EDISON

Spotlight - Initiation

BluGlass

Tech hardware & equipment

9 June 2021

Brighter future, lower temperature

BluGlass has pivoted its innovative compound semiconductor manufacturing technology onto the development of high performance laser diodes which it intends to start shipping at scale over the coming year. This will be a key step to achieving management's goal of capturing 8% of the laser diode market by calendar year 2026, potentially generating almost A$75m revenues annually.

Making higher performance laser diodes

BluGlass's patented remote plasma chemical vapour deposition (RPCVD) technology is used in conjunction with well-established metal organic chemical vapour deposition (MOCVD) technology to deposit the epitaxial layers forming a compound semiconductor device such as a laser diode, micro-light emitting diode (LED) or cascade LED. RPCVD operates at lower temperatures than conventional MOCVD technology and involves less active hydrogen when depositing layers of gallium nitride (GaN). Operating at lower temperatures and with reduced hydrogen gives higher performance epitaxial layers, potentially resulting in brighter compound semiconductor devices that are also less expensive to manufacture.

Shipments represent revenue inflection point

BluGlass has been generating modest revenues for several years from manufacturing compound semiconductor epitaxy for third parties. Entering the laser diode market represents a route for BluGlass to grow revenues much more rapidly. Based on industry sources, management estimates that the global laser diode market will grow from A$369m in CY21 to A$849m in CY26, driven by demand for lasers in industrial, display, biotech, scientific and lighting markets. Noting a delay to the laser diode product launch related to third-party production steps, BluGlass is raising up to $8.0m through a private placing of $2.0m and non-renounceable rights issue of up to $6.0m, both at $0.03/share, to provide a cash runway through to initial customer revenues.

Aiming to secure 6–10% of global laser diode market

While management has not provided formal guidance, it aims to secure 6–10% of the global laser diode market by 2026, which it estimates will then total US$658m (A$849m). This represents annual revenues of around A$60–90m. It is dependent on BluGlass successfully completing the development of the next generation of higher performance laser diodes using its RPCVD technology. Based on our assumed gross margins ranging from 35% to 45%, our scenario analysis calculates this level of revenues would generate EBITDA of A$14.1–21.6m.

Historical financials

Year end	Revenue (A$m)	EBITDA* (A$m)	PBT* (A$m)	EPS (c)	DPS (c)	P/E (x)
06/17	0.6	(2.9)	(3.3)	(0.88)	0.00	N/A
06/18	0.7	(3.8)	(3.8)	(0.97)	0.00	N/A
06/19	0.4	(5.1)	(5.1)	(1.21)	0.00	N/A
06/20	0.7	(3.6)	(4.8)	(1.01)	0.00	N/A

Source: Company reports

Price	**A$0.056**
Market cap	**A$43m**

Share price graph

Share details

Code	BLG
Listing	ASX
Shares in issue (prior to June fundraising)	722.6m
Net cash (A$m) at end March 2021(excluding lease liabilities)	2.5

Business description

BluGlass is an Australian technology company that is developing and commercialising a breakthrough compound semiconductor technology for the production of high efficiency devices such as laser diodes, light emitting diodes (LEDs) and micro-LEDs.

Bull

- RPCVD offers potential for manufacturing higher performance laser diodes.
- RPCVD offers potential for manufacturing higher-performance LEDs and micro-LEDs.
- BluGlass's first generation laser diodes will be available in hard-to-obtain form factors.

Bear

- Weaknesses with post-epitaxial process steps need to be resolved.
- Epitaxy for BluGlass's next-generation, higher performance laser diodes under development.
- Laser diode gross margin initially affected by outsourcing processes.

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BluGlass is a research client of Edison Investment Research Limited

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Investment summary

Company description: Making better epitaxial layers

BluGlass has developed a novel, patented technique, known as RPCVD, for depositing some of the epitaxial layers that form GaN-based compound semiconductor chips. The RPCVD technology enables BluGlass to improve the performance of a range of compound semiconductor devices. These include laser diodes used in industrial, display, biotech, scientific and lighting markets, as well as micro-LEDs used in displays and smart glasses and high brightness cascade LEDs used in general lighting and projectors. RPCVD also potentially reduces the cost of these devices by improving device efficiency and manufacturing yield. BluGlass has several routes for commercialising the technology. Using a combination of RPCVD and MOCVD techniques to create higher performance laser diodes represents the quickest route. In parallel, the company is offering an RPCVD foundry service and working with potential licensees on novel micro-LED and high brightness cascade LED structures.

Financials: Revenue uptick as sales of laser diodes begin

Revenues from customers halved year-on-year during H121 because Epiblu foundry orders were temporarily held back by coronavirus-related lockdowns in Europe and the US. EBITDA losses were at similar levels to the prior year period. Cash (there is no debt except for lease liabilities) reduced by A$1.1m during H121 to A$4.3m at end H121. The company benefited from A$1.5m R&D tax rebate relating to H121. Following a set-back to product launch schedules related to third-party production steps, management now expects to start shipping laser diodes at scale over the coming year. It has announced it is raising up to $8.0m at $0.03/share to provide sufficient cash runway to support the company to this point.

Aiming to secure 6–10% of laser diode market by 2026

While management has not provided formal guidance, it aims to secure 6–10% of the global laser diode market by 2026, which it estimates will then total A$849m. This would represent annual revenues of around A$60–90m. In our opinion, BluGlass will need to complete the development of its next-generation, higher brightness laser diodes manufactured using RPCVD for certain key epitaxial layers to achieve these levels of market penetration. Our scenario analysis calculates this level of revenues would generate EBITDA of A$14.1–21.6m. This assumes BluGlass is able to achieve gross margins of between 35% and 45%, which is in line with peers manufacturing laser diodes and subsystems. We assume incremental indirect costs are 10% of incremental sales, which will require good cost discipline, and that grants remain at H121 levels. The group already has sufficient epitaxial manufacturing capacity to achieve its 2026 revenue target.

Sensitivities: Post-epitaxial production issues to be resolved

The key sensitivities in our view are: (1) BluGlass needs to resolve the post-epitaxial production issues before it can start to send sample laser diodes to customers. As well as technical risk, there is also limited evidence yet to show whether the relative performance and price of the current generation of laser diodes, which do not include RPCVD layers, compared with laser diodes from established vendors is acceptable. In addition, BluGlass has not finished developing the epitaxy for its next generation of high brightness laser diodes incorporating RPCVD layers which management expects will exhibit superior performance to the competition. (2) There remains significant technical risk with regards to use of RPCVD to manufacture LEDs and micro-LEDs. (3) While BluGlass is dependent on several third parties for processing of laser diode epitaxy into laser diode devices it has identified alternative suppliers for each of these steps. (4) Financing, see above.

