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Sensational 2D nano materials that could challenge Graphene

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Before the rise of graphene it was a slogan among the physicist that existence of 2D materials in our 3D universe is only an imagination. However, groundbreaking work of Prof. A. Geim has proved the existence of 2D structure in 3D universe is a veracity [1]. The astonishing and unique properties of graphene is now playing a very decisive game in the every field of science and technology. Thus unprecedented characteristics and inimitable sp^2 honeycomb crystal lattice of graphene have opened doors for the scientists towards a novel area of nanoscience. And result nearly 10000 citation per year has been scientometrically reported by Andreas *et al.* after the inception of graphene [2]. Lately, some very special atomically thin materials have been discovered and have attracted great attention[3]. They are the IV and V group materials and few transition metal dichalcogenides [3]. It has been demonstrated that group IV 2D materials are to be topological insulators, on other hand transition metal dichalcogenides are valuable for valleytronics [3]. In this special issue authors are briefing about research current scenario of some very new 2D nanostructures such as ***Germanene, Silicene, Phosphorene, Stanene, Borophene and Boron nitride nanosheets***. It is believed that these materials might be trump uniqueness of graphene [3]. Most of the cousins of graphene (mentioned above) do not exist in nature in free standing form but they can be produced on appropriate metallic single crystal substrates. In this line Aufray *et al.* (2010) efficaciously isolated atomically thin 2D allotrope of silicon (i.e. Silicene), with a honeycomb hexagonal crystal lattice analogous to that of graphene [4]. To obtained perfect single layer silicene they deposited silicon atoms on Ag (110) and Ag (111) [4]. Using DFT calculation Gao *et al.* ascertained that silicon atoms incline to form a unique honeycomb structures on silver, and adopt a slight curvature that makes the silicene with a periodically buckled hexagonal topology which is pretty different from the flat graphene morphology [4, 5]. Voon *et al.* (2016) has defined the reason of buckled curvature in silicene morphology and stated that unusual hybridization in silicene responsible for buckled curvature [6]. This type hybridization makes silicene extremely chemically active on the surface and allows its electronic states to be easily tuned by suitable chemical modifications [7]. For instance hydrogenation reaction silicene is much more exothermic than graphene [7, 8]. However, according to Jose *et al.* (2013) both graphene and silicene have a very comparable Dirac cone, linear electronic dispersion around the **k** point and quantum spin Hall effect [8]. As it well established that a material with a few atoms thin possesses different characteristics from a material made of the same molecules in solid form. And also "Even if the bulk material is an old one, if you can get it into 2D form it opens up new opportunities," says Yuanbo Zhang, physicist at Fudan University in Shanghai, China. Evidencing the statement of Prof. Yuanbo, Liu *et al.* (2014) successfully isolated single atom thin 2D allotrope of phosphorus using mechanical exfoliation techniques [9]. This monoatomic layer of black phosphorus is commonly called as Phosphorene and treated as one of the most appropriate competitor to the graphene [9]. Till the date many approaches has been developed including chemical exfoliation and plasma etching for the Phosphorene synthesis [10]. However, scalable production of this new phenomenal material is very challenging task, because it react badly with water vapor and oxygen in the presence of visible light [10]. Researchers of various fields has reported numerous potential applications of Phosphorene like and even better than

graphene [11]. The electronic structure of Phosphorene is very critical and its quantum spin hall behavior a matter of deep study [3,11]. Another cousin of graphene called Germanene, is a material made up of a single layer of germanium atoms (arranged in hexagonal lattice) recently reported by Le *et al.* showing many versatile features [3,12]. They deposit a single layer of germanium atoms on a suitable substrate under an appropriate experimental conditions [11]. Exploring uniqueness of this unusual 2D nano structures researches investigated that the novel electronic properties of Germanene is very suitable for new generation semiconductor device applications, optoelectronics research, field-effect transistor and will be a key constituent in future for the nanoelectronics [3,12]. In the recent 4-5 years a very close alternative to graphene with boron and nitrogen has exclusively been studied often called Boron nitride nanosheets [3,13]. This single layer semiconductor material exist as hexagonal lattice entirely made up of constant boron and nitrogen atoms which shape a specific honeycomb structure of B_3–N_3 hexagon [3]. It is a soft, low density, highly crystalline six-atom sp^2 hybridized hexagonal rings with the rings stacked impeccably atop each other in alternating manner [13]. For this nano structure regular spacing between two consecutive layers is 0.334 nm and bond length between two successive B and the N atoms is 1.44 Å which is very close to graphene [3,13]. This similarity of Boron nitride nanosheets is not limited only to structure and properties, but also with enormous potential in the progress of corresponding composite and ultramodern devices [3]. *Jung el al.* reported that Boron nitride nanosheets very active material and express similar quantum mechanical properties to graphene [3,14]. In contrast to Boron nitride nanosheets Stanene is a newly invented 2D topological materials and insulator in nature[3]. It is composed of Sn atoms arranged in layered hexagonal form, in a manner similar to the other mentioned analog of graphene. However, it is quite different in terms of properties and crystal lattice [3]. Tang *et al.* (2011) first theoretically predicted about the reality of this topological insulator materials [15]. In 2015 Sumit *et al.* of IIT Bombay, India have reported a reliable method for synthesis of Stanene [16]. They have reported interesting optical transitions in few-layer stanene using Raman spectroscopy, UV analysis, and other related optical techniques [16]. Takahashi *et al.* (2015) stated that properties of stanene can studied better at low temperature [3]. The next emerging 2D materials like graphene drawn huge attention is Borophene[3]. As it well established that many atomic cage of boron similar to fullerenes, Andrew *et al.* (2015) have reported synthesis of this atomically thin 2D boron sheets with very high Crystallinity on Ag surfaces under a very high vacuum [3]. His research groups provided many strong support, that unlike must all bulk allotropes of boron Borophene consist metallic nature with a very high anisotropic behaviour [3,15,16].

For conclusion, this editorial issue signifies only the apex of the iceberg and most noteworthy achievement till the date about the some new 2D materials including graphene. Many 2D materials are still under the investigation with exceptional properties and it is believed they will be divulged very soon for the readers. Authors hope that this special issue brings active to the researchers for the present challenges regarding 2D nano materials.

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