Optical Analysis of C36 Fullerene

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***Abstract*:- Fullerene is one of the 0D (zero dimensions) materials of carbon's new family. Fullerene has some great electrical and optical property to overcome current optical silica waveguide in terms of dimensions, optical parameter and technique. In this paper we present fullerene based optical simulation for optical interconnect at communication wavelength 1550 nm and 775nm and take mode analysis of that substrate.**

Key words: C36 fullerene, optical communication wavelength, half communication wavelength, bonding, anti-bonding, fullerene, carbon nano tubes, grapheme sheets.

INTRODUCTION

to match the foot with latest optical technology like low power requirement, less dimensions, tera-hertz modulator we need to fabricate optical waveguide with a new material which should have fast response, low absorption and less scattering losses. The new carbon family is the best option for latest requirement. This new carbon family is available in 0D (fullerene), 1D(Carbon nano tube), 2D(garphene sheet) and in 3D(graphite). As the prime material for the semi-conductor industry, silicon channel have to be fabricated on a large scale up to micro meter in comparison to fullerene based optical waveguide. Due to this reason , fullerene is one of the best option.

Fullerene is actually a zero dimension hexagonal structure of carbon atom in which each carbon atom is co-valet bonded to another three carbon atom, because of this each carbon atom have one free or dirac electron to make electrical or optical conduction so fast. This is the key property of fullerene which is in contrast for optical communication. Graphene is also a single layer of hexagonally packed carbon atoms, was first isolated from graphite via mechanical exfoliation in 2004. For these confined two-dimensional crystal, in plane carbon atoms are connected by strong bond, while adjacent layer only share weak van de waals force.[1]

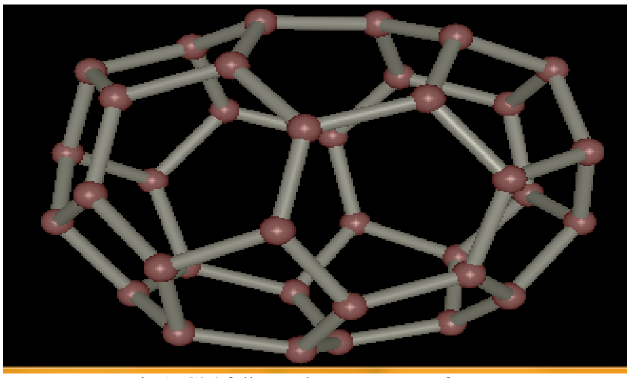

Fig.1. C36 fullerene by NINITHI software.

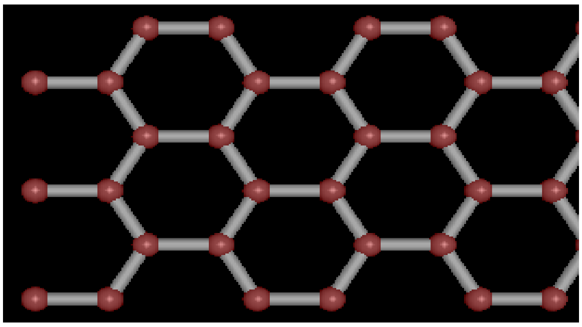

Fig.2. graphene sheet by NINITHI software.

Carbon nano tube is an another design in1D from carbon nano family and we can even work on this material to reduce size, attenuation, scattering losses and many more hidden effects. With the help of carbon new family we can even make hybrid optical waveguide which can propagate electric signal as well as optical signal. We can also make fullerene and silica based optical waveguide with same properties like silica based optical waveguide.

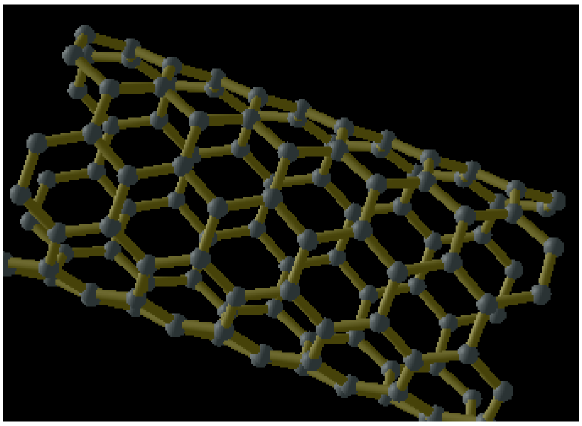

Fig.3. carbon nano tube(SWNT) by NINITHI software.