Company description: Platform technology with multiple go-to-market options

BluGlass has developed a novel, patented technique, known as RPCVD, for depositing some of the epitaxial layers that form GaN-based compound semiconductor chips. The technique enables critical layers in photonics devices to be deposited at a substantially lower temperature than conventional MOCVD techniques. By using nitrogen plasma as the source of nitrogen atoms rather than ammonia, which is a combination of nitrogen and hydrogen, it avoids the issues caused during MOCVD deposition when active hydrogen interacts with the epitaxial layer being formed. The RPCVD technology enables BluGlass to potentially improve the performance of a range of compound semiconductor devices. These include laser diodes used in industrial, display, biotech, scientific and lighting markets and micro-LEDs used in displays and smart glasses and high brightness cascade LEDs used in general lighting and projectors. By potentially enabling the creation of higher brightness devices with a better yield, RPCVD may reduce the cost of these devices. BluGlass's IP is protected by 75 international patents, awarded in key semiconductor manufacturing jurisdictions.

BluGlass has four paths for commercialising this technology:

- **Laser diode manufacture:** using the RPCVD technique in combination with more conventional MOCVD processing to manufacture enhanced performance laser diodes. The company intends to start shipping its first generation laser diode samples at scale over the coming year. These do not include RPCVD layers. It is also developing higher performance variants which do include RPCVD layers. Management has prioritised laser diode-related activity because it potentially starts to generate revenues during FY22 and is therefore the swiftest route to meaningful revenue generation. It aims to generate between A$60m and A$100m revenues annually by 2026 by capturing a 6–10% share of the addressable global laser diode market. This business activity was launched in October 2019.
- **Manufacturing services:** manufacturing compound semiconductor epitaxy wafers for customers at its Epiblu facility in Sydney. Epiblu has been offering low volume foundry services using RPCVD and MOCVD equipment for the manufacture of custom nitride templates and device wafers as well as R&D facilities and staff to help clients develop new devices for several years. Epiblu's smaller scale compared with IQE (which has over 100 reactors compared with BluGlass's five), for example, enables it to be a cost-effective partner for those wanting smaller development and experimentation services.
- **IP licensing:** licencing process IP for manufacturing micro-LEDs, high brightness cascade LEDs and other devices to companies designing and selling compound semiconductor chips. This would be accompanied by revenues from retrofitting the licensees' MOCVD equipment with RPCVD functionality. BluGlass started to work with potential licensees in 2019, but this activity is lower priority than commercialising laser diodes and has not generated any revenues so far.
- **Equipment module sales:** partnering with key manufacturers of MOCVD equipment who will add RPCVD functionality to their systems, enabling compound semiconductor material manufacturers to process most of the epitaxial layers using MOCVD while switching to RPCVD for those layers where it will enhance the performance of the end devices. This potential route to market has become less significant over the last year as potential partners Aixtron (AIXA:GR) and Veeco (VECO:US) appear less interested in RPCVD for laser diodes but continue to have interest in micro-LED and electronics applications.

BluGlass was founded in June 2005 to commercialise technology originally developed at Sydney's Macquarie University. After a decade of development, the company started to generate revenues from the provision of a foundry service in FY14. It is headquartered in Sydney, Australia, which is where it carries out R&D and manufactures the epitaxy for its own laser diodes and for customer projects. In June 2020, BluGlass opened its laser diode test facility in Nashua, New Hampshire, US. This facility manages the chain of third parties that execute the steps required to produce finished laser diodes from the epitaxial wafers manufactured in Sydney. BluGlass floated on the Australian Stock Exchange in September 2006 and employs around 25 people.

Laser diodes

Why this is an attractive market

High-brightness GaN laser diodes are used in a growing number of applications that include industrial lasers used for cutting and welding materials, automotive and general lighting, displays and life sciences. Based on industry sources including Strategies Unlimited, Markets and Markets and Laser & Photonics Marketplace 2018, management estimates growth in these market segments will result in a total addressable market worth A$849m by 2026.

Exhibit 1: Global laser market

Market	Applications	Wavelength
Industrial	Welding, cutting, machine vision, machine sensing, 3D printing	405nm, 450nm, 525nm
Display	Augmented reality/virtual reality, heads-up display, pico-projectors, business/cinema projectors	450nm, 525nm
Life sciences	Flow cytometry, medical diagnostics, DNA sequencing, endoscopy, bio-fluorescence	405nm, 420nm, 450nm, 490nm, 525nm
Lighting	Automotive headlights, general lighting, spotlight/torch	450nm
Other	Quantum computing, sensors for navigation, precise timing solutions	420mn, 488nm

Source: Edison Investment Research, Company data.

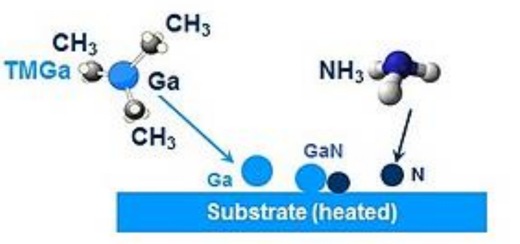
In support of management's analysis, we note that a report from Expert Market Research states that the global laser diode market, which is broader than just high brightness GaN laser diodes, was worth US$8.2bn (A$10.5bn) in 2020 and predicts that rising demand from the healthcare sector will support a CAGR of 7.7% between 2021 and 2026, resulting in a market totalling US$12.8bn (A$16.4bn) by 2026. A report from Mordor Intelligence notes that the global laser diode market was valued at US$8.8bn in 2020 (A$11.3bn) and predicts that the market will grow at a CAGR of 11.2% between 2021-2026 to reach US$16.3bn (A$20.8bn) by 2026.

