Semiconductors

Silicon Carbide could be a profitability tailwind

Equities

Global
Semiconductors

David Mulholland, CFA
Analyst
david.mulholland@ubs.com
+44-20-7568 4069

Francois-Xavier Bouvignies
Analyst
francois.bouvignies@ubs.com
+44-20-7568 7105

Shingo Hirata
Analyst
shingo.hirata@ubs.com
+81-3-5208 6224

Kenji Yasui
Analyst
kenji.yasui@ubs.com
+81-3-5208 6211

Bill Lu
Analyst
bill.lu@ubs.com
+852-2971 8360

Nicolas Gaudois
Analyst
nicolas.gaudois@ubs.com
+852-2971 5681

Stephen Chin
Analyst
stephen.chin@ubs.com
+1-212-713 4111

Steven Chin
Analyst
steven.chin@ubs.com
+1-415-352 5675

Silicon Carbide could become a profitability tailwind

We hosted a call with Jean-Christophe Eloy, President and CEO of Yole Développement a market research firm, where we discussed the future of Silicon Carbide (SiC). This report includes our key takeaways and a full transcript. Our key takeaways from the call were: 1) Yole forecast the SiC market inflecting from 2020 onwards as modules start to see much wider adoption (which we believe is supportive for Infineon's position); 2) At this point, Yole has taken a conservative approach to its assumptions around adoption of SiC in EV's but this could be a source of upside and drive the market. 3) While today STMicro holds c10% share, Jean-Christophe believes that longer-term it will likely need module capabilities (either in-house or through partnership) to gain share. 4) Longer-term, Jean-Christophe sees scope for profit margins to be higher in Silicon Carbide vs. IGBT products due to lower competition assuming wafer supply improves.

Substrate capabilities likely to be helpful short-term but less-so long-term

In the short-term having the substrate / wafer supply in-house will likely be a benefit to those like Wolfspeed (Cree) and Rohm given the wafer supply is limited. However, as the market ramps, Jean-Christophe expects we will see more of a merchant market develop and so in the medium-term the value driver will shift more towards module capabilities and play towards the strengths of companies like Infineon or Mitsubishi Electric that have module capabilities in-house and are leaders in the IGBT market.

Profitability could be higher longer-term with Silicon Carbide modules

One of our key takeaways from the call with Jean-Christophe is his view that actually long-term the profit margins in SiC could be higher. The IGBT market is a competitive market and with higher content and potentially wafer prices coming down as the market ramps, he believes profit margins could be higher on SiC compared to those seen in IGBT today thought obviously with numerous moving parts.

Potential beneficiaries include Cree, Infineon, STMicro and Rohm

The main listed beneficiaries of Silicon Carbide remain Cree, Infineon, STMicro and Rohm. We continue to see Silicon Carbide as more of an opportunity than a risk for Infineon and reiterate our Buy rating.

This report has been prepared by UBS Limited. **ANALYST CERTIFICATION AND REQUIRED DISCLOSURES BEGIN ON PAGE 18.** UBS does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision.

Summary of our takeaways

Q. What is driving the Silicon Carbide adoption?

A. Jean-Christophe Eloy believes that the adoption will be driven by: **1) Size and weight reduction** at the module level as silicon carbide requires less cooling and passive components relative to silicon. This helps to decrease the size and have a significant weight reduction. **2) Efficiency**. You're able to decrease the losses from power conversion within the modules; **3) High temperature function.** Silicon carbide is able to operate at much higher temperatures compared to silicon and it opens applications in oil and gas and also helps to decrease the amount of cooling you need for the system.

Q. What should we expect in terms of growth from Silicon Carbide?

A. Yole Développement estimates the silicon carbide market could be worth >$1bn in revenues in 2022 with growth accelerating materially beyond 2020 as module solutions ramp.

Q. What kind of applications will drive this growth?

A. The applications that Yole Développement expects to be the largest by 2022 are the solar (PV) market - worth $308m, uninterruptable power supplies worth $172m and then the EV/HEV market worth $146m. Jean-Christophe did flag however that there is potential the EV market could accelerate more significantly than they have assumed.

