ElectronicsIQ.

Information Quarterly from Linde Electronics.

THE LINDE GROUP

Spring 2014

Welcome to ElectronicsIQ, the quarterly update from Linde Electronics. In this issue, we will explore innovation in materials recovery. In a world where there is an ever increasing demand for electronic goods, finding innovative solutions to recover materials is a priority – from both an economic and sustainability perspective. This issue covers a wide range of gas recovery – from Xenon to Helium; Argon to Sulphuric Acid – including expert insight from Carl Jackson, Head of Customer Solutions at The Linde Group and Paul Stockman, Technology Manager, The Linde Group.

Innovation in Materials Recovery

The unmatched technological progress demonstrated in the semiconductor manufacturing industry has ultimately been made possible through an industry norm of constant technical and engineering innovation. The pace of change is relentless and for this to be sustainable it needs a supportive eco-system, including materials suppliers, who are advancing at the same pace.

Read more…

Manufacturing Sustainability and the Future

By freelance journalist, Simon Augustus

Over the last decade there has been an increase in public awareness on issues surrounding environmental sustainability. In a world largely dependent on the manufacturing of electronics, nowhere is it more important that crucial steps be taken to ensure sustainability at every available stage of the processes involved.

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Argon: Reducing Logistics Costs and Risks through Recovery

While sufficient argon is produced for global demand, sometimes large users are situated far from the argon sources. This supply chain requires large shipping containers transporting the gas via land and sea in a journey that can take as long as 35 days round trip.

Read more…

Table of Contents

ElectronicsIQ.

Information Quarterly from Linde Electronics.

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Spring 2014

Helium: Finite Resource and Specialised Recovery

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Xenon: Rarity and Recovery

Xenon – the name derives from the Greek word for stranger – is a particularly rare gas. With approximately only one part in 10 million in the atmosphere, it is also obtained from large ASUs as a 1:13 crude mixture with krypton. This mixture is then separated, purified, and packaged at one of Linde's global rare gas manufacturing centres. Due to the low starting concentration, only about 10 million litres of xenon are made each year.

Read more…

Sulphuric Acid: Fresh Water and Logistics

The drivers for sulphuric acid recovery are very different to the other elements discussed in this newsletter. Here the benefits are: reduction of disposal costs and the associated demands for fresh water and waste water volumes.

Read more...

My Life at Linde

We speak to Paul Stockman about what inspires him; why he has stayed with Linde for 17 years and his proudest achievement.

Read more...

Table of Contents

ElectronicsIQ.

Information Quarterly from Linde Electronics.

By Carl Jackson, Head of Customer Solutions at The Linde Group

Innovation in materials recovery

The unmatched technological progress demonstrated in the semiconductor manufacturing industry has ultimately been made possible through an industry norm of constant technical and engineering innovation. No other industry has ever reached so many fundamental limits, only to have collective industry talent find solutions that enable continuous improvements in scale, cost and performance. The pace of change is relentless and for this to be sustainable it needs a supportive eco-system, including materials suppliers, who are advancing at the same pace.

In this fiercely competitive and diverse market, the constant drive for progress has driven manufacturing complexity. Production of semiconducting devices such as microprocessors and memory is becoming increasingly sophisticated, requiring manufacturers to optimise process performance with increasing levels of resolution and accuracy. For materials suppliers, the portfolio of materials required continues to grow, as does the supply chain complexity and quality requirements.

However with increasing environmental focus; a scarcity of key materials, such as the well documented reduction in the supply of helium; and complex supply chains, reducing operating costs and ensuring a secure and reliable supply of materials is intrinsic to staying competitive.

In fact, it is becoming increasingly important to consider exactly where materials are coming from to ensure consistent quality, stable supply and ultimately the lowest overall cost of ownership. Electronics manufacturing plants are not always located in the optimum position for material supplies, making it vital to think about how materials could potentially be recovered, purified and re-used on site, saving both shipping costs and reducing logistics risks.