Why RPCVD gives better performance laser diodes

Well-established MOCVD technique requires high temperatures

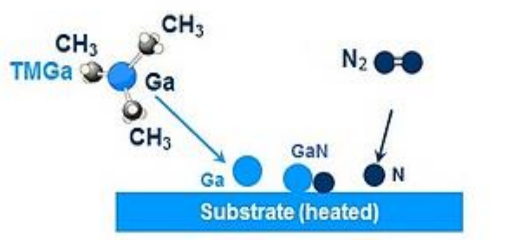
Many types of laser diodes, LEDs, power transistors and opto-electronic devices are based on the compound semiconductor material GaN. Typically, a layer of GaN is formed by reacting an organometallic compound containing gallium with ammonia (NH_3), which is a combination of nitrogen and hydrogen atoms, inside a MOCVD deposition chamber. The two gases react when they reach the heated substrate to form GaN. The substrate needs to be heated to at least 940°C to crack the ammonia into nitrogen atoms, which form the nitride in GaN, and hydrogen atoms (Exhibit 2). At lower temperatures than this, insufficient amounts of ammonia split to create nitrogen atoms, giving defects in the crystal structure where nitrogen atoms ought to be.

Exhibit 2: Deposition in MOCVD chamber



Source: BluGlass

Exhibit 3: Deposition in RPCVD chamber



Source: BluGlass

High hydrogen levels in MOCVD impairs p-GaN performance

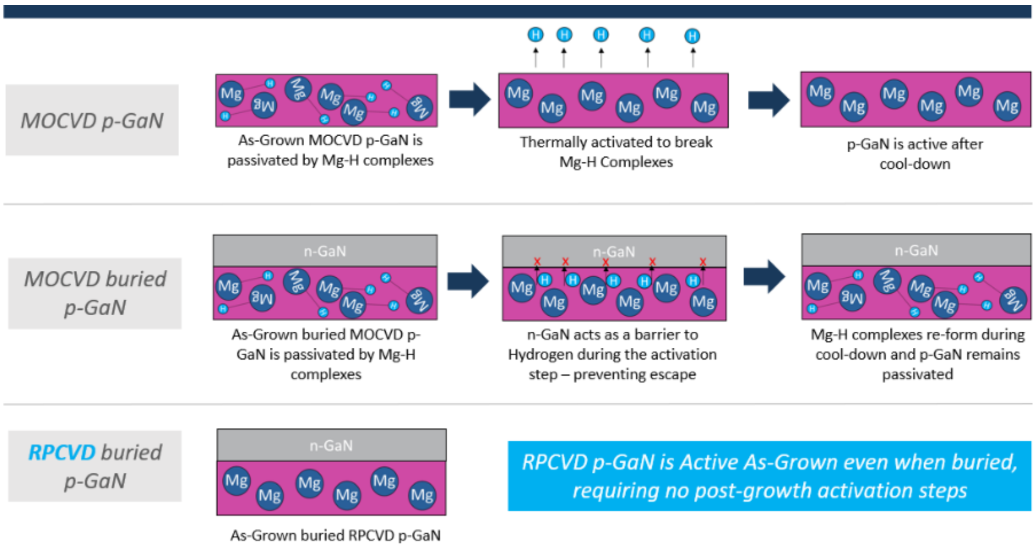
There are relatively high levels of hydrogen atoms close to the layer being deposited in an MOCVD reactor. Some of these are from the hydrogen carrier gas used to transport the other gases into the chamber, some are formed when the organometallic compound splits up to release gallium and some are formed when the ammonia splits to liberate nitrogen. These hydrogen atoms cause problems when manufacturing the p-type GaN layers in the laser diode structure. P-type layers of GaN are doped with magnesium atoms to create 'holes' or positive electric charge carriers. The hydrogen atoms bond with the magnesium atoms, stopping them from releasing holes. More magnesium needs to be added to give sufficient holes, increasing the resistance of the p-GaN layer. This hydrogen has to be driven out of the p-GaN layer by heating, a process that adds additional cost (Exhibit 4). Tunnel junctions, which are a key structure in high-performance laser diodes (Exhibit 6), have a thin p-GaN layer covered by a thin n-GaN layer that traps the hydrogen in the p-GaN, making it very difficult to drive off the hydrogen and activate the magnesium atoms.

High temperatures with MOCVD impair performance of critical MQW layer

There is also a problem with high temperatures when depositing GaN layers on top of the critical multi-quantum well (MQW) structures, which is where electrical energy is converted to light energy. The processing temperature needs to be as low as possible to prevent some of the indium diffusing both out of and within the indium GaN (InGaN) layer forming the MQW structure, causing performance degradation. However, higher temperatures (1050–1110°C) result in higher-performance GaN layers. Typically, there is a compromise, so the temperature at which the overlying GaN layers are deposited (940°C) is below that required to form an optimal quality p-GaN layer and above that required to avoid any negative impact on the MQW layer.

RPCVD is lower temperature and involves less active hydrogen

Exhibit 4: RPCVD process results in superior performance p-GaN layers



Source: BluGlass

BluGlass's patented RPCVD process uses nitrogen plasma (Exhibit 3), a form of energised nitrogen gas, instead of ammonia. As there is no longer any need to split up ammonia molecules, the substrate is only heated to 800–850°C. Importantly, there are far fewer hydrogen atoms close to the layer being deposited because less hydrogen is required as a carrier gas and there is no hydrogen created when sourcing the active nitrogen from nitrogen plasma rather than from ammonia as in the MOCVD process. The magnesium doping in any p-GaN layers provides the holes without recourse to any additional processing to drive off the hydrogen (Exhibit 4). In addition, as the plasma subsystem can provide more nitrogen atoms than is possible when ammonia is cracked at a low temperature, it can deposit a high performance GaN layer at a low temperature.

Laser diodes manufactured using MOCVD are inefficient

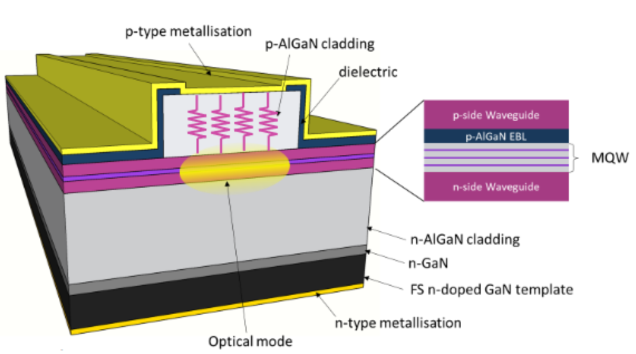
Both laser diodes and LEDs are based on the conversion of electricity to light in the MQW layers. GaN-based LEDs achieve a conversion efficiency of almost 90%, but GaN laser diodes have conversion efficiencies of around 45%. The waste energy becomes heat, limiting device performance. Being able to manufacture more efficient laser diodes brings cost advantages, because the wafer area required for the same light output becomes smaller, enabling more devices to be manufactured on a single wafer and improving yield.