Q. How the competitive landscape looks like?

A. Yole Développement estimates that in 2016, Wolfspeed was the market leader for SiC Power Devices with 24% share, followed by Infineon and Rohm both on 22%. There is then a notable gap to Mitsubishi and STMicro each on 10% share. Jean-Christophe believes that, at the moment internal wafer manufacturing is key as it gives you more flexibility on pricing. But long-term this advantage could disappear if the substrate supply increases as the market ramps. Longer-term Jean-Christophe expects module development will become more of a differentiator between suppliers to the market.

Q. Will Silicon Carbide be positive or negative for profit margins?

A. Jean-Christophe Eloy believes that silicon carbide products could be **much higher in term of margin in the mid-term**. This is supported by: 1) The higher price of the silicon carbide semiconductor component and 2) the shift towards a module market will increase the ability for providers to deliver more value (the overall system cost reduction) and extract better margins.

Raw Conference Call Transcript

Moderator: David Mulholland, UBS European Tech Hardware Analyst

Speaker: Jean-Christophe Eloy, President and CEO Yole Développement

We present below highlights from our recent call with Jean-Christophe Eloy of market research firm Yole Développement. We have edited the transcript below for clarity. Minor grammatical changes that do not impact the meaning of content have been applied. Changes to content to clarify meaning have been underlined. The opinions expressed by Jean-Christophe Eloy herin do not necessarily reflect the views and opinions of UBS. UBS accepts no responsibility for the accuracy, reliability or completeness of the information and will not be liable either directly or indirectly for any loss or damage arising out of the use of this information or any part thereof.

Wednesday, August 23 @ 3.30pm UK Time

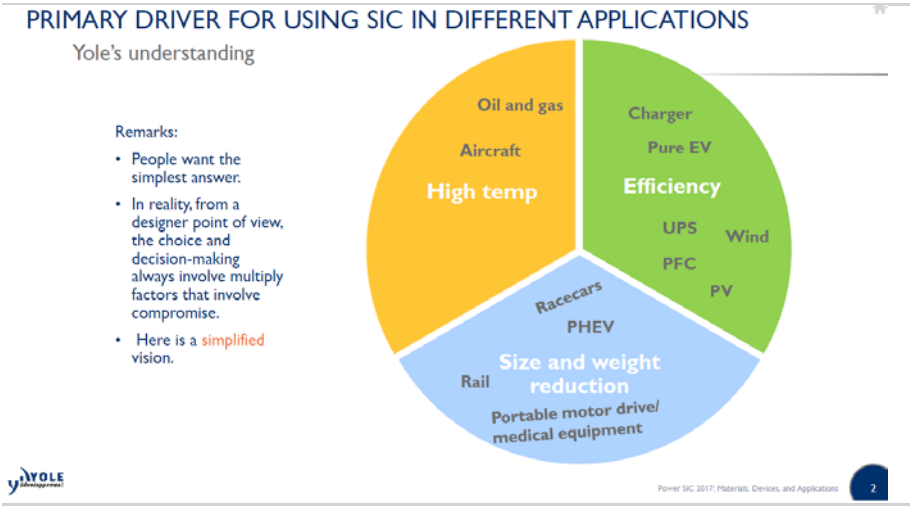
David Mulholland: Hi, everyone, and thanks very much for joining us especially when there's quite a few people out of the office on holiday, but if you've had a break I hope you had a good break and welcome back. It's my pleasure today to have Jean-Christophe Eloy, who is the President and CEO of Yole Développement. He did a lot of work in terms of research around different areas including the power semiconductor market.

So, today, the focus of the call will really be on power semiconductors with a real focus on silicon carbide. So, with that I think Jean-Christophe is going to give us a five- to ten-minute presentation. You should have received the slides from me in the last couple of minutes. If you haven't had them feel free to shoot me an email and then we'll go into a Q&A session after that.

So, with that, over to you, Jean-Christophe.

Jean-Christophe Eloy: Thank you for the introduction. So, I will read through the slides that has been sent to you to give you the background and also the essential data of this evolution of the silicon carbide markets or power devices.

Figure 1: Slide 2 - primary drivers for using SiC in different applications



Source: Yole Développement

So, moving to slide 2, the drivers behind this adoption of silicon carbide for different applications are three main drivers. One is the size and the weight reduction at the module level because with silicon you need to have a lot of special devices, cooling systems, and so on, so moving to silicon carbide you're removing a lot of parts at the system level and it helps to decrease the size and have a significant weight reduction.