Materials recovery at Linde is not a new concept with some notable long-standing product offerings available across The Linde Group. This recovery technology is now being transferred and developed from our industrial gases portfolio into our electronics business.

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Information Quarterly from Linde Electronics.

To meet current industry demands we presently operate three main types of materials recovery solutions – tailored to individual customer requirements.

Firstly, there is the on-site, closed loop approach where waste materials are recovered and returned into the customer manufacturing process via purification and quality control systems. This solution can be used for materials such as helium and argon. Another alternative is on-site, open loop recovery. In this case, materials are recovered on-site but then removed and re-used for other applications – for substances like sulphuric acid. The final option is off-site recovery, which is mainly used for high cost materials. Here, the materials are recovered before shipping off-site for recovery and purification, for example, in the case of xenon.

All types of recovery can offer numerous benefits including cost reduction, supply chain security and a lower carbon footprint.

At Linde, we see materials recovery as a challenging and increasingly important area of our business to meet our customer needs. Innovation in electronics manufacturing can never stand still. Neither can Linde.

ElectronicsIQ.

Information Quarterly from Linde Electronics.

Author: Simon Augustus, freelance journalist

Manufacturing sustainability and the future

Over the last decade there has been an increase in public awareness on issues surrounding environmental sustainability. These have driven monumental changes in government policy, inviting scrutiny and highlighted a number of serious problems which, without balanced, well thought out approaches and an energetic attitude towards innovation, could mean a bumpy ride ahead. In a world largely dependent on the manufacturing of electronics, nowhere is it more important that crucial steps be taken to ensure sustainability at every available stage of the processes involved.

The production of semiconductors, for instance, has been associated with some rather sinister environmental side effects, and even now the long term impacts of the chemicals used in the manufacturing processes of semiconductors remains, in some cases, largely unknown. Coupled with this is the huge energy and water consumption associated with semiconductor manufacturing, and harmful air emissions. However, before we go about dismantling fabrication units, it is important to note that semiconductor-enabled technologies have the potential to reduce energy consumption across a variety of manufacturing areas, and the advancement of this technology, coupled with other emerging technologies can, and will, help towards reducing wastage.

The manufacturing process involved in producing semiconductors and other electronics must be meeting the strictest policy guidelines. This means that fabrication units should be looking towards, and already are, employing the most innovative technologies to become as sustainable as possible. Increased gas purification and recycling methods have helped, and will continue to help, meet environmental standards through reducing wastage of raw materials. Alongside this, gas purification and various gas delivery solutions have helped to lower harmful waste and increase efficiency respectively.

Material recovery is another important aspect to ensuring longevity of the manufacturing industries. Recovering important materials, like helium, a precious natural resource used in manufacturing, for purification and reuse is leading the way in green solutions, but that does not mean profit margins should suffer. Research has suggested that companies employing the use of gas recovery and purification can make significant reductions in the cost of ensuring a constant supply of bulk helium. With the right partner and expertise, recovery systems of this sort can be integrated thanks to design innovations that take into consideration factors like consumption levels, purity requirements, pressure and flow rate.

Installation of recovery facilities can prevent supply disruption issues due to shortages, which will become more of a reality as resources become more precious. Material recovery technologies are available for a wide range of process-necessary materials and industrial gases. These solutions make good business sense economically, logistically and environmentally.

In a world dependent upon manufacturing processes requiring the use of limited resources, coupled with an ever increasing demand for electronic goods, finding innovative solutions to increase the sustainability of manufacturing is not an easy feat. The responsibility falls on companies within the manufacturing industries to employ technologies that reduce waste, increase productivity, recycle and purify, and lift the strain on natural resources. These are now being achieved in ways that profit competition in a globalised world, contribute towards lower costs, provide flexible logistical solutions, and benefit the environment for a sustainable manufacturing future.

ElectronicsIQ.

Information Quarterly from Linde Electronics.

By Paul Stockman, Technology Manager, The Linde Group

Argon: Reducing logistics costs and risks through recovery

Unlike other “rare” gases, argon is in fact quite abundant. It makes up 1% of the air, and is extracted most economically at our largest Air Separation Units (ASUs), which are built primarily for on-site supply to chemical and steel plants.