C36 fullerene based optical simulation:

In this paper we are presenting C36 fullerene based optical waveguide with high optical mode with constant velocity parameter 10^8cm/s^2. We are designing and analysis at different diameter of C36 fullerene and taking out optical mode analysis graphical analysis of that and getting final conclusion from previous analysis at different diameter.

Simulation and mode analysis:

We are simulating C36 fullerene based optical waveguide on COMSOL multi-physics in 2D mode with EWFD (electromagnetic wave, Frequency domain) physics with following equation:

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$$\nabla \times \mu_r^{-1}(\nabla \times \mathbf{E}) - k_0^2(\epsilon_r - \frac{j\sigma}{\omega\epsilon_0})\mathbf{E} = 0$$

$$\lambda = -j\beta - \delta_z$$

$$\mathbf{E}(x,y,z) = \tilde{\mathbf{E}}(x,y)e^{-ik_z z}$$ …….eq.1

We are simulating optical mode analysis with carrier wavelength of 1550 nm and half wavelength of 775 nm at different diameter of 1nm, 10nm, 100nm.

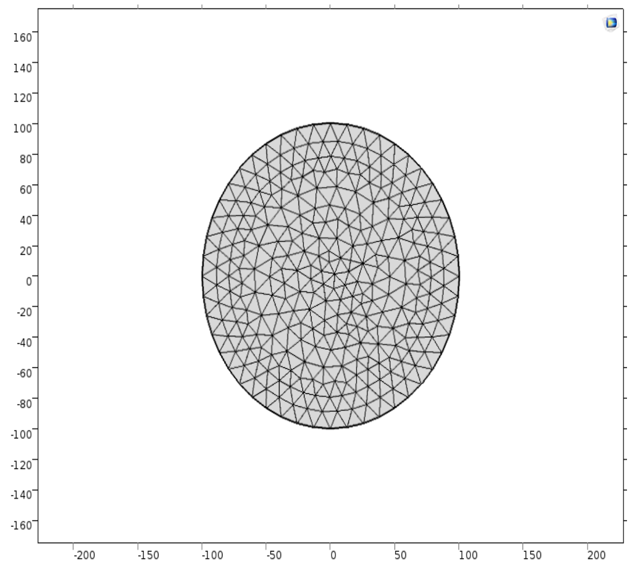

Fig.4. mash analysis of C36 fullerene by COMSOL Multiphysics.

Analysis 1:

In this analysis we are designing at diameter of 1nm with material C36 fullerene. Actually to fabricate optical waveguide at 1nm diameter is practically almost impossible but we are here showing optical electromagnetic field and effective mode index at this scale:

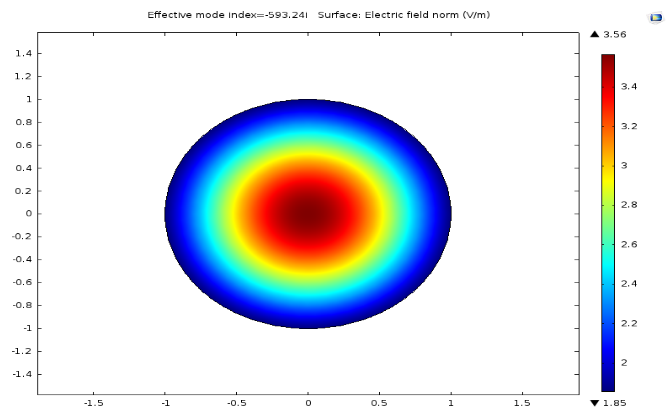

Fig.5: Mode analysis at 1nm diameter.