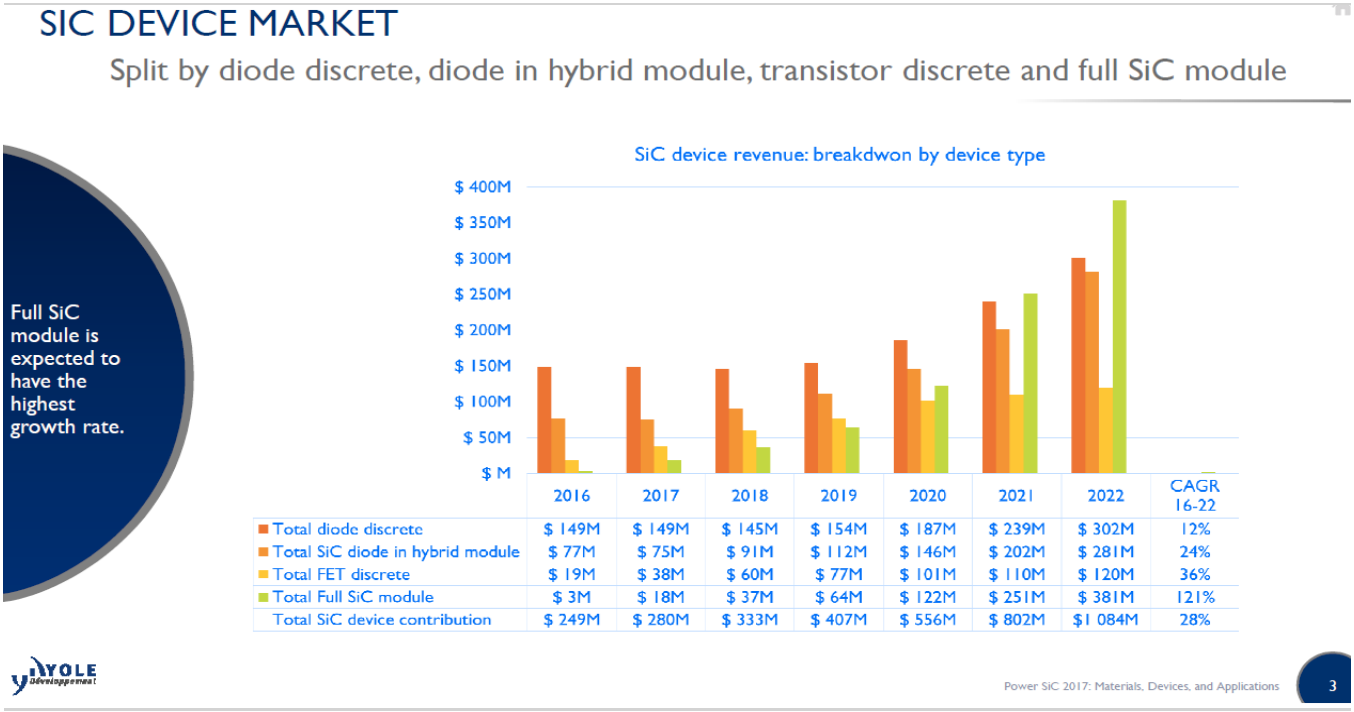
Just an example, Toyota has developed the old silicon carbide power modules for the electric vehicles and the other factor of size in terms of size reduction compared to silicon-based solutions. So, a very strong decrease in terms of size of the modules based on the capabilities of the silicon carbide in terms of switching power you, in terms of analysing the characteristic of the silicon battery life.

The second thing is the efficiency. So you're able to decrease the losses of the power modules and it's very useful for applications like chargers, like UPS, like wind for voltage applications when you're able to save a few percent in terms of efficiency, your return on investment is much shorter so very significant.

And the last one is high temperature function. Silicon carbide is able to work at the much higher temperature compared to silicon and it opens applications in oil and gas and also helps to decrease the amount of cooling you need for the system.

So, moving to the slide 3, all in all you can see that the market last year for the total silicon carbide device was $250 million, including the silicon carbide diode, which is the most important part of the market today, including silicon carbide transistor which is just starting at $20 million last year and the full SoC module, that means modules that are integrated both in silicon carbide diode and transistor.