While sufficient argon is produced for global demand, sometimes large users are at far distances from argon sources. Making this supply chain requires large shipping containers transporting the gas via land and sea in a journey that can take as long as 35 days round trip. This is an expensive and time consuming option for the largest users of argon, which can require one or two containers of the gas every day.

In the electronics industry, argon is used in various applications including the deep UV lithography lasers used to pattern the smallest features in semiconductor chips, and plasma deposition and etching processes.

Two applications, however, use enough argon that recovery can be both economically and technically viable. In the manufacture of silicon wafers, large amounts of argon are used to protect the silicon crystal from reactions with oxygen and nitrogen while it is being grown at temperatures > 1400 ^{o}C. And increasingly, tools using small droplets of liquid argon are employed to clean debris from the smallest, most fragile chip structures.

The argon recovery process – which is very similar to that which was first used to produce the fresh molecules of argon during separation at the ASUs – takes minutes. With approximately 80% recovery efficiency, investing in an on-site, closed-loop recovery system can help electronics customers reduce both transportation costs risks associated with argon supply.

ElectronicsIQ.

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Helium: Finite resource and specialised recovery

Even though helium is an abundant element in the observable universe, on earth it is a relatively rare and non-renewable resource, found in the ground and co-located with some natural gas deposits.

Despite its scarcity, helium's unique properties – such as being the second lightest element and the coldest liquid – mean that it is useful in many applications. MRIs and some types of metals processing and welding are only possible by using helium. In electronics manufacturing, helium is used at hundreds of points in the fab for cooling, plasma processing, and leak detection. Beyond essential uses, helium is also in demand for small and large entertainment balloons. Since 1994 Linde has been sole helium provider to the balloons of Macy's annual Thanksgiving Day Parade in New York.

Helium is recovered as part of the natural gas extraction process and is not economically viable to be produced on its own. Linde is the world leader for the design and manufacture of equipment to separate, purify, and liquefy helium to a temperature of -269 °C. Only in its pure, liquid state can helium be economically transported across the globe.

Linde already provides helium recovery for applications for many different industries. By combining several of its core technologies, Linde has created a hybridized plant design to extend helium recovery to electronics applications, where the waste streams are often more dilute and contaminated. Groups of large fabs clustered in one major site will be able to receive the most benefits of our helium recovery system in terms of cost.

ElectronicsIQ.

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Xenon: Rarity and recovery

Xenon - the name derives from the Greek word for stranger - is a particularly rare gas. With approximately only one part in 10 million in the atmosphere, it is also obtained from large ASUs as a 1:13 crude mixture with krypton. This mixture is then separated, purified, and packaged at one of Linde's global rare gas manufacturing centres. Because of the low starting concentration, only about 10 million litres of Xe are made each year.

Xenon finds uses as a premium filling in double glazed windows and high-brightness halogen lamps. It also has a unique application for the propulsion of spacecraft and satellites.

In electronics manufacturing, xenon is used in small amounts in lithography lasers, and in higher amounts and concentrations in etch applications. Sometimes xenon is used as itself in plasma etching, and alternatively as the fluorinated compound XeF_2.

Linde has deployed xenon recovery systems for more than 10 years in the glazing and lighting industries. Xenon is captured in proprietary vessels, shipped back to the global rare gas centres for re-purification. The original customer receives a credit for the xenon recovered at their site.

Recovering xenon in this way can have real tangible results. Being able to recover molecules of xenon enables us to expand the supply for all of our customers, and stabilise the cost of the material for larger users.

ElectronicsIQ.