We conclude that at 1nm with communication wavelength of 1550nm we have effective mode index of -593.24i which is too much large and minimum electric field is 1.85V/m and maximum electric field is 3.56V/m. it has maximum intensity at center and decreasing at outer radius.

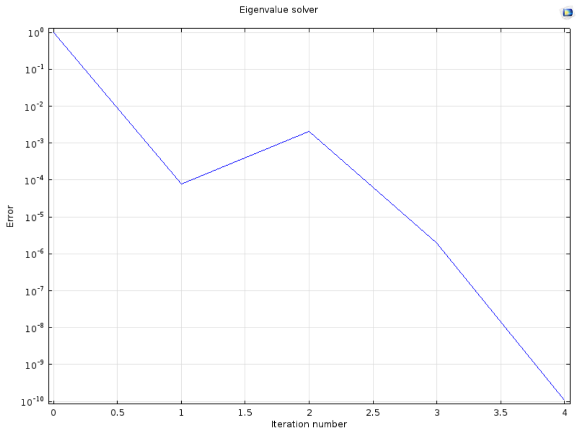

Fig. 6. Error probability at 1nm diameter with 1550 nm.

We also analyze same diameter at half wavelength:

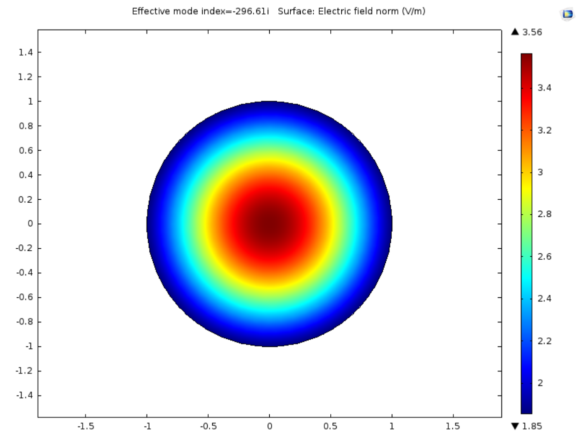

Fig.7: Mode analysis of 1nm fullerene with half wavelength of 755nm.

We conclude that at 1nm with half communication wavelength of 1550nm we have effective mode index of -296.61i which is less than actual communication wavelength operation and minimum electric field is 1.85V/m and maximum electric field is 3.56V/m. it has maximum intensity at center and decreasing at outer radius.

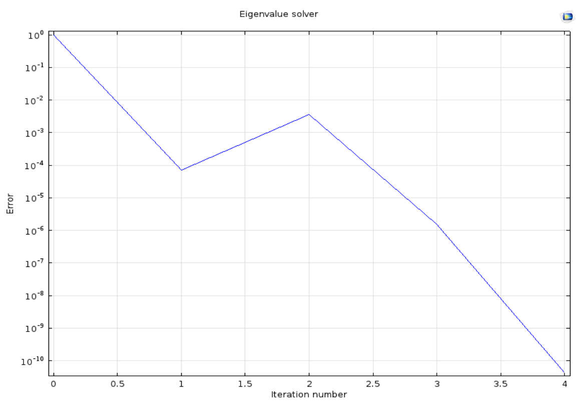

Fig. 8. Error probability at 1nm diameter with 755 nm.

Analysis 2:

In this analysis, we are again analyzing C36 fullerene with different diamantions i.e. 10 nm and after simulation we have some differenent parameter and different mode analysis and effective mode index i.e -59.272i which is 10 times smaller than 1nm simulation with same electromagnetic field.

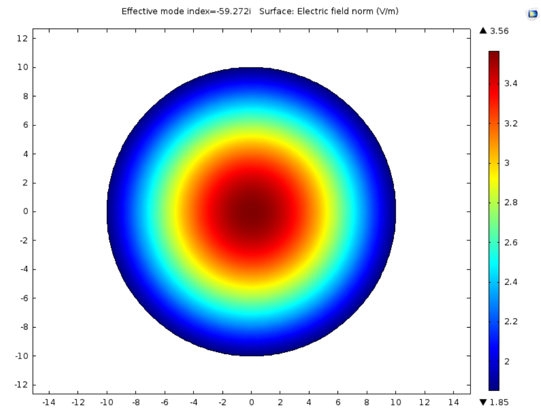

Fig.9. Mode analysis at 10 nm.

