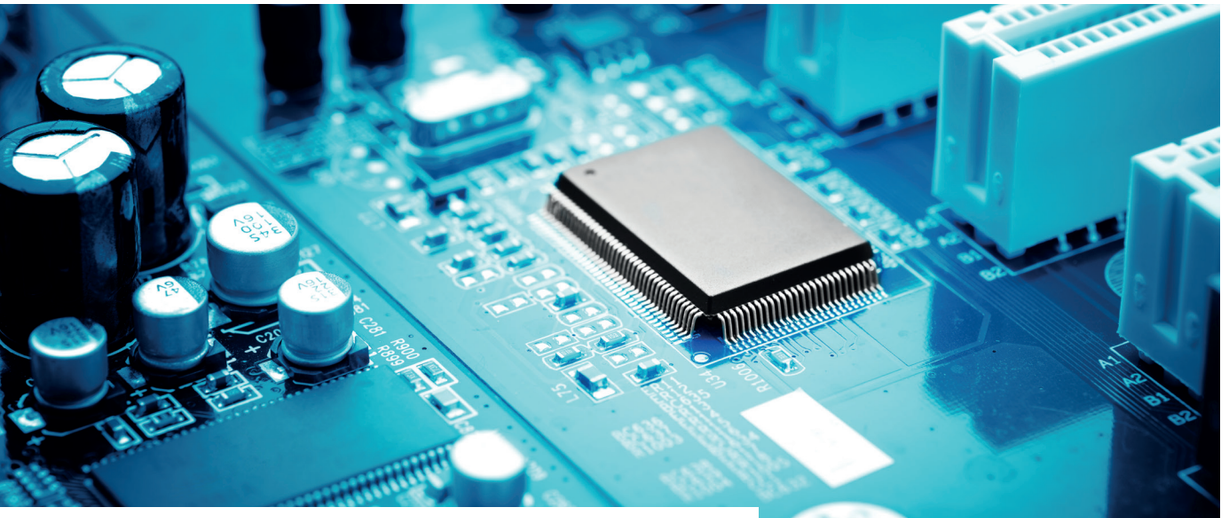

Higher and higher

Higher purities, and higher growth in specialty gases

By Rob Cockerill

At a time when so many markets see growth challenged by sluggish economies or the effects of sustained low oil prices, two factors often inextricably linked, it is encouraging to see one section of the global gases industry be the subject of growth the world over. Those products are, specialty gases.

It may be a 'niche within a niche' but the specialty gases business of 2016 is breaking out and arguably casting a shadow over the wider industry at large like never before. It continues to go from strength to strength, and everything about the specialty gases business right now is 'higher' – higher purities, higher demand, higher expectations, and higher growth.

Chief among the growth drivers for specialty gases are key sectors like electronics, healthcare and manufacturing, while growth is also underpinned by solid demand from areas such as academia, chemicals, and environmental applications. Further still, the list of new applications for specialty gases and mixtures continues to lengthen, creating new opportunities not only for specialty gas sales every day, but for the necessary equipment and instrumentation to facilitate their use and delivery too.

Manufacturing

In its recently released Specialty Gas Market: Forecast 2016 – 2021 report, Research and Markets cites applications in the manufacturing sector such as lighting, lasers, chemicals and automotive as being among the drives for strong specialty gas market growth over the next five years.

This essentially correlates with estimates of Ohio-based investment bank and M&A experts League Park, which told **gas**world last year that the US manufacturing sector represents up to 45% of the end-user market for specialty gases and notes that growth rates in this business are projected to grow at 2.8% through to 2018.

League Park's definition of the manufacturing sector includes chemicals business, with Director Wayne Twardokus noting that chemicals and lighting/laser markets represent the largest sectors and are expected to continue to drive specialty gas expansion as the market benefits from low energy prices.

Oil and gas and refining markets are significant demand drivers for core specialty gases, with high purity nitrogen, hydrogen, and other gases used in oil and gas processing and in the laboratories that monitor and test oil and gas products and by-products.

But as with so many end-user markets, the list of specialty gases and applications is growing all the time. An array of ultra high purity (UHP) gases, calibration gases, and cylinder gas mixtures are used in many manufacturing processes and must be free from harmful contaminants that could interfere with controlled processes or vital instrumentation. Biotechnology, chemicals and metal fabrication are among the sectors that are big consumers of these gases, while increasingly innovative technology and approaches in manufacturing like lasers, plasma cutters and additive manufacturing are driving growth for specialty gases and related equipment.

