

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 \[4\]](#) (MoS₂) 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 (MoS₂) — 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 MoS₂. 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 MoS₂ 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 cm²/Vs compared to around 1500 cm²/Vs for silicon and 200,000 cm²/Vs for graphene. These MoS₂ transistors will not be at the forefront of high-frequency devices.

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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.

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http://www.ecnmag.com/blogs/2012/10/filling-gap?qt-video_of_the_day=0

Links:

[1] https://www.google.com/#hl=en&scient=psy-ab&q=graphene+&oq=graphene+&gs_l=hp.3..0l4.188809.188809.3.189969.1.1.0.0.0.110.110.0j1.1.0.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/>