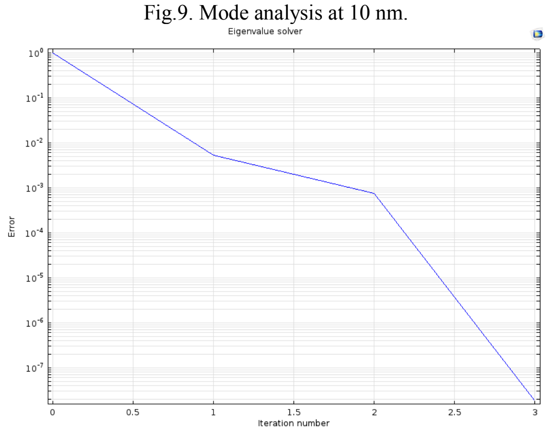

Fig.10. Error probability at 10nm with communication wavelength 1550nm.

We can see from fig. 10 and fig.6 that when we are increasing radius of waveguide than error probability is going down.

Now, we are analysis same radius at half communication wavelength i.e.755nm:

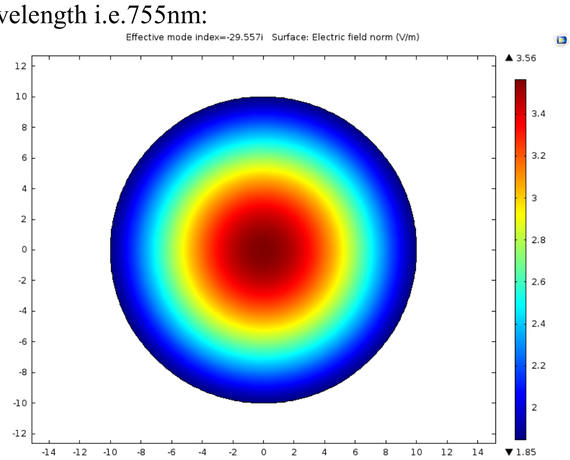

Fig.11. mode analysis of 10 nm with half communication 755nm wavelength.

We have less effective mode index than 1550 nm with same diameter i.e. -29.557i, we also have different error probability with less sharp point at 10^{-1} to $10^{-2,}$ which was sharp at 1550 nm. :

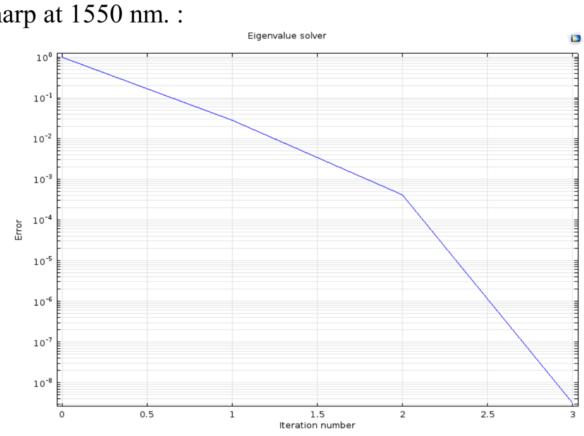

Fig.12. error probability at 10 nm with 755nm.

Analysis 3:

Now we are increasing radius of c36 fullerene with 10 times more than previous analysis i.e. analysis 2 and finally we get mode analysis with effective mode index of -5.38i at 100nm which 10 times smaller than analysis 2 i.e. at 10 nm.