RPCVD potentially provides solutions for manufacturing more efficient laser diodes

The main reason for the low efficiency of laser diodes is significant optical and electrical resistive losses in the p-GaN waveguide and cladding layers above the MQW structure (Exhibit 5). One solution that BluGlass is developing is to grow the p-GaN layers using RPCVD technology. This results in a lower electrical and optical resistance because the magnesium is not deactivated because the hydrogen levels are low, so smaller concentrations of magnesium doping are required to create enough holes. Additionally, as discussed above, the performance of the p-GaN layers is better than that achieved using temperatures at the lower end of the MOCVD range because the crystal structure is better.

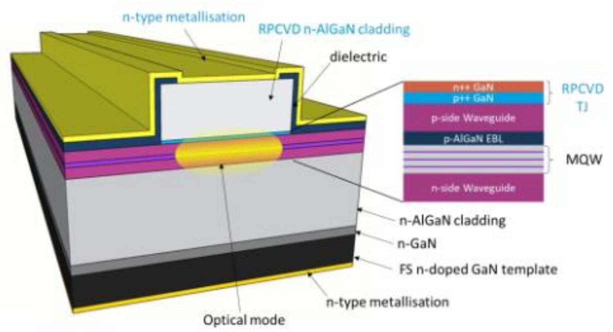
Another solution that has even better potential for delivering brighter laser diodes is to use RPCVD to grow a tunnel junction on top of the MQW structure. This allows the p-type cladding to be replaced with n-type cladding, which has an inherently lower electrical and optical resistance. As described above, RPCVD enables engineers to deposit a p-GaN layer in a tunnel junction that is functional without the need for additional complex processing steps to activate the holes.

Exhibit 5: Conventional laser diode manufactured using MOCVD technique



Source: BluGlass

Exhibit 6: Tunnel junction laser diode



Source: BluGlass

The lower temperature required for RPCVD also helps improve yield. Indium atoms are initially deposited uniformly across the critical MQW structure. The high temperature needed for MOCVD causes some of the indium to diffuse both out of and within the MQW layer, creating areas that are brighter than others, impairing performance. This is particularly important for longer wavelengths of light that require higher levels of indium, which is why BluGlass is focusing on laser diodes with a wavelength of 450nm and longer. Operating at lower temperatures also stops the dopants in the thin p-type and n-type layers forming a tunnel junction from diffusing into the other layer, impairing performance.

Competitive position of RPCVD: Unique, patent-protected technology

To our knowledge, BluGlass is the only company globally to use RPCVD technology to manufacture GaN on a commercial basis. Two of the three major companies globally manufacturing MOCVD equipment (Aixtron and Veeco) seem more interested in working with BluGlass than developing their own RPCVD technology, which is patent protected. The third, Advanced Micro-Fabrication Equipment China appears to be focused on high-volume LED and power device markets. In our opinion, the competition is from manufacturers of molecular beam epitaxy (MBE) equipment such as Riber (RIB:FP) and Veeco. MBE operates at a substantially lower temperature than either RPCVD or MOCVD and uses a beam of nitrogen molecules rather than ammonia, so does not have the problems that MOCVD does when manufacturing tunnel junctions. MBE is also being evaluated for manufacturing micro-LEDs. However, MBE does not have the throughput of MOCVD technology and cannot be retrofitted into MOCVD equipment in the way that RPCVD technology can, enabling different layers in the same epitaxial structure to be grown using either MOCVD or RPCVD without removing the wafer from the reactor chamber. Potential advances in substrates may enable engineers to develop more efficient red LEDs manufactured using MOCVD equipment without the need for RPCVD to deposit critical layers, although this is only at a research stage.

Micro-LEDs

As the name suggests micro-LEDs are very small LEDs, typically 20µm × 20µm (a micrometre, µm, is one millionth of a metre) compared with 200µm × 200µm for a conventional LED. Because a micro-LED emits no light at all when the electric field across it is off, the contrast between light and dark is much better than a liquid crystal display (LCD) pixel, which will still let a little light from the backlight through when it is in 'off' mode. As a result, arrays of micro-LEDs are being proposed as a technique for improving the colour contrast, colour saturation, response time and energy efficiency of flat panel displays, with each micro-LED forming a single pixel in the display. In addition, the improved energy efficiency makes micro-LED technology a desirable alternative to conventional LCD technology for applications such as smart watches, smart phones and augmented reality or virtual reality headsets where lower power consumption extends the time between battery charges. Moreover, the individual pixels can be made smaller, without compromising on brightness. This is desirable for these applications because it enables users to see the screen even in bright sunlight. Further into the future, micro-LEDs may also be used for multi-site neuron stimulation in brain/machine interfaces, miniaturised opto-electronic tweezers and optical cochlear implants.

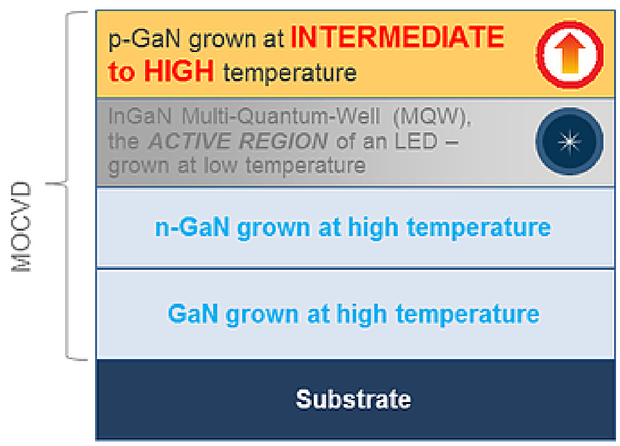
BluGlass is working with partners on paid-for development programmes to improve colour availability of micro-LEDs. These programmes represent potential licencing opportunities as the volumes required in the micro-LED market are too large for BluGlass's facility. These revenues will be incremental to the target revenues from the laser diode market.

Making longer wavelength micro-LEDs

BluGlass's RPCVD process also has potential in the manufacture of RGB micro-LEDs, which are a composite of a red, a green and a blue LED that collectively produce a white light or can be tuned to emit a complete range of colours depending on the intensity of each individual colour LED. Most LEDs emit a blue light and are made from GaN, with an active MQW layer of InGaN. If higher levels of indium are added to the active layer, it will emit a green light. If even more indium is added to the active layer it will emit a red light.