Figure 2: Slide 3 - Silicon Carbide Device market breakdown



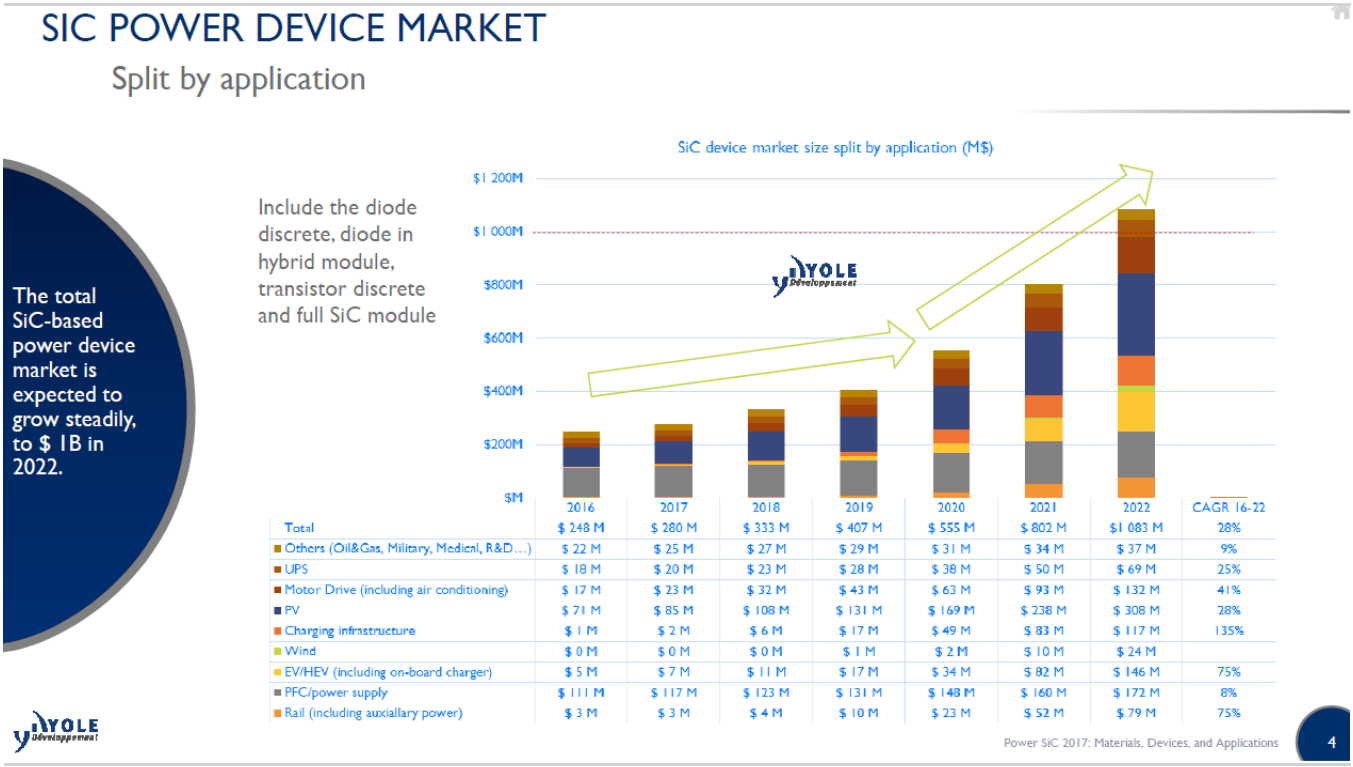
Source: Yole Développement

The evolution is very significant because of the total markets we think we'll be moving to more than $1 billion in 2022. This is a significant growth of the different types of devices, but the biggest growth is really coming from the module because it is at the module level that you can take full benefit of the silicon carbide properties and characteristics compared to silicon.

You see where you can save lots in terms of costs, but also in terms of increase a lots of performances for the full silicon carbide module approach and that just started in fact two years ago. This is the first module introduced by Mitsubishi Electrics for example for the wide industry and step by step, more and more players are both offering silicon carbide diode and silicon carbide transistor, and in addition to that developing specific modules.

Slide 4 is looking at the evolution of the markets by applications. So, we have the first phase of growth from now to 2020 where we have roughly [*indiscernible*] growth per year. And then the second growth phase after 2020, we're more into 30% growth mainly for three applications that are really driving adoption of the silicon carbides, one on the charging infrastructure for electric vehicles. The other one is for electric vehicles, hybrid vehicles, which at one point could be a very significant market. But introductory of the applications that are still important and growing quite fast, which are the photovoltaic, which will be in 2022 the biggest market in terms of the use of silicon carbide devices because of the efficiency and performance into efficiency.

