How to achieve lighter and better battery

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As human society develops, the demands of source also rises dramatically. The limited natural resources, low efficiency of energy transfer and restricted methods of energy storage, always cannot match the increasing demands of energy, which leads to a series of energy crisis. For example, the Argentine energy crisis happened in 2004, is an electricity shortage due to the unbalance between the slow transportation of fossil fuel and high demands of electricity. At that point, both industries and normal people suffered intermittent cuts in their supply of electricity.

We have to accept the truth, on this plant with more than 6 billion people, if we cannot find a suitable solution for this problem, energy shortage, especially electricity shortage will occur Moreland more frequently. Cities may only receive limited electricity prepay, entertainments may disappears resulted from the lack of electricity, industries will be limited, our offspring will suffer from considerable hardship caused by high prices of food and necessities.

One possible way for energy problem, is to develop innovative battery. As we mentioned above, the energy crisis is always related to the low efficiency of energy storage and transfer, as we all know, battery can not only directly provide power to keep machines and devices running, but also store and transfer energy as a backup for the future. A promising battery, Lithium ion battery, has been a hot candidates for decades, since it is controllable, relatively cheap, can store and transfer energy efficiently and safely. For per kilogram, it can store more than 540,000 Joule energy, comparing to

However, lithium ion battery has not reached a perfect state currently, there are still several problems have not been solved. One important issue is the weight of battery, since it will limit the application of battery. Generally, larger weight means larger size, if the battery itself is too large, it is hard to be installed into devices. Moreover, if the size is too big, it is hard for long distance transport, also easily causes trouble during the transportation, like leakage and explosion. Another important problem is the ability to store energy. To solve energy problem, we hope the new battery can store energy as much as possible, in the meantime, not increase the weight of battery.

Is it possible to achieve a both lighter and better lithium ion battery? Fortunately, lithium ion battery can combine with different electrode and through that way, it is highly possible to

realize our target. A novel two-dimensional (2D) material, hydrogen boride, or HB, which successfully synthesized by researchers in 2015 [1], provide potential to be electrode candidate of lithium ion battery. Many researchers predicted, if we use HB as anode electrode of lithium battery, we can make future battery with lighter weight and higher performance. What is HB and why it can reach this target? Firstly, HB is an atomic single layer composed of boron and hydrogen. Imagining we put a lot of boron and hydrogen atoms in one layer, and arrange these atoms as we want, we can create so many different structures, for example, hexagon like a honeycomb. By changing the structure, we can make atoms arrange dense or sparse. After we understand what HB is, it is reasonable to state the truth, HB is one of the lightest 2D material we have ever discovered, because it is composed only by very light atom boron and hydrogen, and atoms can be placed as a sparse way, to make the density of HB as small as possible.

To show the advantages of our HB, we can make a comparison between HB and the famous 21th century material, graphene. Graphene is a single layer of carbon atoms that are tightly packed into a 2D honeycomb structure. It is called as wonder material because of good conductivity, thinnest and strongest, also low cost. Therefore, it has been regarded as promising battery electrode for many decades. Firstly, if we evaluate the weight of 2D material, we can use surface density to describe. For graphene, the surface density is 760 ug/cm^3, and our HB with a honeycomb structure, is 475 ug/cm^3. Secondly, to evaluate an electrode material, one key point is the capacity, which describe the charge storing. For graphene, it can reach 55 mAh per gram weight (mAh is the unit to measure electric energy store in battery), however, honeycomb HB will reach to more than 1000 mAh per gram. That means, if we make a lithium battery with HB electrode, we can use the same weight battery to store much more electric energy.

However, theoretically HB electrode in lithium battery is so powerful, it is still difficult to produce it industrially. We still know little about this novel material, since it only appears for less than 10 years. One problem remaining, we still have not figured out how to produce stable HB. To overcome this challenge, more experiments are in need. Not only synthesis, we also need to understand the characteristics of HB from basic physics and chemistry field, for example, to understand the stability of HB, we need to investigate how hydrogen and boron atoms connect with each other. Moreover, if we change the structure of HB, will it make HB more stable? Which kind of structure is the most stable structure of HB? Only if we gain further understanding of HB, we can start to apply it in future lithium battery. For this purpose, chemists, physicist and material scientists are gathering to conduct various

experiments, we believe, in the near future, these remained problems can be solved.
In summary, HB can be perfect electrode to realize novel lithium battery, and have potential to solve future energy. The novel lithium battery with HB electrode can store more energy with a lighter weight (Fig. 1). In the future, I believe we can store energy with that kind of new battery, and we can build more energy storage devices with that battery. When energy shortage occurs in any place in the earth, we can transport energy by transport battery to help, under a safe and efficient state. I believe with the help of HB-lithium battery, our society will overcome the energy shortages and reach to a brighter future!
Fig. 1: The main 3 advantages of hydrogen boride (HB), with typical honeycomb structure (cited from open source materials project).

[1] A. J. Mannix, X.-F. Zhou, B. Kiraly, J. D. Wood, D. Alducin, B. D. Myers, X. Liu, B. L. Fisher, U. Santiago, J. R. Guest, M. J. Yacaman, A. Ponce, A. R. Oganov, M. C. Hersam, N. P. Guisinger, Science 2015, 350, 1513.