DESIGN AND CHARACTERIZATION OF MOEMS OPTICAL TWEEZERS

Rajeev Chaubey, Gaurav Dwivedi, Vaibhav Dwivedi, Nirmala Sagar, Joseph Thomas Andrews

National MEMS Design Center, Department of Applied Physics, Shri G S Institute of Technology & Science, Indore - 452 003 India.

INTRODUCTION

Optics is playing important role in communication and material study. Currently studies on submicron sized particle concentrate more on understanding Physics and Engineering at single particle level for single electron devices. For such studies non-contact diagnostics methods such as Optical Tweezers would be the best option.

PRINCIPLE

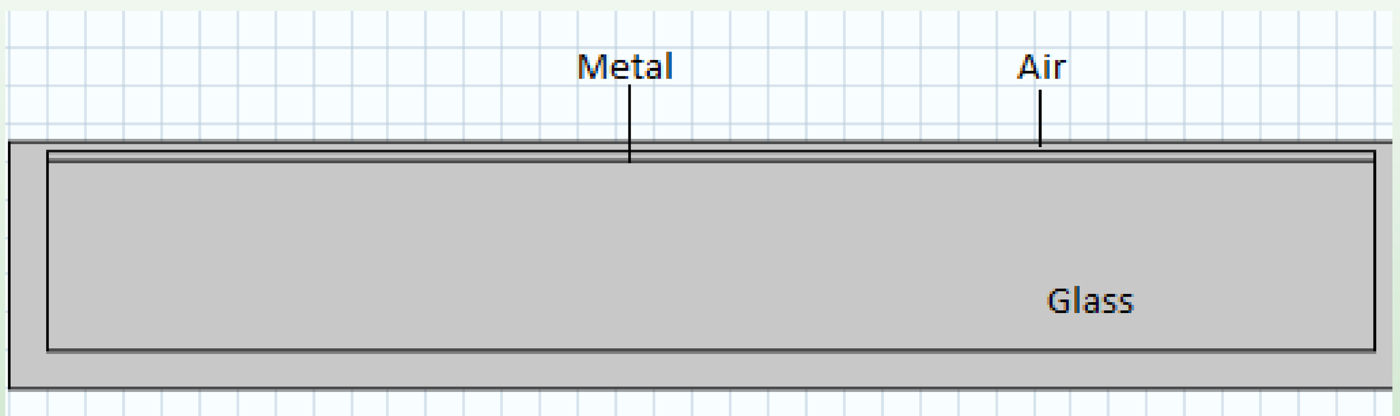
Optical tweezers are based on the gradient and scattering forces, in which gradient force is more critical as compared to scattering force. On the other hand, diffraction limitation constraints focus of the laser beam smaller than the wavelength. In order to over come the diffraction limitation we suggest a novel method.

BASIC IDEA

Since focusing of any optical beam below its wave length is not possible by using simple lenses so we can not simply focus an optical beam and can also not trap a subwavelength particle. For this we have discovereed a new method that is could be possible by using Surface Plasmon Resonance. Since in surface plasmon resonance optical beam is travelling inside the metal dielectric boundary. So we can fetch it at any point and at any dimention without differection limit.

MULTIPHYSICS MODEL

While simulating this model using COMSOL Multiphysics, we have used frequency domain study to evaluate the effect of the particular wavelength on the particle. Also we have determined the power at different points of the geometry.



Simulated Geometry

OPTICAL TWEEZERS

Different types of particles experience different forces. These forces are summarized as follows:

- **Scattering component:** It acts along the direction of propagation of the incident beam. The Scattering force F_S is directly proportional to the intensity of the laser beam (I) as:

$$F_{scatt} = I_0 \frac{\sigma n_m}{c} \tag{1}$$

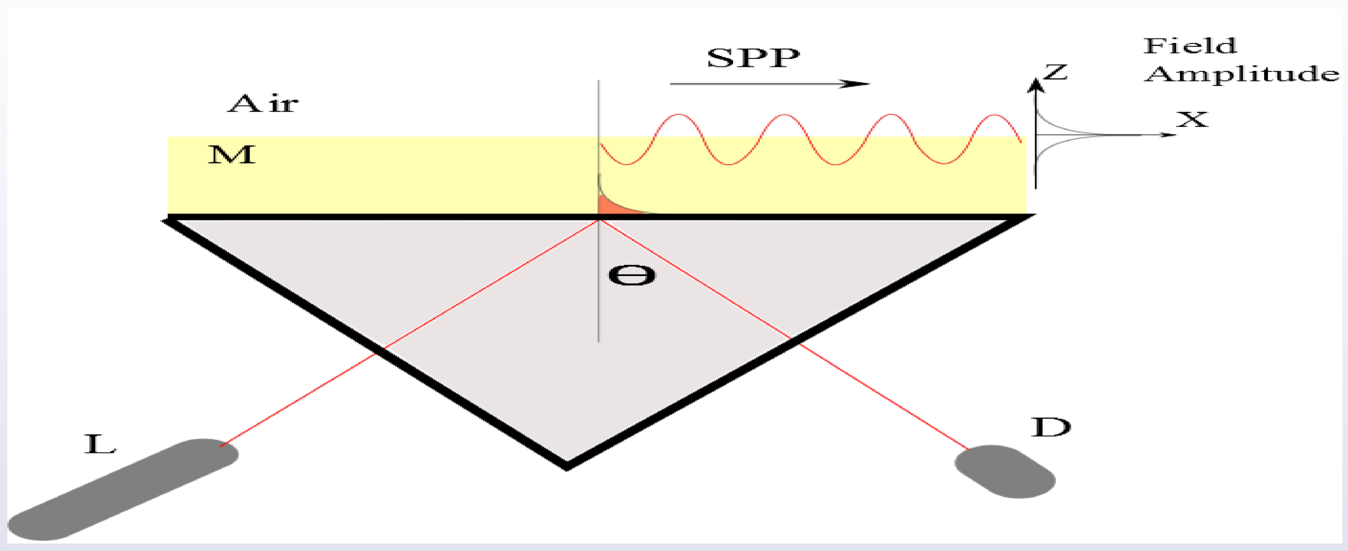
where $\sigma = 128 \frac{\pi^5 a^6}{3\lambda^4} \left(\frac{m^2-1}{m^2+2}\right)^2$