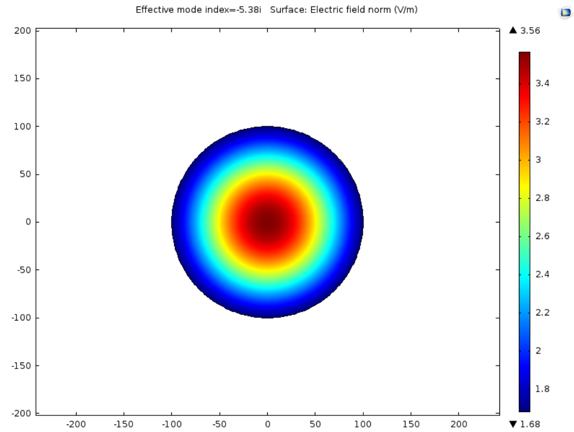

Fig.13. mode analysis at 1550 nm with radius of 100nm.

Finally we are getting less effective mode index when increasing radius of 2D circle. We also have different error probability plot with more smooth point shown in fig.14.

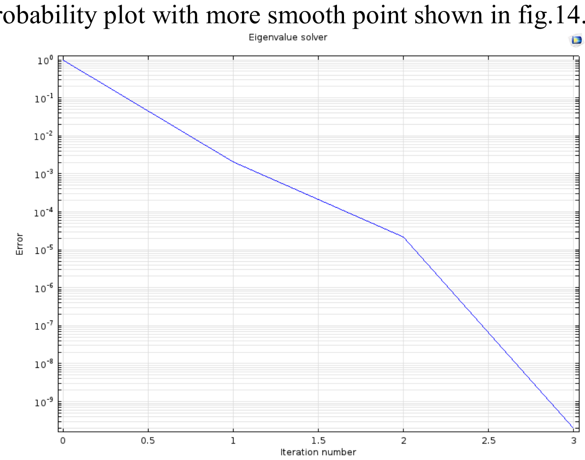

Fig.14. error probability plot at 1550nm wavelength with 100nm radius.

We are also analyzing at half communication wavelength 755nm with same dimensions and getting accurate parameter almost close to silica glass 25micro meter single mode fiber with effective mode index of -1.59641i.

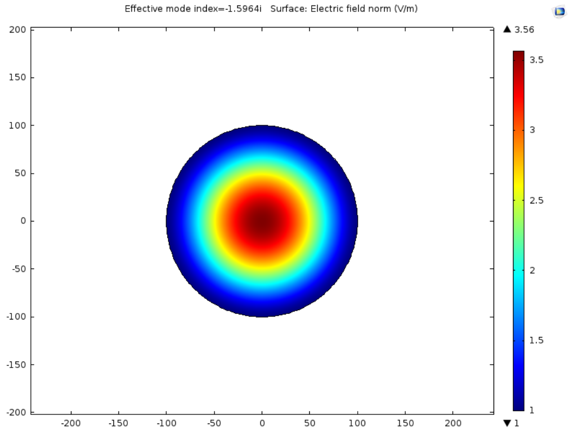

Fig.15. mode analysis of 100nm radius with 755nm wavelength.

RESULT:

in this simulation we can see that this property of fullerene can overcome drawbacks of current optical interconnect technology i.e. SOI (silicon on insulator) in terms of dimensions and as well as in speed. When we are incressing radius size we are getting less effective mode index which was required. It has also great property than fiber that is it has only 2.5% absorption of signal light hence we can transmit signal light with less attenuation and with a great high speed for optical interconnect on chip. We also can use this material as a high-speed optical sensor at tera-hertz renge.

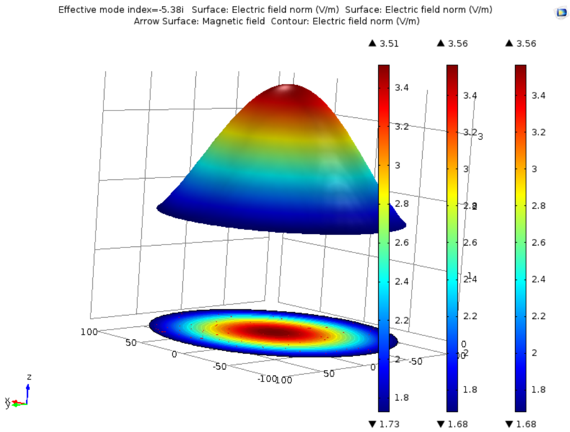

Fig. 16. 3d intensity image by COMSOL Multiphysics.

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