Figure 3: Slide 4 - Silicon Carbide Power Device Market

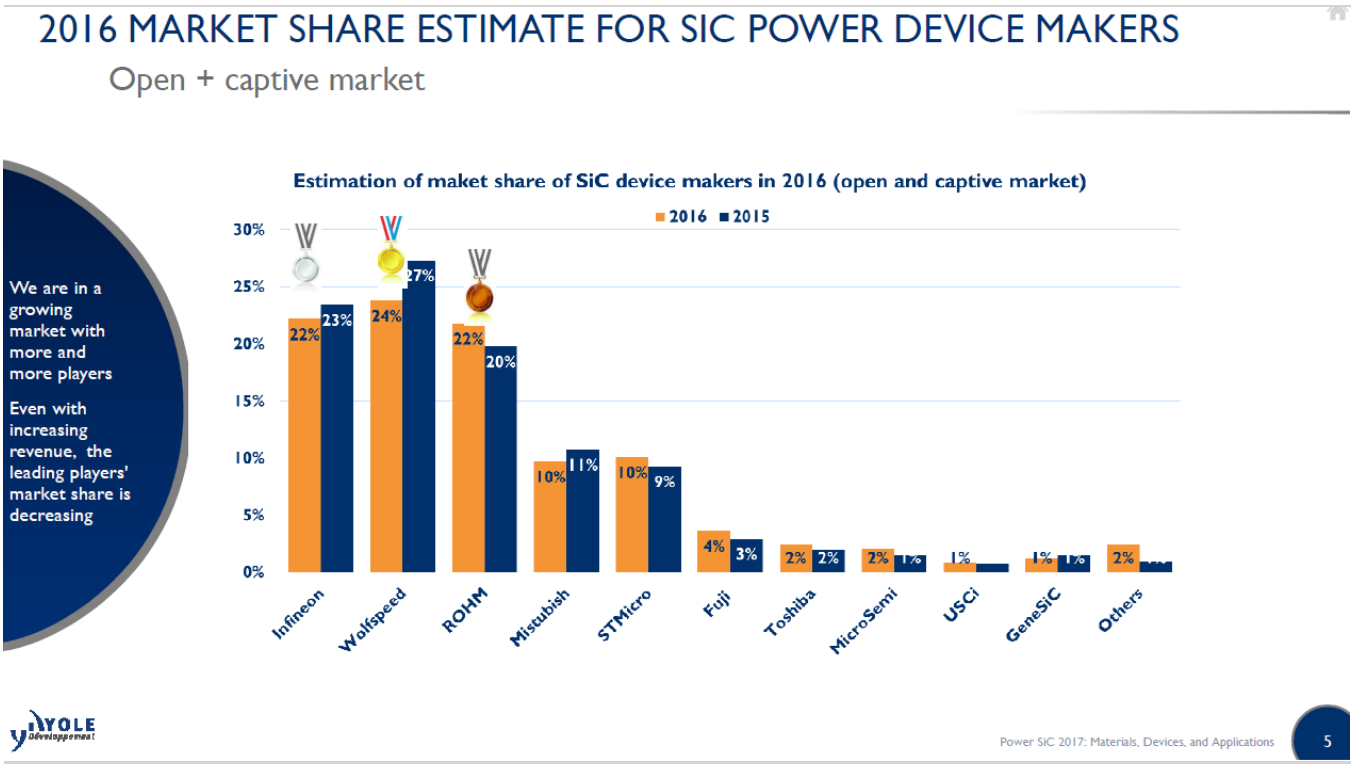


Source: Yole Développement

So, all in all the market will be *[indiscernible]* for the next five years, very significant growth. And if you're looking at the slide 5 and the competitive landscape, you're having in orange around 2016 market share in blue the 2015. So, last year, the same for 2016 the first company was Wolfspeed, Infineon being strong at number 2 and almost at the same level compared to Rohm. And then two other

companies that are quite mature in terms of market share, so 10% each, each from Mitsubishi Electric and STMicro and then multiple other companies that have below 4% in terms of market share.

Figure 4: Slide 5 - 2016 market shares for Silicon Carbide Power Device Makers



Source: Yole Développement

So, the market between 2016 and 2015 has grown significantly, more than 30% growth, and the markets increase benefits for clearly a lot to Rohm that has increased market share in 2016. Decrease of market share for Wolfspeed and Infineon, but total increase of the SiC device is very significant.

