Manuscript ID: 237543
old title:
"Long-range photonic crystal surface waves designed for semiconductor light-emitting devices"

new title:
"Long-range surface plasmon amplification with current injection on a one-dimensional photonic crystal surface"
by V.N. Konopsky

Response on the reviewers' comments:

The author is thankful to all reviewers for the second review of my manuscript. I have made changes and additions in the revised version of the manuscript in accordance with some of their recommendations and provide responses on all reviewers' comments below.

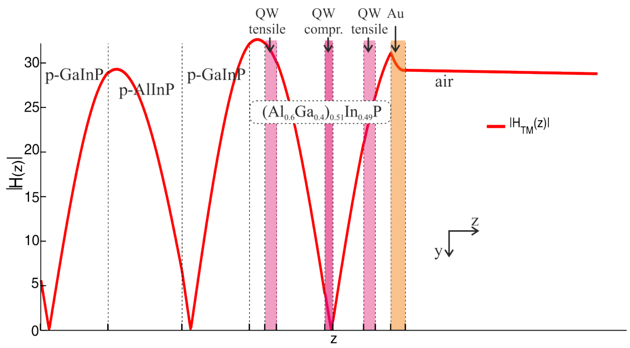
Reviewer 1:

"As for my previous comments, I have one question still unclear:
(1) In Fig.2, the $|Enor(z)|$ be enhanced abruptly to a value of 30 at the Au/air interface is easy to understand as an SP enhancement, while for everywhere in the structure, it is strange to find that the $|E|$ is always below 8, much less than the pure SP enhancement value of 30. For a spaser, the field in the active region should be amplified to a considerable amount. Could the authors give some explainations please?"[1]

The explanation is very simple: air has RI $n = 1$, while semiconductor layers have RI $n \sim 3.5$. The ratio 30/8 gives approximately the same value. And it seems to me that I catch on a Reviewer's expecting: probably (s)he is accustomed to see a figure where spatial distribution of **magnetic** field of SP is presented. In this case, indeed, the field values at both sides of the metal film will be comparable. The reason is also very simple: $\mu \equiv 1$ for any materials at optical frequencies (forget about *meta-*, pls). To put this another way, through equations (see, e.g., my article [19] in NJP):

$$Z_p = \frac{E_y}{H_x} = \frac{\cos(\theta)}{n} \qquad \text{(for TM wave)} \qquad (3).$$

The magnetic field distribution in the same system is presented below for Reviewer's satisfaction:



But in my article I presented electric field distributions because it is important to point that two type of QWs (with two types of polarization) may be used in the proposed structure.

[1] hereinafter quotations from reviewers' comments will be done in *slanted* type.

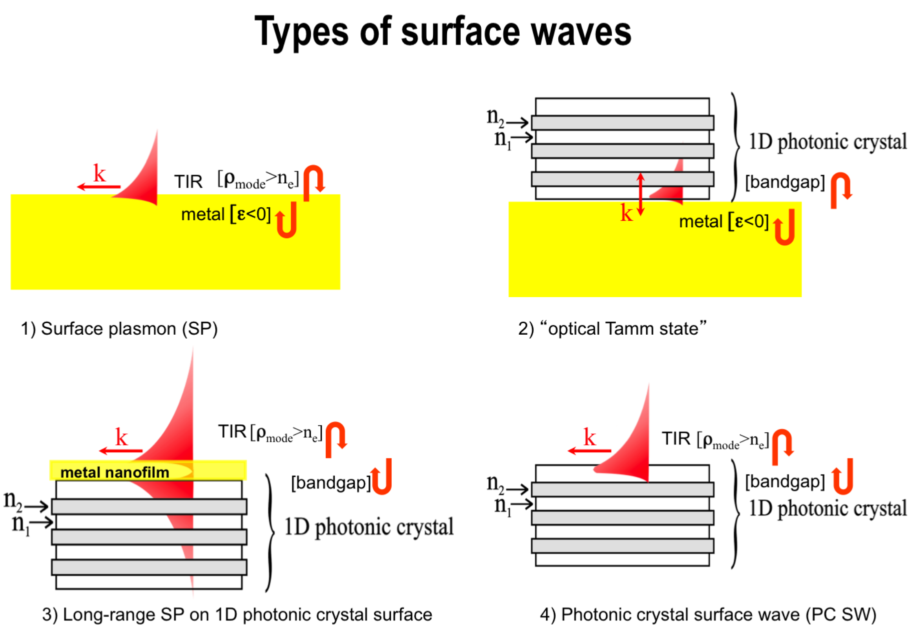
Reviewer 2:

"I still think this is a TAMM state. TAMM state does not have to have k-in-plane equals to zero. Since the dispersion of TAMM state is parabolic, your manuscript focus on the region that the TAMM state intersects with the free-space light line. Your structure was explicitly considered in Fig. 1b in M. Kaliteevski, I. Iorsh, S. Brand, R. A. Abram, J. M. Chamberlain, A. V. Kavokin, and I. A. Shelykh, "Tamm plasmon-polaritons: Possible electromagnetic states at the interface of a metal and a dielectric Bragg mirror," Physical Review B, vol. 76, p. 165415, 2007."

No, the "optical Tamm state" and my ultra-long range surface plasmons on 1D PC are different kinds of waves and even physical foundations for their localization near an interface are different. I am grateful to Reviewer 2 for providing a ref.[Physical Review B, vol. 76, p. 165415, 2007] because on the first page (165415-1, 1st paragraph in the 2nd column) the authors wrote:

"As in the case of a conventional plasmon-polariton, the confinement in the metal is achieved as a result of its negative dielectric constant, but the confinement in the dielectric multilayer structure is due, *not to total internal reflection*, but rather to a photonic stop band of the Bragg mirror."

This is exactly the same point that I wrote in my previous answer: "Total internal reflection (TIR) is not used in the "optical Tamm state" for localization of the wave near the surface" (while all other SWs use TIR) — and this is the reason why "optical Tamm state" may be excited at normal incident with k near zero. Also, in the illustration presented in my previous reply, I pointed the physical foundations for localization of different SWs near their interfaces (look at curved red arrows at both sides of interfaces):



One can see that "optical Tamm states" differ from all other SWs (no TIR!).

In Fig. 1b Kaliteevski et al. present 30 nm gold film on 1D PC. Nevertheless, a difference with my 11 nm gold film is important. As the authors wrote (165415-3, last paragraph in the 1st column): **"It should be noted that the electromagnetic field of the TP decays much faster in the metal than in the Bragg reflector; the penetration depth in the gold is $c/\omega_p \simeq 20$ nm,"** i.e., their 30 nm gold film plays the role of a metal reflector again and it is used for localization of the optical field between the metal film and the 1D PC (and this localization occurs even at normal incident). While in my case, the main part of optical field is localized in air, beyond the metal nanofilm, and it is TIR that is used for the optical confinement.

In the response on this comment I insert the provided ref.[Physical Review B, vol. 76, p. 165415, 2007] in the revised version of the article (now it is ref.[18]) and rewrite the last paragraph in the 1st column on page 2 in the next edition:

"The confinement of optical field (for the PC SWs in question) is the result of a photonic band gap from one side and total internal reflection (TIR) from another side of an interface. Note that PC SWs, which do not use TIR, fall into another category of so-called "optical Tamm states", where the confinement of optical field near an interface between a 1D PC and a semi-infinite metal (or a metal film with a thickness larger than the penetration depth in the metal) is achieved as a result of the photonic band gap from one side and negative dielectric constant of the metal from another side [18]. A strong intrinsic damping in the metal is unavoidable for the "optical Tamm states", while for the PC SWs in the presented structure it is considerably reduced."[2]

Reviewer 3:
"This manuscript (ID: 237543) is a revised version of an old manuscript (ID: 233951). The author has addressed a number of comments pointed out the reviewers. Therefore, the manuscript could be accepted for publication in Optics Letters. However, the words "photonic crystal surface waves" in the title is misleading. I suggest the author to replace the title with a more accurate description, like "Long-range surface plasmon amplification with current injection on a one-dimensional photonic crystal surface."

I accept this recommendation of Reviewer 3.
The title of the manuscript is changed to the proposed one.

Reviewer 4:
"The author proposes a design for electrically-pumped light-emitting devices based on long range surface waves coupled to semiconductor quantum wells. The surface mode of interest has an effective index very close to one, as well as a large propagation constant. The combined attributes of low reflection loss and low Ohmic damping make the long range mode attractive for use in low power LEDs and lasers.

[2] quotations from the revised manuscript will be done in sans serif type.