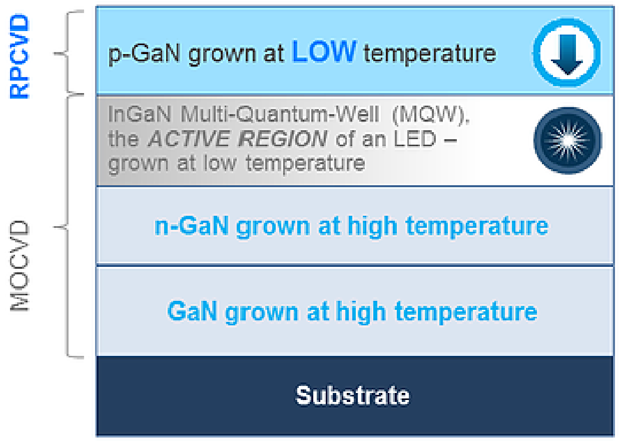
As discussed above, the high temperatures needed for MOCVD deposition of the p-GaN layer on top of the MQW layer in an LED (Exhibit 5) degrades the MQW structure, but the lower temperatures needed for RPCVD makes it possible to make red LEDs from InGaN. The ability to create red light from a GaN based epilayer is particularly important for micro-LED applications. Currently, gallium arsenide or aluminium indium gallium phosphide are used to generate red light, but neither material converts electricity to light efficiently enough to make bright enough LEDs when the pixel size is shrunk to below 5µm.

Exhibit 7: LED structure manufactured using MOCVD



Source: BluGlass

Exhibit 8: LED structure manufactured using RPCVD



Source: BluGlass

High brightness cascade LEDs

LEDs have become commonplace for lighting in homes and businesses and, as a result, the technology has been commoditised. However there remain some specialist applications such as projector lamps where higher brightness LEDs are required. BluGlass has recently worked with partners on paid-for development programmes to create higher brightness LEDs and has indicated it will revisit these programmes once the RPCVD based laser diodes have been developed. As with the micro-LED programmes, these represent potential licencing opportunities because of the volumes required.

Making LEDs brighter

Because LEDs convert electricity to light, supplying more electric power to an LED should result in more light coming out. However, past a certain point, doubling the amount of power results in less than double the amount of light being emitted and as more and more power is supplied, the proportion of energy converted reduces further, a phenomenon known as ‘efficiency droop’. Putting two LEDs next to each other does not improve the brightness per area because the light is transmitted from a wider area. One approach that is being developed is to stack LEDs on top of each other to form a ‘cascade LED’ with the LEDs separated from each other with tunnel junctions. As noted above, RPCVD is better than MOCVD for manufacturing tunnel junctions. Cascade LEDs are particularly suitable for projector applications as these require small form-factor high brightness LEDs, preferably ones that can be operated at lower current densities to keep the temperature down.

Progress executing strategy

As discussed above, BluGlass has four paths for commercialising the RPCVD technology: sales of laser diodes; Epiblu foundry revenues; licencing process IP; and potentially licencing production of RPCVD equipment. The focus over the last year has been on developing BluGlass’s laser diodes and ensuring these can be manufactured in sufficient volume. This continues to be the focus.

Own-brand laser diodes

BluGlass intends to start shipping its first-generation laser diodes at scale over the coming year. These will operate at 405nm, 420nm and 450nm. These first generation devices are being manufactured using only MOCVD techniques to gain market penetration ahead of the launch of RPCVD enabled devices. When the current post-epitaxial production issues have been resolved (see below), BluGlass expects that these will have similar performance to existing laser diodes on the market. However, BluGlass will offer devices in a greater range of form factors than its competitors.

The company intends to follow-up the first generation product launch with the launch of higher performance laser diodes incorporating either lower resistance p-type cladding or tunnel junctions that have been manufactured using RPCVD for critical layers. BluGlass has manufactured the epitaxy for both types of higher performance laser diode and is working with partners to process the epitaxy into complete devices. The performance of these devices will not be known until the devices are complete and can be tested. Management has not disclosed when it expects either of these types of devices to be launched.

In parallel with developing the devices, BluGlass has set-up a supply chain for manufacturing laser diodes in volume on 2" diameter wafers. As well as ensuring there is enough production capacity in-house for the epitaxy (see below), it has evaluated third parties who carry out the different steps converting the epitaxial wafer to fully functional devices. These include cutting the wafer into individual laser diode chips, adding an optical coating, packaging the chips and burn-in. The company has also set-up its own facility in the US for testing the finished devices, which was opened in June 2020.

BluGlass had hoped to start shipping samples of its first generation laser diodes by the end of FY21 (June 2021). The performance of these devices could not be confirmed until the epitaxy processed at BluGlass's facility had been packaged into fully functional devices by third parties. Tests on the packaged prototype devices showed lasing results consistent with commercial specifications for output power and wavelength. This showed the soundness of BluGlass's epitaxial process. However, when the prototypes went through reliability testing they showed a gradual loss of light output over time which did not meet with commercial specifications. This issue is related to the part of the devices where light leaves the diode and is caused by problems in the post-epitaxial processing steps carried out by third parties. While this is the first time that BluGlass has experienced this issue with its devices, the phenomenon is well understood within the laser diode industry. BluGlass intends to seek additional experienced assistance regarding post-epitaxial processing from those with established production capabilities in the industry to help resolve the issue. Newly appointed non-executive director, Jean-Michel Pelaprat, and senior laser scientist, Dr Arkadi Goulakov (see below), are already helping solve this problem.

Expanding production capacity for anticipated laser diode demand

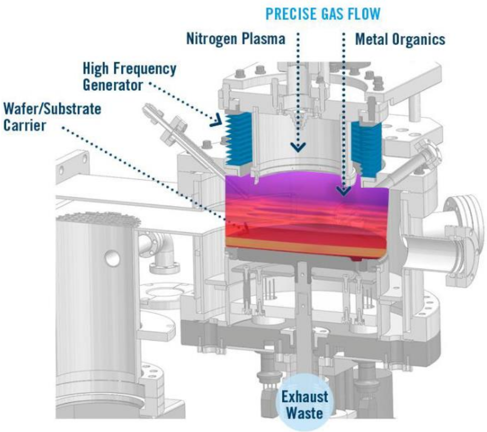
In August 2019 BluGlass officially opened its upgraded Sydney facility, which increased capacity by more than 30% at the time. The facility now has five deposition systems. Four of these are RPCVD deposition reactors, of these, one is a higher capacity BLG-500 (see below), which is an MOCVD system retrofitted in collaboration with Aixtron to include RPCVD capability, and one is a retrofitted system from Veeco. The BLG-500 system did not come online until calendar year H220. The fifth deposition system is a standard MOCVD platform. The facility is being used to manufacture the epitaxy for laser diodes and to make custom epitaxy for customers, including LED development projects. Management estimates the facility has capacity to output up to 10,000 wafers per year and is sufficient to reach the target of AUS75m revenues from manufacturing its proprietary laser diodes.