So, this is the heart of the introduction. After that we have backup slides, which are into the comparison between the impact on the silicon carbide compared to silicon in power electronic markets, especially transistor compared to the IGBT especially for certain applications, and the impact in the next five years in terms of market size and a few slides describing also this IGBT market and evolution of the landscape with two scenarios linked to the adoption of silicon carbide for the electronic and hybrid vehicles.

Okay, so this is just background slide, but I can use it if you need it at one point. Especially for the adoption of silicon carbide in electric vehicles like [*indiscernible*], this adoption is really effective. It could be a big disruption both for the silicon carbide market in term of growth and for the IGBT business in term of decrease of that market because of the replacement by silicon carbide transistor. The scenario I presented with the slide 5—sorry the slide 4 is based on limited adoption of silicon carbide in the electric vehicle and hybrid vehicles. So, it could be a significant upside if such a big thing happens.

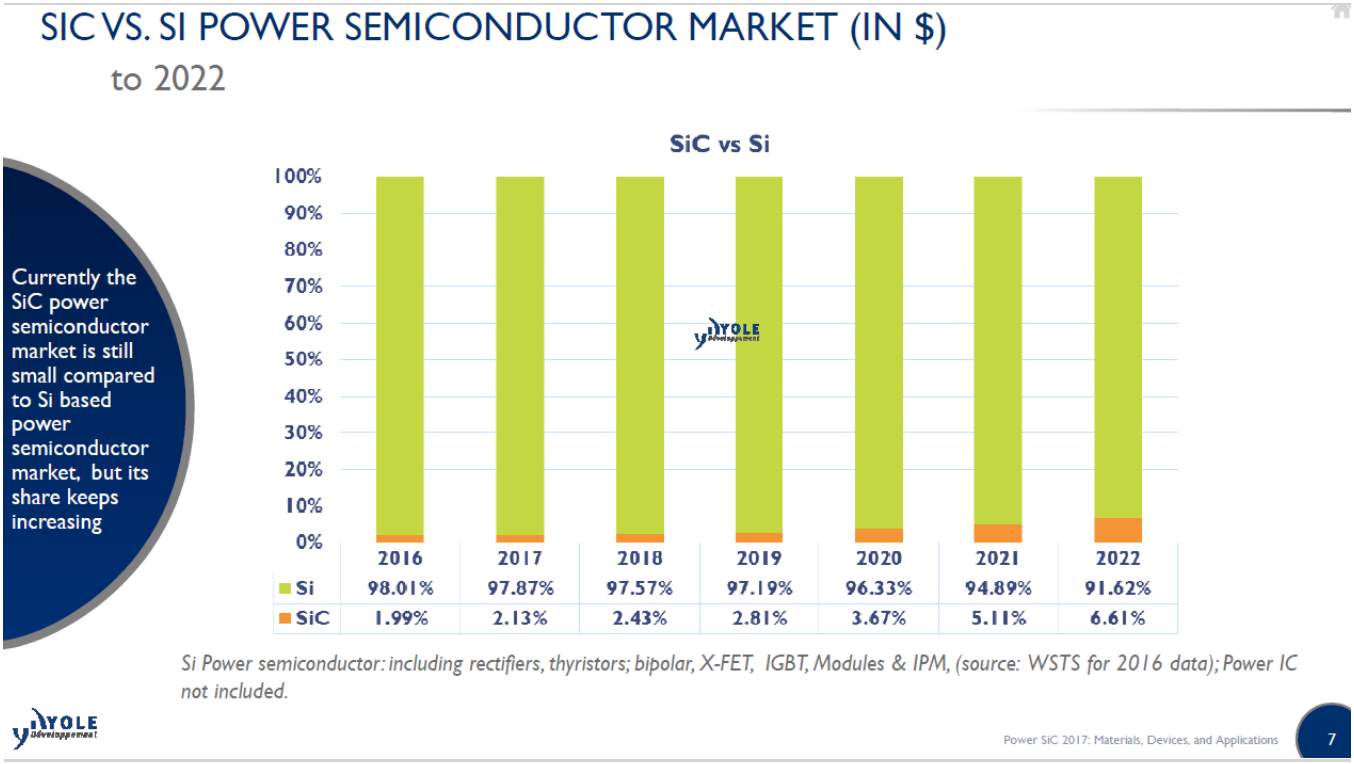
So, this is the end of the introduction.

