

Research In Wires: Graphene

Move Over Graphene: IBM Expects Copper Interconnects to Hold the CMOS Line ExtremeTech, November 16, 2017

“It’s been 20 years since IBM first introduced copper interconnects in CMOS processing, sparking a minor revolution in the process. Within a handful of years, both Intel and AMD had made the jump as well, paving the way for reduced interconnect power consumption and improved performance when compared with the older aluminum interconnect standard. Now, IBM believes there’s enough life left in copper — and enough problems with graphene — that copper-based interconnects will last until CMOS is itself replaced by something new.

“... IBM fellow Dan Edelstein...argues graphene is too difficult to manufacture, doesn’t flow uniformly, and doesn’t achieve the same consistent performance as modern copper interconnects. ... No one has yet found a cost-effective way of manufacturing graphite at scale or of manufacturing it to the tolerances required.

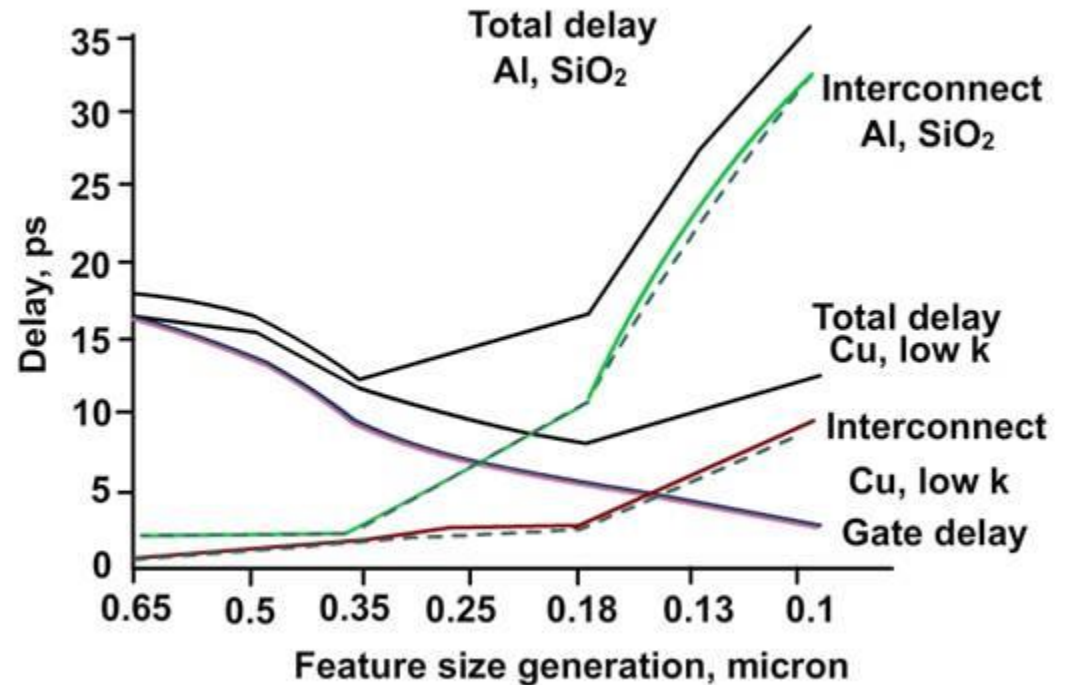
“Copper with a thin cap of cobalt is better than graphene at carrying current and even at the smallest sizes imaginable copper interconnects are still the best solution, perhaps with cobalt, nickel, ruthenium or another platinum-group noble metals brought in to underlay it,” Edelstein said.

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“Copper offered significant benefits over aluminum, as shown in the image [right], but it also required a tantalum-nitride sheath to act as a diffusion barrier between copper ions and the silicon itself. IBM had to develop entirely new methods of connecting the various layers of the CPU; the techniques that had worked well for aluminum did not function for copper.

“At first our competitors said that it would only last one generation, but so far it has lasted 12,” Edelstein told EETimes.



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“ ‘And we believe that for CMOS it will last forever, except perhaps on the bottom layer next to the advanced node silicon transistors which may require cobalt, nickel, ruthenium or another platinum-group noble metals.’

“As semiconductor nodes have become smaller, interconnect delay has risen and become an increasingly difficult problem to solve. It’s part of the reason why CPU clocks haven’t advanced much. We need a better interconnect solution, no question, but so far, we simply haven’t found one. The problems facing graphene are significantly more difficult than the issues that made copper integration difficult in the 1990s, and until we can actually produce the stuff in the commercial volumes required for mainstream manufacturing, it wouldn’t matter if it was the best interconnect material on Earth.”