BluGlass's RPCVD technology uses modified MOCVD systems. As part of the programme of expanding production capacity, BluGlass worked with Aixtron to create the BLG-500, which is the largest RPCVD manufacturing platform to date. This involved retrofitting RPCVD functionality into an Aixtron AIX-2800G4 MOCVD system. The new deposition platform, which completed its final performance tests in October 2020, can process six 6" diameter wafers or 42 2" wafers simultaneously. This is several times the capacity of the previous largest RPCVD system, the BLG-300, which can process a single 6" wafer or 19 2" wafers. In June 2020 BluGlass was awarded a A$0.25m matched-funding innovation grant from the Australian government to create smarter, more efficient plasma sources for the BLG-300 systems.

Exhibit 9: BLG-500

Source: BluGlass

Exhibit 10: Schematic of RPCVD system



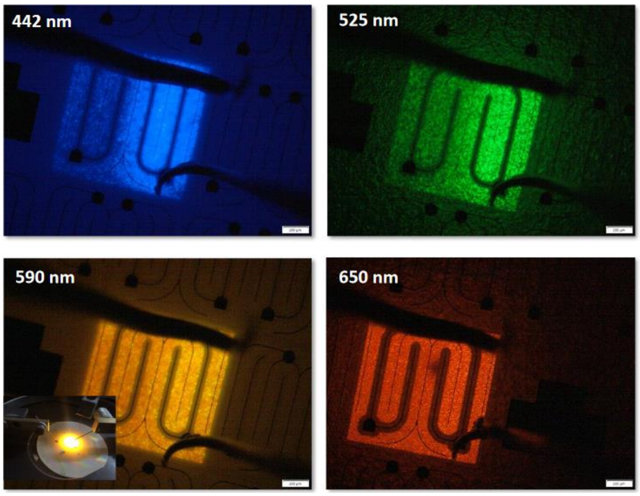
Source: BluGlass

Licencing IP to photonics chip manufacturers

In September 2019 BluGlass signed a collaboration agreement with Bridgelux, an LED lighting specialist selling over 100 million LED die each month, to develop cascade LEDs for commercial lighting applications. In December 2019, BluGlass signed a non-exclusive collaboration agreement with LED innovator Luminus on cascade LEDs for entertainment, head-up displays and projector applications. BluGlass is also working with Xdisplay, which was spun-off from X-Celeprint in 2019, on micro-LED display prototypes for mobile phones. Development work for third parties slowed during H220 as BluGlass concentrated its R&D resources on tunnel junction development for laser diodes and customers temporarily closed operations in response to coronavirus restrictions, although two of the three micro-LED customers recommenced operations in FY21. BluGlass has, however, demonstrated good progress in manufacturing epitaxy for orange and red LEDs and microLEDs using RPCVD technology (Exhibit 11). It has also completed a critical proof-of-concept milestone with regards to cascade LEDs, demonstrating a two-colour cascade LED with a green LED on top of a blue one. We note that the work on tunnel junctions for cascade LEDs supports the development of higher performance laser diodes.

In February 2021, BluGlass announced that it was working with Yale University on the US Defense Advanced Research Projects Agency-funded lasers for universal microscale optical systems research (Lumos) programme that seeks to combine efficient integrated optical systems and complete photonics functionality onto a single substrate for applications such as compact optical phased array light detection and ranging (LiDAR) and neuromorphic optical computing. BluGlass will be supplying custom GaN laser diodes and laser epitaxial wafers to Yale for incorporation into a photonic integrated circuit. The first phase of the tri-partite programme is scheduled to last 18 months. The value of the contract has not been disclosed.

Exhibit 11: Demonstration of RPCVD grown RGB LEDs fabricated into devices



Source: BluGlass

Management

BluGlass's board is very experienced in commercialising technology in new markets. Chair **James Walker** has over 25 years' experience as a chartered accountant, company secretary and senior executive of AIM and ASX-listed technology companies. He has successfully completed multiple ASX IPOs, corporate acquisition transactions, secondary round raises on both the ASX and UK AIM markets and private capital raises. Following the resignation of the CEO in June 2021, James has moved from a non-executive to an executive role while the company seeks a replacement CEO. The new CEO is likely to have deep laser diode industry experience. We note that Jean-Michel Pelaprat, who joined the board as a non-executive director in May 2021, is co-founder and director of blue GaN laser pioneer Nuburu and has over 30 years' experience establishing, commercialising and scaling laser and semiconductor businesses.

Key members of the management team are chief technology and operations officer **Dr Ian Mann**, VP of business development **Brad Siskavich,** senior laser scientist **Dr Arkadi Goulakov** and financial controller **Izzat Shadid**. Ian has worked for several cutting-edge technology companies in the US and Australia where he managed technology teams, developed and executed transition strategies and business plans and facilitated mergers and acquisitions as well as establishing spin off companies to commercialise intellectual property. Brad is based in the US and has more than 20 years' experience in developing, marketing and commercialising new technologies in start-up and high-growth environments in the compound semiconductor, photovoltaic, laser, photonics and opto-electronics industries. His expertise includes transferring technology from prototype to commercial production. Arkadi joined BluGlass in March 2021. He has more than 30 years' experience developing and commercialising cutting edge opto-electronics and held technical leadership positions at US laser organisations including, II-VI Optoelectronic Devices, Western Digital and Seagate Technologies and technical roles at Microsemi, AlfaLight and Corning Applied Technology. His appointment provides enhanced depth to BluGlass's laser diode business development, bringing extensive fabrication and back-end processing expertise to complement BluGlass's existing design and epitaxial capabilities. Izzat took over day-to-day responsibility for the company's finance and accounting functions in October 2017, having worked for BluGlass for nine years before that.

Sensitivities

Completion of laser diode development

BluGlass needs to resolve the post-epitaxial production issues before it can start to send sample laser diodes to customers. As well as technical risk, there is also commercial risk because there is little feedback yet from potential customers to show whether the relative performance and price of the current generation of laser diodes compared with laser diodes from established vendors is acceptable. In addition, BluGlass has not finished developing the epitaxy for its next generation of laser diodes, which management expects will exhibit superior performance to the competition.