David Mulholland: That's great and thanks, Jean-Christophe, maybe if we can just jump in on the first backup slides and the shift between silicon carbide and

silicon and how that develops over the next five to six years. How should we think about the drivers of that? Obviously, you've presented what you say is a scenario, but what could be the puts and takes that could drive more rapid adoption or more conservative adoption over the six to seven years?

Jean-Christophe Eloy: So, the slide 7 is presenting the adoption of silicon carbide to silicon power device. So, last year we are at 2% of the total power electronic markets to be linked to silicon carbide and moving to 6.6% in 2022. What is linking at the moment — there were two things — there are two things that are linking this adoption of the silicon carbide businesses. One was the reliability of silicon carbide transistor that's here in terms of specification, reliability and price at the right range and it's really available since 12 months or 18 months or so. This milestone has been very important and that's one of the reasons that we see an increase of the market.

Figure 5: Slide 7 - Silicon Carbide vs. Silicon Power Semiconductor market in US$



Source: Yole Développement

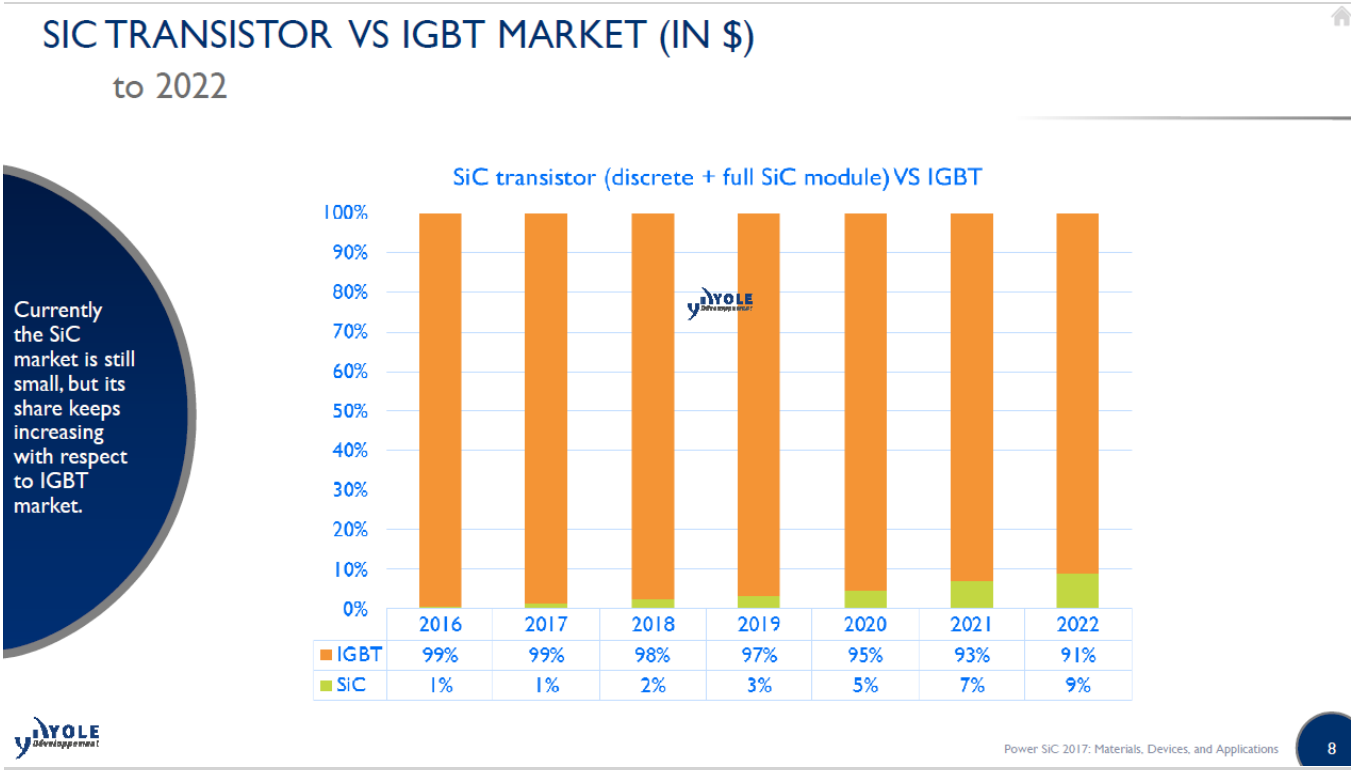
And the second point that could really increase faster silicon carbide business is the decrease of the price of such devices. So silicon carbide based devices are very expensive because of the material. The price has decreased a lot since the introduction of the first silicon carbide diode in 2001, but it still remains high in terms of price and you can justify the adoption of silicon carbide devices because of the cost saving you can have at the module level.