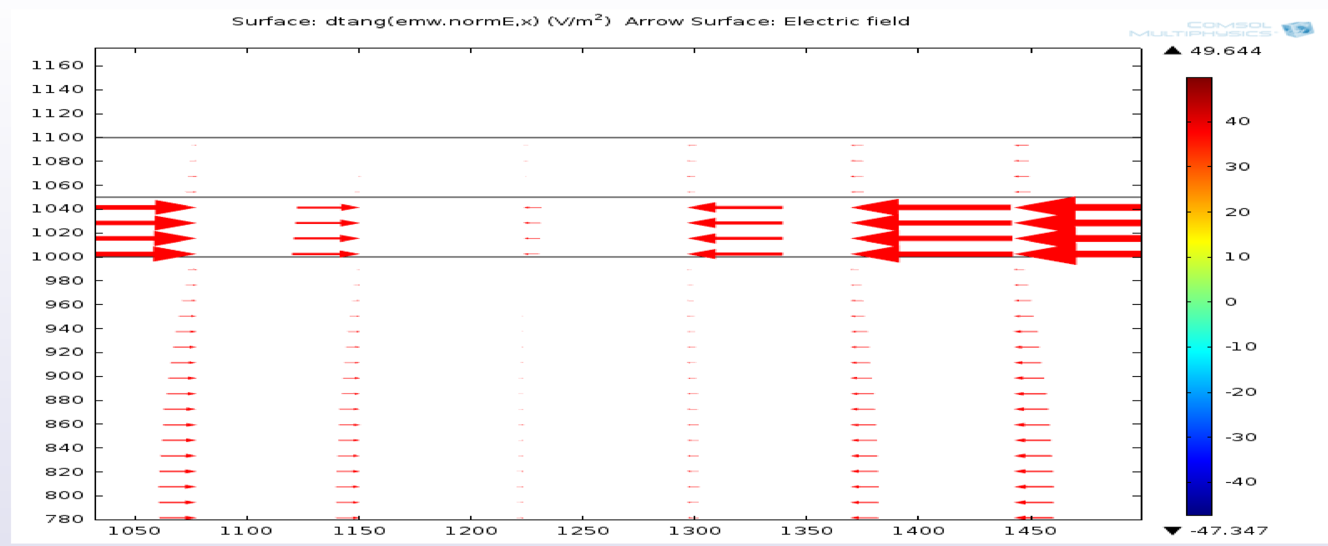
- **Gradient component:** The gradient force arises due to the reaction forces. The gradient force is in the direction of maximum change in laser intensity. Hence its magnitude is perpendicular to the gradient of intensity and is given as:

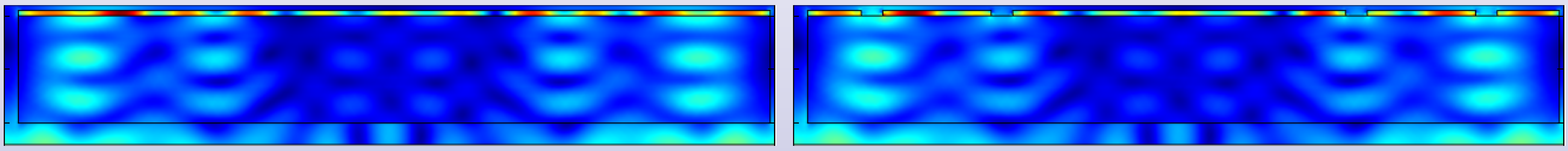
$$F_{grad} = \frac{2\pi\alpha}{c n_m^2 \nabla I_0} \tag{2}$$

Where $\alpha = n_m^2 a^3 \left(\frac{m^2-1}{m^2+2}\right)$

RESULTS







Field components of Electro-magnetic wave

CONCLUSIONS

In conclusion we proposed a novel method for trapping of subwavelength particles using a simple SPR generator, which generates the SPR at metal dielectric boundary and at taht point we made the holes to trap the particle. The simulated results show that we are getting sufficient enough force on the particle so that trapping of the particle is possible. gradient force is opposite in the opposite direction of he particle. So it is possible to study submicron size particles using Surface plasmon as an MEOMS optical tweezers.

REFERENCES

1. T.-J. Wang, C.-W. Tu, and F.-K. Liu, ‘Integrated-Optic Surface Plasmon Resonance Biosensor Using Gold Nanoparticles by Bipolarization Detection’ IEEE J. Sel. Topica in Quan. Electron., 11, 2, (2005).
2. J. C. A. Castro, A. S. C. Beltran, ‘Surface Plasmon Resonance of a Few Particles Linear Arrays’, Journal of Electromagnetic Analysis and Applications, 3, 458-464, 2011.
3. J.R. Martijn, et al. ”Hybrid Silicon Photonic Integrated Circuit Technology” J. Quan. Electron, 19, 223, 2013.

Contact Details

jtandrews@sgsits.ac.in; Fax: +91 731 2432 540; SGSITS, Indore - 452 003

Contact Details

Comsol Conference Bangalore, 2014

International Conference on Comsol, Bangalore, November 13-14, 2014.