Success of IP licensing

Because BluGlass has been focusing on the development its own laser diodes over the last year, and continues to do so, it has not completed the development work on cascade LEDs or micro-LEDs that it could potentially licence to third parties. There remains significant technical risk in this area as well.

Contract manufacturing supply chain

BluGlass is dependent on several third parties for processing laser diode epitaxy into laser diode devices. BluGlass has identified alternative suppliers are available for each of these steps. BluGlass may bring some of these steps in-house in future (see below).

Financing

BluGlass is generating modest levels of revenue at present and is still consuming cash. BluGlass has announced it is raising $2.0m through a private placing and up to $6.0m through a non-renounceable rights issue, both at $0.03/share, to provide a cash runway through to initial customer revenues. We note the group has sufficient epitaxial manufacturing capacity to achieve its 2026 revenue target. Management may invest up to A$3m bringing additional processes in house longer term to improve gross margins as volumes justify this.

Financials: On cusp of revenue growth

Revenues up to this point (see Exhibit 12) have been derived entirely from epitaxy services. Revenues from customers halved year-on-year during H121 because Epiblu foundry orders were delayed by coronavirus related lockdowns in Europe and the US. The cost of consumables rose by A$0.7m reflecting high levels of R&D activity on laser diodes. However, the company benefitted from A$0.6m government grants, including funding from the Job Keeper programme and an A$1.5m R&D tax rebate relating to H121, so EBITDA losses were at similar levels to the prior year period. Depreciation charges were A$0.5m higher, reflecting commissioning of the BLG-500, which is worth c A$4m, at the start of H121, so reported losses after tax widened by A$0.5m to A$3.7m. EPS losses reduced by 33% to 0.51c/share because of the dilutive effect of a rights issue and shortfall placement collectively raising A$5.9m (gross) in April 2020. Q321 revenues were similar to H121 levels as BluGlass generated $84k from foundry services for micro-LED and LED customers and A$33k relating to the Yale/DARPA development programme.

Cash (there is no debt except for lease liabilities) reduced by A$1.1m during H121 to A$4.3m at end H121. Investment in capital equipment was minimal (A$74k) as the investment in production capability completed during FY20. All R&D activity is expensed and 43.5% of the cost is covered by government tax rebates. The A$1.2m reduction in trade and other receivables relates to the R&D tax rebate provided by the Australian government. At the end of June 2020 the balance sheet showed 12 months of accrued rebate, while the December 2020 value showed only six months. Cash at the end of March 2021 was A$2.5m.

Exhibit 12: H121 and H120 performance compared

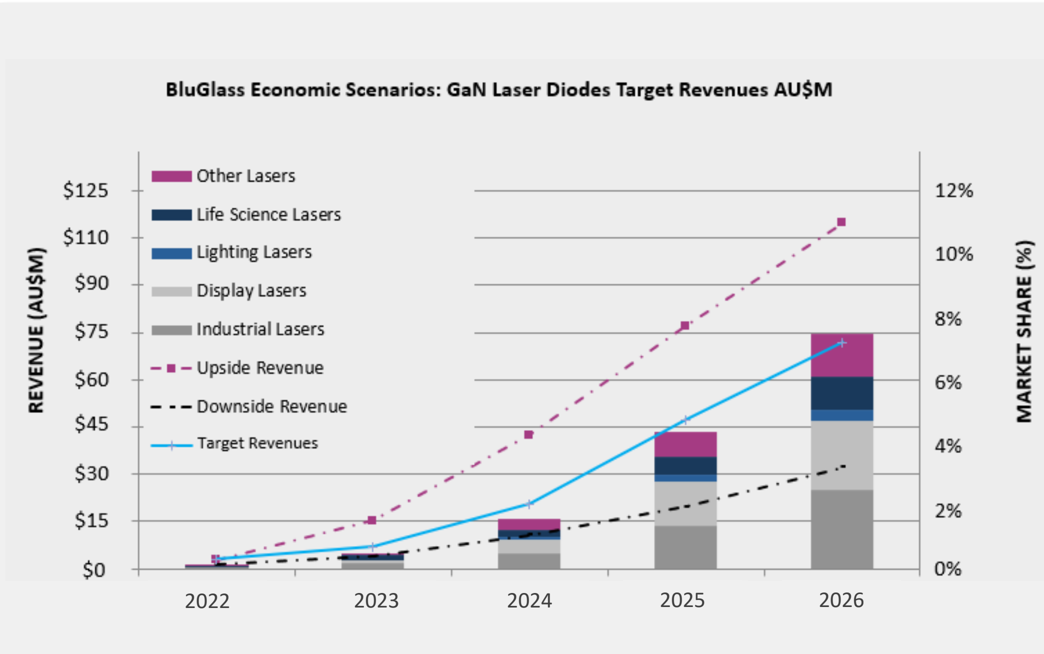
A$000s	H121	H120
Sales revenue	220	477
Grants	1,996	1,266*
Consumables	(1,726)	(1,055)
Other expenses	(2,611)	(2,786)
EBITDA	(2,121)	(2,098)
Depreciation and amortisation	(1,079)	(532)
Share-based payments	(448)	(515)
Reported operating loss	(3,648)	(3,145)
Finance costs (net)	(37)	(19)
Reported loss before tax	(3,685)	(3,164)
Tax	0	0
Reported loss after tax	(3,685)	(3,164)
Reported EPS (c)	(0.51)	(0.76)

Source: Company data. Note: *Including $560,000 Job Keeper and other government grants.

Scenario analysis

While management has not provided formal guidance, it aims to secure 6–10% of the global laser diode market by 2026, which it estimates will then total US$658m/(A$849m). This represents annual revenues of around A$60–90m, excluding any contribution from IP licencing linked to LEDs or manufacturing epitaxy for third parties.

Exhibit 13: GaN laser diode target revenues (A$m)



Source: BluGlass based on industry sources including Strategies Unlimited, Markets and Markets and Laser & Photonics Marketplace 2018

Management has not provided any information on its goals regarding cash generation or profitability. There are very few listed companies specialising in laser diodes that can be used as comparators. Akela Laser, Nichia and Nuburu are privately held. Many of the listed companies offer laser diodes as part of a much broader portfolio of products, some of which are highly commoditised, such as LEDs. IQE supplies compound semiconductor epitaxy, around half of which is for power amplifiers in handsets, rather than complete devices. Aixtron, Riber and Veeco are equipment manufacturers. We summarise margins of the listed companies in Exhibit 14.