Additive manufacturing, or '3D printing' as it is widely known, is very much the new kid on the block in manufacturing – and growing up fast, with the use of specialty gases. Factors such as increasing demand from the design and manufacturing sectors, and growing demand from the healthcare sector, are driving the 3D printing market in developed regions, with growth in healthcare, consumer products and automotive industries in underdeveloped regions also offers much promise going forward. In fact, the design and manufacturing segment is widely projected to be the fastest-growing end-use industry in the next five years.

Gases such as argon, nitrogen, and gas mixtures are extensively used in additive manufacturing, particularly in the medical, consumer products, automotive, aerospace, and defence sectors. Argon is estimated to be the gas in largest demand, but gas mixtures are expected to play a significant role in advancing the additive manufacturing field in the future.

Specialty gases may well be leading the future in the automotive business too. Gases for use in the automotive sector are poised for growth, as emissions legislation changes take effect in the transport sector and the industry shifts to ever-lighter vehicles using materials like aluminium, which could see more use of laser gases in laser metal processing. Increased use in energy-saving headlights could also drive demand for rare gases, think krypton and xenon.

Electronics

The electronics business remains one of the more profitable platforms for the specialty gases industry, regardless of any slow progress coming out of the global economic slowdown. With the semiconductor business firmly in the midst of an upward curve, boasting consistently strong book-to-bill figures and strong market growth, the electronics sector offers a particularly bright spot right now for those in specialty gases.

Twardokus agrees and told gasworld, "Our data would agree with SEMI. We think that the electronics market is poised for strong growth. For example, US demand for semiconductors is forecasted to have annual growth of 3% from $46.9bn in 2015 to $54.4bn in 2020."

"Strong ongoing worldwide demand for electronics featuring enhanced speed, lower power consumption, and reduced size will determine the trend and be a major component that is driving Integrated Circuits (IC, largest product segment). We also think the development of the Internet of Things (IoT) will increase consumption in the communications equipment; computers; consumer electronics; motor vehicles; and industrial, medical, and military equipment markets."

"In summary, we believe the demand drivers will be in place to support increased gas consumption in the electronics market."

The range of gases subject to such demand continues to grow ever-wider. Electronics gases are a very diverse family; the industrial gas industry produces a variety of specialty and tonnage gases, specialty and bulk chemicals, and services and equipment for the manufacture of silicon and compound semiconductors, displays (LCDs), and closely related photovoltaic systems and devices. It also works closely with electronics manufacturers to identify and supply diverse and sophisticated materials and equipment used in virtually every manufacturing processes to produce critical electronics components. Which gases are used depends on the manufacturing process.

Industrial gas products like nitrogen, argon, helium and hydrogen are used as utility gases, as well as in processing, while a range of electronics specialty gases and electronic precursors more broadly known as electronic materials (EMs) are deployed in the chip manufacturing process. The use of EMs can be classified into four categories: deposition, etch/clean, lithography, and implant.

In terms of deposition, thin films form the basis of semiconductor devices. Most of the deposition steps involve some silicon-based film, whether it is silicon (Si), silicon dioxide ($Si O_2$), or silicon nitride (SiN). Metal and metal oxide films are also commonly deposited, while silane and its derivatives are used to form oxide and nitride films. Etching is required to remove layers and to form the device structure, with clean gases used to clean deposits off process chamber walls and chamber cleaning mostly achieved via nitrogen trifluoride (NF_3). Fluorine (F_2) is rising in popularity for this purpose, however, given its better cleaning performance and zero global warming potential (GWP).

As aforementioned, this list keeps growing, and Twardokus believes the increasing rate of technological development will continue to be a major challenge and opportunity for those operating in the electronics business. "The increasing rate of technological development will continue to be a major challenge and opportunity for the electronics market. Not only does technological advancement enable electronics manufacturers to keep pace with changing end-user preferences (particularly for cheaper, faster, lighter, and smaller components), but it also affords enhanced production efficiencies."

"These changes will require gas companies to be nimble – common requirements are improved purity and more complex mixtures. Gas companies will need to meet these demands while simultaneously working to lower unit pricing."

