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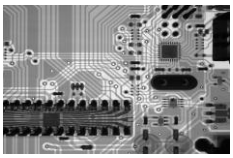
Edison Explains

Semiconductors

How are semiconductors performing in the current market?



How quickly is the semiconductor market growing?

The semiconductor market is cyclical, with extended periods of strong performance followed by downturns. The first half of 2018 showed signs of a strong cycle with the Semiconductor Industry Association reporting sales up mid-year by 20.5% compared to the second half of 2017, with worldwide sales of $118bn.

That strength may not extend through the rest of the year as the stock market reveals signs of sector volatility and the start of a potential downturn. The volatility is evidenced by a series of falls in the Philadelphia PHLX Semiconductor Sector index.

The index's decline is partly a result of Morgan Stanley's and private equity firm Baird's warning of sector volatility and partly due to US tariffs disrupting the semiconductor supply chain.

What are semiconductors?

When passing through a conductor electricity faces little resistance, creating an uncontrolled, free-flowing current. In an insulator, electrical current cannot travel due to high levels of resistance.

Semiconductors sit somewhere between the two, allowing a degree of control over the flow of electricity by providing a slightly resistant material.

Silicon chips are the industry standard, but silicon is usually an insulator. This is because pure silicon is constructed from atoms that contain four electrons in the orbital furthest from the atom's nucleus.

This atomic structure causes silicon atoms to bind together with powerful covalent bonds and form a crystalline lattice. On their own, silicon lattices do not conduct electricity, as the electrons are strongly held in place.

To create semiconductors, electrons must be added or subtracted from the silicon lattice through doping.

How are semiconductors doped?

During doping, materials with three or five electrons are mixed into silicon to disrupt the crystal's strong covalent bonds.

N-type doping uses materials with a five-electron outer orbital, such as phosphorus or arsenic. This adds a fifth free electron to the lattice. The extra free-flowing electron allows the material to conduct electricity.

P-type doping uses materials with three electrons in its outer ring, such as boron or gallium. The addition of an atom containing three electrons in its outer orbital leaves the absence of an electron, or 'hole', through which free-flowing electrons can travel.

How are semiconductors used in electronics?

N- and p-type semiconductors are used to create transistors, small devices that are essential components in modern computers.

When a small electrical current is input through a transistor's 'gate', the device outputs a large current. The effect acts as both an amplifier and an electrical switch.

Several transistors together make up a logic gate, a device that processes binary information, the code of ones and zeros used by computers. Transistors can also be used to retain binary code as memory blocks.

These semiconductor-based devices are crucial to microchip manufacturing, from processors to memory cards.

Edison's insight:

'In 1965 Gordon Moore, the co-founder of Fairchild Semiconductor and Intel, presented a paper in which he predicted that the number of components per integrated circuit would continue to double every year. The intervening decades have seen chip complexity increase as Moore predicted, enabling his vision of PCs, autonomous vehicles and mobile phones to become a reality.' Anne Margaret Crow, TMT analyst, Edison

What are compound semiconductors?

Compound semiconductors are typically constructed from two or more materials, which contain three or five electrons in their outer orbital, eg gallium (III) and arsenide (V) form gallium arsenide (GaAS).

These semiconductors have a number of advantages over silicon chips, the first of which is their superior electrical properties. Some compound semiconductors can increase the speed at which electrons

pass through them sixfold, allowing for faster processing speeds.

Just as important, compound semiconductors have particularly strong photonic properties, allowing them to turn light into electricity and electricity into light highly efficiently. This makes them perfect for light-based communications like fibre optics.

Why are silicon rather than compound semiconductors the industry standard?

Silicon semiconductors are the industry standard for most microchips – not because they are faster, but because they are cheaper. Compound materials are expensive to produce compared to their silicon alternatives.

One solution is to layer compound semiconductors onto a silicon substrate, which reduces cost but leads to problems of its own. Silicon's crystalline lattice does not work well with compound semiconductors. The resulting semiconductor contains faulty electron pathways due to the mismatch of both materials.

The problem is not insurmountable. IBM is using a technique known as confined epitaxial lateral overgrowth to develop silicon compound hybrids. IQE uses its patented cREO technology instead, adding a buffer between the silicon and compound material to mitigate compatibility issues.

What is driving growth in the semiconductor market?

The adoption of increasingly complex electronics in all fields drives semiconductor sales, but some segments are particularly influential. Among them, explosive smartphone adoption has led to strong semiconductor sales ever since the devices came to market. As smartphones become increasingly complex, the amount of semiconductors required in their sophisticated microchips will likely continue to grow the market.

One of the features most in demand in the current generation of smartphones is face recognition, which encompasses the field of semiconductor photonics. Photonics as a whole provides fertile ground for semiconductor growth due to the increasing importance of fibre optic broadband, complex cameras and light-based communication systems.

In the long term, autonomous vehicles, artificial intelligence and the Internet of Things are huge potential markets for semiconductor chips, although these industries have yet to fully mature.

Which companies are heavily involved in the semiconductor market?

The semiconductor market is showing signs of a cyclical downturn, as is common in the industry. Large semiconductor companies, from SK Hynix and KLA-Tencor to Texas Instruments, have also lost value following warnings of a potential oversupply.

Intel traditionally led the semiconductor market as the largest vendor by revenue until 2017. It primarily produces microprocessors, with its memory division making only $3.2bn of the company's $62.8bn in revenue last year.

Samsung, by comparison, generates one-third of its revenues from the memory card market. The memory-focused chipmaker unseated Intel as the largest semiconductor company by revenue in 2017, due to price hikes in the memory microchip market, a market often considered volatile.

Samsung and Micron suffered more than their contemporaries in the recent market rout Bloomberg reports that Samsung's share price fell by 3.7% following Baird's downgrading of memory chip manufacturer Micron and Morgan Stanley's fears of an oversupply.