ナノコラムレクテナに向けた電磁界シミュレーション

Electromagnetic simulation for nanocolumn rectennas

上智理工 (M1)ゴサイン　シュバム，プルクティチャイパット　ヨッワルット，中岡俊裕

Sophia Univ. , Shubham Gosain, Yodarit Prukthichaipat, Toshihiro Nakaoka

E-mail: b1778501@eagle.sophia.ac.jp

Optical rectennas are an attractive technology for potential high-efficiency, low-cost solar cells. These devices combine submicron antennas with ultra-high speed diodes to rectify incident radiation. The efficiency could be enhanced by collective antenna coupling [1]; however good platform for the submicron antenna array has not been proposed yet. In this paper, we propose a nanocolumn rectenna that has a metal-coated, highly ordered GaN nanopillars, called nanocolumn [2], with MIM diodes as a potential platform of integrated optical antennas. One schematic example is depicted in Figure 1. Our electromagnetic simulation shows the antenna resonances at near infrared wavelengths.

We used a commercial finite element solver (COMSOL Multiphysics) to perform the simulations. In the model, the GaN nanocolumn has a diameter of 50 nm and a length of 500 nm. It has a gold layer that is 20 nm thick as depicted in Figure 2. The scattering cross section is calculated by the integrating the Poynting vector over the inner sphere's surface and dividing it by the energy flux that is incident.

Figure 3 shows the scattering cross section of the structure when light is shined at 30 degrees. This angle of excitation is chosen because all the possible resonant peaks can be obtained at this angle. The main peaks are attributed to longitudinal modes (LMs)[3] caused by free electrons oscillating in a direction parallel to a nanocolumn. The first LM peak lies at 1600 nm, and the second LM peak is at 800 nm. These resonant peaks are about 1.6 times redshifted than the prediction of classical antenna theory, which can be attributed to the geometrical effect, surface impedance, skin depth, and contribution from electric field induced in GaN region.

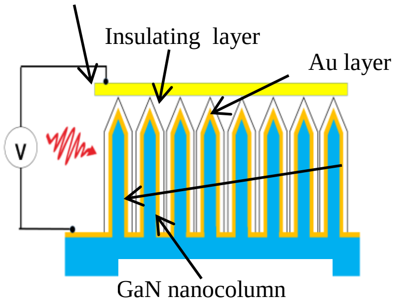

Fig. 1: Schematic of nanocolumn rectenna

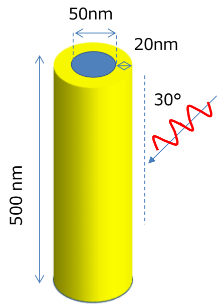

Fig. 2: Structural model for a simulation

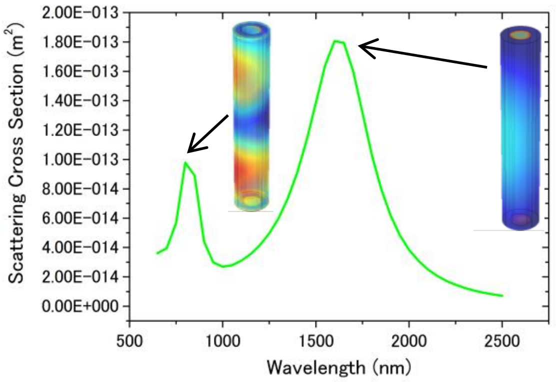

Fig. 3: Scattering cross section and electric fields.

References

[1] A. Sharma, V. Singh, T. L. Bougher, and B. A. Cola, Nature Nanotechnology 10, 1027 (2015).

[2] T. Kano, R. Miyagawa, K. Kishino, J. Yoshida, T. Oto, and Y. Mizuno, Electronics Letters 51, 2125 (2015).

[3] P. Tuersun, Optik - International Journal for Light and Electron Optics 127, 3466 (2016).