# Filling the gap

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Graphene has been getting a lot of press [1] lately touting it as the electronics material of the future. It is a strong single-layer material with high electron mobility [2]. All good things for a semiconductor material.

But single-layer graphene lacks something very important for a semiconductor material: a band gap. By going to multilayers, [3] a band gap can be created. This is very promising news. But there is even more promising news. [4]

Molybdenum disulfide [4] ($MoS_2$) inherently has a band gap and can be used to make semiconductors. It all depends on the "flatland" concept. Two dimensional materials. Well, two and a half dimensions actually, as they cover area but are only a few atoms thick.

> The latest “new” material, molybdenum disulfide ($MoS_2$) — which has actually been used for decades, but not in its 2-D form — was first described just a year ago by researchers in Switzerland. But in that year, researchers at MIT — who struggled for several years to build electronic circuits out of graphene with very limited results (except for radio-frequency applications) — have already succeeded in making a variety of electronic components from $MoS_2$. They say the material could help usher in radically new products, from whole walls that glow to clothing with embedded electronics to glasses with built-in display screens.

MIT is doing some serious work [5] on the material. They report that because of its high band gap (1.8 volts compared to silicon's 1.1 volt [6]), the off-state of a transistor made with $MoS_2$ will have much less leakage than one made with silicon.

No material is perfect, however; electron mobility [7] in molybdenum disulfide is not very high. On the order of 500 $cm^2/Vs$ compared to around 1500 $cm^2/Vs$ for silicon and 200,000 $cm^2/Vs$ for graphene. These $MoS_2$ transistors will not be at the forefront of high-frequency devices.

The meaning of all this is straightforward. As time goes on, we will see semiconductors better-tailored for each individual application. We already are seeing that now with various semiconductors for LEDs. Silicon carbide for power applications and even germanium (in conjunction with silicon) is making a comeback. With these new materials, the range of what is economically possible will get wider.

M. Simon's e-mail can be found on the sidebar at Space-Time Productions [8].

*Engineering is the art of making what you want from what you can get at a profit.*



**Links:**
[1] https://www.google.com/#hl=en&sclient=psy-ab&q=graphene+&oq=graphene+&gs_l=hp.3..0l4.188809.188809.3.189969.1.1.0.0.0.0.110.110.0j1.1.0.les%3B..0.0...1c.1.lHuaezZoyAk&pbx=1&bav=on.2,or.r_gc.r_pw.r_cp.r_qf.&fp=751c212e7cc57ca6&bpcl=35277026&biw=1280&bih=824
[2] http://phys.org/news119030362.html
[3] http://infrared.als.lbl.gov/content/the-news/167-bilayer-graphene-gets-a-bandgap
[4] http://www.azonano.com/news.aspx?newsID=25434
[5] http://www.gizmag.com/molybdenite-outshines-silicon-and-graphene-for-electronic-applications/17746/
[6] http://en.wikipedia.org/wiki/Band_gap
[7] http://arxiv.org/ftp/arxiv/papers/1112/1112.4397.pdf
[8] http://spacetimepro.blogspot.com/