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Graphene Based 3D Nanotubes and Nanochannel Sensors

Technology No. 20170240

Self-assembling Nanoscale 3D Structures

A self-assembly process can build free-standing 3D, micro/nanoscale, hollow, polyhedral structures configured with a few layers of graphene-based materials (graphene and graphene oxide). The 3D structures have been further modified, without impacting their intrinsic properties, with metal patterns on their 3D surfaces. Coupling in all directions results in 3D plasmon hybridization on the surface of the graphene forming the 3D structures. This effect produces a closed, 3D box graphene that generates a highly confined electric field within as well as outside of the cubes. Moreover, since the uniform coupling reduces decay of the field enhancement away from the surface, the confined electric field inside of the 3D structure shows two orders of magnitude higher intensity than that of 2D graphene. These structures might be used for detection of target substances in sensor applications, THz imaging or spectroscopy of nanoscale molecules inside these channels, plasmon-based catalytic reaction enhancement or for storing and sensing the properties of the liquid and gases inside a closed, sealed 3D box. Tubes and open box structures can act as fluidic channels and for non-labeled flow cytometry or as a waveguide to transmit THz light to long distances.

Uniform Coupling Produces Higher Enhancement Area

Current methods cannot construct 3D graphene structures in well-defined shapes without losing the intrinsic properties. 2D nanoribbons suffer from very low field enhancement, limited sensing area and sensitivity, and may require sticking molecules to their surface. Graphene based stacks and nanoribbon arrays produce a higher field enhancement than the single 2D ribbons, but also have drawbacks. 2D graphene arrays produce resonance with multiple peaks, which are spectrally very broad and give them low quality factors, limited sensitivity and sensors that cannot be used at low concentrations. In addition, the high enhancement area between the layers in graphene based stacks is not accessible to the molecules being detected. This 3D assembly technology features a self-folding technique on graphene that uses uniform coupling between graphene from all three dimensions, similar to the components of light. This approach confines the field inside and produces a single peak in the waveform, which is easier to monitor for changes due to foreign materials than the multiple broad

resonance peaks of 2D arrays. Furthermore, the uniform coupling produces a higher enhancement area, both within the structures as well as significantly beyond, than 2D coupled systems and stacks, resulting in molecules that no longer need to be stuck to the surface for detection which can lead to loss of intrinsic molecular properties.

BENEFITS AND FEATURES:

- 3D graphene through self-assembly
- Enhanced sensitivity and signal (2x higher than 2D graphene)
- Uniform coupling between graphene from all 3 dimensions confines the field inside and produces a single peak in the waveform
- Metal patterning on the surface without impacting its intrinsic properties
- Label-free sensing: cost effective, less time-consuming, enables real-time sensing and improved accuracy
- Volumetric plasmon-based field enhancement within and outside the 3D graphene structures
- Large surface area hotspots of high intensity field.

APPLICATIONS:

- Nanosensors
- Next generation micro/nanodevices
- Label-free biosensing and flow cytometry
- Optoelectronic devices
- Tubes/channels for sensing roperties of the blood, fluid, gases or other substances flown through them
- THz imaging or spectroscopy of nanoscale molecules inside channels
- Closed box, sealed 3D structures for storing and sensing properties of the liquid and gases inside
- Fluidic channels for non-labeled flow cytometry
- Tubes used as a waveguide to transmit THz light to long distances

Phase of Development - Prototype developed

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Publications

Self-Assembled Three-Dimensional Graphene-Based Polyhedrons Inducing Volumetric Light Confinement

Nano Letters, 2017, 17 (3), pp 1987–1994