So who will thrive or wither as a result of these challenges? Twardokus responds, "We believe that the gas companies that embrace the aforementioned shifts will thrive, which will require meaningful investments in technology and training. Furthermore, we believe many customers may reallocate →

production capacity, a shift which could force gas suppliers to navigate the logistics and legal requirements for shipping products to Asia versus California, while simultaneously maintaining the same delivery performance, or require improved purity/mixture complexity. As end product tolerances increase, these shifts will require suppliers to provide gas products that have another nine to the right of the decimal and lower variation on a cylinder to cylinder/batch to batch basis. Producing to industry specification may not be good enough."

League Park points to two new electronics production technologies that could drive change in the years ahead – extreme ultraviolet (EUV) lithography, and nanomaterial developments. EUV lithography uses a light source wavelength of 13.5 nm, compared to the 193 nm argon fluoride laser sources already in service, but technology has not yet been implemented in high-volume manufacturing. Nanomaterials, however, which measure 1-100 nm in one dimension, could have a more immediate impact.

> "Spending for home healthcare is projected to exhibit the most rapid growth among all segments..."

"For example, in February 2016, engineers at the University of Utah discovered a new two-dimensional (2D) semiconducting material only one atom thick, composed of tin and oxygen," Twardokus said. "Because the material is 2D, electrical charges are able to move through it much faster than conventional three-dimensional (3D) materials (like silicon). The engineers think this material can be used to make transistors that are faster, more energy efficient, and create less heat than current transistors."

Healthcare/medical

The medical market is renowned to have been a growth space for the gases industry in recent years, particularly as the homecare business has risen to greater prominence. Medical gas supply, like oxygen, nitrogen, nitrous oxide, and carbon dioxide, is vital at healthcare installations and is a growing business.

Other important applications for specialty gases in healthcare include oxygen and special breathing mixtures used in hyperbaric therapy, helium used in MRI applications, a variety of anaesthesia gases including new xenon technology, special deep breathing mixtures used while under anaesthesia, and nitric oxide mixtures used to treat pulmonary hypertension in neonatal cases. The demand for specialty gases also spills over into the equipment side of the business, with the growing market for medical gases understood to be a key driver in the cryogenic pump market too.

Air Products' supply agreement with Vizient, Inc., the largest member-owned healthcare company in the US, is a great recent example of the growth potential in this business for the gases industry. The new $100bn agreement announced this summer expands Air Products' opportunities to supply medical gases to healthcare facilities – becoming an approved Vizient supplier gives the company the opportunity to supply its medical gases at negotiated pricing to Vizient's membership of academic medical centres, paediatric facilities, community hospitals, and integrated health delivery networks. It also opens up these opportunities to non-acute healthcare providers who access the Vizient contract portfolio.

So is healthcare still one of the biggest areas of growth for the specialty gases business? League Park thinks so, certainly in the US at least, and Twardokus explained, "We think so, as US national healthcare expenditures are forecasted to total $4.1 trillion in 2019, representing 5.8% annual growth."

"Growth in healthcare demand is attributed to the continued ageing of the population as well as growing enrolment in private plans and Medicaid due to the Affordable Care Act. Providers are expected to benefit from growth in consumer incomes and a projected rise in the number of acute and chronic conditions, driven by above-average growth in the 55-years-and-older cohort of the population. The number of persons 65 years of age and older is projected to rise 3.3% per year through 2019, four times as fast as the total population."

"The US insured population is projected to total 300.5 million persons in 2019, representing gains of 1.7% annually. The uninsured rate in 2019 is forecast to fall to 8.1%. Key factors contributing to the rise in insurance as expansion of Medicaid and subsidies to purchase private insurance available through the Health Insurance Marketplace."

"Spending for home healthcare services is projected to exhibit the most rapid growth among all segments, with expected annual increases of 7.2% to $119bn in 2019," Twardokus added. "The lower costs associated with home healthcare services, relative to nursing homes, and the desire of many persons to remain in their home is expected to drive spending. In addition, the growing elderly population is projected to boost demand."

"The cost savings from utilising home healthcare services stem primarily from the absence of the large overhead costs associated with running nursing homes. Demand is also supported by technological innovations that expand the scope of services that can be provided in home settings (chemotherapy). In addition, home healthcare eliminates the risk of hospital acquired infection."

The portable oxygen concentrator (POC) market is an example of an equipment group showing signs of expansion as a result of this rise in home healthcare, a trend that Luxfer explains more about from page 26 of this supplement.