. M. Chamberlain, A. Yu. Egorov, A. P. Vasil'ev, V. S. Mikhrin and A. V. Kavokin, *Appl. Phys. Lett.* **92,** 251112 (2008).