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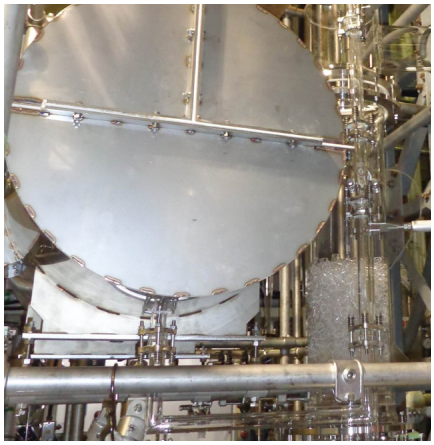
Sulphuric acid: Fresh water and logistics

The drivers for sulphuric acid recovery are very different to the other elements discussed in this newsletter. Here the benefits are reduction of disposal costs and associated demands for fresh water and waste water volumes.

Sulphuric acid is used in electronics manufacturing to remove sacrificial materials, to dissolve stray particles, and to otherwise clean semiconductors. Disposing of the used acid involves first neutralizing and then diluting the waste until it is acceptable for general waste water discharge to local standards.



The Linde Group joint venture, AUECC, is recovering sulphuric acid from the waste material, at a cost much less than disposal and with reduction on community waste flows. Linde uses proprietary exchange technology, and is able to recover a high percentage of sulphuric acid from a customer's waste material each time. The material can be purified for re-use in the electronics or other industries.

At the largest use semiconductor sites, the logistics of delivering fresh sulphuric acid and removing liquid waste can lead to congestion of delivery vehicles and large storage facilities. By moving in acid recovery, the logistics traffic and facilities can be significantly eased.

The result: reduced disposal costs, lower environmental impact, lighter traffic.

ElectronicsIQ.

Information Quarterly from Linde Electronics.

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How would you describe your role in 5 words?
Creatively combining people and opportunities.

What motivates you to get out of bed in the morning?
The potential to learn and to contribute.

Describe your colleagues in three words
Committed, Engaging, Collaborative.

Tell us a little about your background – university, degree qualification etc.
I have a Bachelors (University of Rochester) and a Doctorate (Caltech) degrees in Chemistry. In my research, I made and used long-wavelength lasers to measure the forces which attract molecules to each other, like those responsible for condensing water into a liquid and folding a protein into an active configuration. My work today shares the same approach: breaking complex things into simple parts, describing the important learning, and imagining the potential for something new.

What was it about Linde that made you join the company? How long have you been a part of the Linde team?
Gosh, at my relatively advanced tenure of 17 years, maybe it's better to comment on what has made me stay! I've enjoyed successive mini-careers in analytical chemistry, equipment development, on-site fluorine generation, and now new product development - all within Electronics. I've constantly been stretched to learn and develop, but also to connect; my greatest asset now is my ever-expanding network of colleagues. But thinking back to the beginning of my career, I was intrigued by the importance of simple molecules in very diverse applications, which is of course still true today.

What does your role entail?
New Product Development puts me at many different interfaces: technology, production, commercial, marketing, supply, our business units, customers, OEMs, materials suppliers. We examine many different technology trends and look for opportunities for new products and applications. But we are also tasked with evaluating the potential for technical and commercial success against our resources and expertise. Ultimately, it's about anticipating and understanding customer needs and finding the areas in which Linde can create value. I especially enjoy when we accomplish something new together.

What has been your proudest achievement during your time at Linde?
My first experience with an equipment project was working on a gas purification cabinet design for what was then, in 2001, on the roadmap to be the next big lithography milestone. The technical specifications were far beyond the current state-of-¬the-art. The team innovated and delivered to the very demanding expectations of the OEM, facilities for volume manufacturing were commissioned . . . and then the whole lithography industry hit an insurmountable (and expensive) technical roadblock, and our commercial offering was killed.
However, we picked ourselves up and used our contacts with the OEM to present ourselves as the best provider for their new needs. I led a team of vacuum, fluid dynamics, and controls experts to produce the first immersion lithography fluid dispense and extraction systems. With a new set of tight and evolving specifications, we went from blank page to delivered prototype in four months. It was a tremendous multi-site team effort, and required daily collaboration with the customer. Nearly a decade later immersion litho is still conquering new nodes - and I'm proud to have helped in a small way to enable it.

Service

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