Exhibit 14: Peers involved in production and sale of laser diodes

Company	Period	Revenues (US$m)	Gross margin (%)	EBITDA margin (%)	Notes
Coherent	FY20	1,229	33.4	N/A	Laser diodes and sub-systems
Everlight	FY19	755	24.5	13.9	LEDs
Hamamatsu Photonics	FY20	1,286	48.8	24.6	Optical components including laser diodes and systems
Kyocera	FY20	14,012	27.6	12.1	Acquired SLD Laser in January 2021 Laser diodes a small proportion of diverse portfolio
Lumentum	Q420	368	47.2	N/A	Laser diodes and modules
Osram Light – Opto Semiconductors	FY20	1,621		20.0	LEDs, laser diodes, infra-red emitters, photodetectors.
Rohm Semiconductor	3Q21	2,419	31.6	20.5	Laser diodes a small proportion of diverse portfolio
Sharp	FY20	20,827	18.0	5.8	Laser diodes a small proportion of diverse portfolio

Source: Edison Investment Research

Based on the gross margins of its closest peers, Coherent, Hamamtsu and Lumentum, our scenario analysis assumes that BluGlass can achieve gross margins of between 35% and 45% once it is gaining meaningful market share by selling next-generation higher performance laser diodes including RPCVD layers. To start with, BluGlass's gross margin is likely to be relatively modest because so many processing steps will be outsourced but will potentially improve as the company invests in equipment to bring some of these steps in-house.

Exhibit 15: Scenario analysis (A$m)

Revenue	1.0	5.0	10.0	16.0	25.0	50.0	75.0
Grant income	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Operating costs	(8.8)	(9.2)	(9.7)	(10.3)	(11.2)	(13.7)	(16.2)
EBITDA at 35% gross margin	(4.4)	(3.4)	(2.2)	(0.7)	1.6	7.8	14.1
EBITDA at 40% gross margin	(4.4)	(3.2)	(1.7)	0.1	2.8	10.3	17.8
EBITDA at 45% gross margin	(4.3)	(2.9)	(1.2)	0.9	4.1	12.8	21.6

Source: Edison Investment Research

We also assume that incremental indirect costs will grow at 10% of incremental sales, which will require good cost discipline, and that grants will remain at H121 levels. The analysis shows that if BluGlass was to achieve 8% of the laser diode market by 2026, this would represent A$14.1–21.6m EBITDA at different gross margin assumptions. It also shows BluGlass could potentially reach cash breakeven with annual revenues of around A$16m and gross margins at the middle of our range. Management's goal is to reach this level during calendar year 2024, although we note this does not represent formal guidance. The group already has sufficient epitaxial manufacturing capacity to achieve its 2026 revenue target.

Exhibit 16: Financial summary

A$000	2017	2018	2019	2020
Year end 30 June	AASB	AASB	AASB	AASB
INCOME STATEMENT				
Revenue (excluding grants)	550	714	425	656
Cost of Sales (excluding direct labour)	(897)	(1,158)	(1,745)	(1,898)
Gross Profit	(346)	(444)	(1,320)	(1,242)
EBITDA	(2,930)	(3,750)	(5,109)	(3,616)
Normalised operating profit	(3,405)	(3,941)	(5,287)	(4,687)
Amortisation of acquired intangibles	0	0	0	0
Exceptionals	0	0	(8,695)	0
Share-based payments	(391)	(56)	(674)	(1,237)
Reported operating profit	(3,795)	(3,997)	(14,656)	(5,925)
Net Interest	135	157	236	(69)
Profit Before Tax (norm)	(3,270)	(3,784)	(5,052)	(4,757)
Profit Before Tax (reported)	(3,661)	(3,840)	(14,421)	(5,994)
Reported tax	0	0	0	0
Profit After Tax (norm)	(3,270)	(3,784)	(5,052)	(4,757)
Profit After Tax (reported)	(3,661)	(3,840)	(14,421)	(5,994)
Basic average number of shares outstanding (m)	372.4	389.4	418.3	473.1
EPS - basic normalised (c)	(0.88)	(0.97)	(1.21)	(1.01)
EPS - diluted normalised (c)	(0.88)	(0.97)	(1.21)	(1.01)
EPS - basic reported (c)	(0.98)	(0.99)	(3.45)	(1.27)
Dividend (c)	0.00	0.00	0.00	0.00
Revenue growth (%)	N/A	29.8%	-40.5%	54.5%
Gross Margin (%)	N/A	N/A	N/A	N/A
EBITDA Margin (%)	N/A	N/A	N/A	N/A
Normalised Operating Margin	N/A	N/A	N/A	N/A
BALANCE SHEET				
Fixed Assets	9,031	8,954	5,395	7,883
Intangible Assets	8,695	8,695	0	0
Tangible Assets	336	259	5,395	7,883
Investments & other	0	0	0	0
Current Assets	10,884	17,716	8,558	8,547
Stocks	104	54	137	140
Debtors	2,217	2,253	2,262	2,919
Cash & cash equivalents	8,511	15,354	6,116	5,430
Other	52	55	43	58
Current Liabilities	(861)	(963)	(1,003)	(1,154)
Creditors	(461)	(530)	(473)	(408)
Lease liabilities	0	0	0	(168)
Short term borrowings (excluding lease liabilities)	0	0	0	0
Provisions	(401)	(433)	(530)	(578)
Long Term Liabilities	(352)	(318)	(1,306)	(2,882)
Long term borrowings (excluding lease liabilities)	0	0	0	0
Provisions and lease liabilities	(352)	(318)	(1,306)	(2,882)
Net Assets	18,702	25,389	11,644	12,393
Minority interests	0	0	0	0
Shareholders' equity	18,702	25,389	11,644	12,393
CASH FLOW				
Net operating cash flow	(2,597)	(3,514)	(4,931)	(4,348)
Capex	(37)	(114)	(4,308)	(1,681)
Acquisitions/disposals	0	0	0	0
Net interest	0	0	0	(9)
Equity financing	7,735	10,471	1	5,507
Dividends	0	0	0	0
Other	0	0	0	0
Net Cash Flow	5,101	6,843	(9,237)	(532)
Opening net debt/(cash)	(3,410)	(8,511)	(15,354)	(6,116)
FX	0	0	0	0
Other non-cash movements	0	0	0	(154)
Closing net debt/(cash)	(8,511)	(15,354)	(6,116)	(5,430)

Source: Company reports

EDISON

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