So, the scenario we are proposing is really a scenario, which is more conservative based on today pricing and the adoption we see. If either the silicon carbide manufacturers are decreasing the price or the innovation in order to be able to have wafers at lower price, we will see suddenly a very significant higher adoption rate of silicon carbide.

So, the slide 8 this is the comparison of the silicon carbide transistor compared to IGBT market in dollars. So silicon carbide compared to IGBT was only 1% in 2016

moving to 9% in 2022. So, it's significant because it's very strong growth of the silicon carbide transistor in terms of market adoption, but still less than 10% with a total IGBT market.

Figure 6: Slide 8 - Silicon Carbide Transistor vs. IGBT market in US$



Source: Yole Développement

This could really change a lot if at one point the adoption of silicon carbide in each vehicle is re-changing. And this is something that we are monitoring since quite a long time and still continuing. So, last year BYD as being the first company to introduce silicon carbide device modules in the cars, electric vehicle for charging applications. And from what we've seen that from the test of the car it has been a good success in the charging modules. It's very effective.

And we will monitor to see if more are moving towards the direction so adopting this silicon carbide modules for the charging and also for the heart of the electric vehicles in terms of into that. So, if it's happening, the market share of the silicon carbide compared to IGBT for 2022 could be much higher (even by a factor of 2) and it could be very effective, very evenly the market.

But before that the price has to decrease and the carmaker has to make the choice of moving to the silicon carbide module and know they have the silicon carbide transistor available for test, for implementation and see what could be the saving at the module level. So, we think that the market could really grow faster compared to expectation at the moment if such tests are positive.

So, we'll see in the next month 6 to 12 months what will happen and what will be the feedback of the carmaker and the module makers in this industry. But the next year, 18 months is maximum, will be really key to see if such adoption of silicon carbide in electric vehicle is happening in a higher level compared to what we have seen and if it is the case then the market will grow much faster.

David Mulholland: That's great and then maybe just coming back on the market shares as you see it for the vendors where they stand today. There's obviously been a few changes that we saw from 2015 to 2016. I wondered if you would maybe lay out what were the key issues there as to why Wolfspeed share has come down the way it has as you see it and Rohm increased. Is that just some of the Japanese vendors are ramping up more aggressively than the Europeans or the US? How do you see the driving factors between the shifts that we've seen over the last 12 months?

Jean-Christophe Eloy: So, last year, Infineon tried to acquire Wolfspeed, so I think it suddenly had an impact on the IT team because it was such a — in some ways there were some that were focussed on that and not on the business. So, I think this is one of the explanations.

The second, Rohm has been really aggressive in terms of pricing, the development of module, we discussed and so on, with something that is certainly helped to grow the IT. The other point is that Rohm is fully integrated vs Wolfspeed that means they are making their own silicon carbide wafers, their own device and their own modules. And based on that they have the ability to define the price results, adding on top of the margin on the wafer, on the device and on the module. So, last year Rohm has been really aggressive in term of price and commercial action in order to get market share on top of the other players.

So, this is one of the main reason and there is a very strong community in Japan of companies that have seen silicon carbide as a key device to save, in fact, cost at the module level, and step by step these modules are coming into production for application like, rail for example rail traction, but also for application needs for the photovoltaic industry, motor drive and I think Rohm will take full benefit of this overall Japanese industry in the power management field using more and more silicon carbide.

David Mulholland: That's great and in one of the comments you mentioned there was the combination for both Rohm and Wolfspeed of having in highest wafer capability on the substrates. Obviously, Infineon and STMicro don't have that today. Do you think that is something that will be necessary as we look at the market over the next five years or will there be more of a merchant silicon carbide market over time from a wafer perspective?

Jean-Christophe Eloy: So, I think there is a short-term and long-term. On the short-term the number of companies that are able to provide silicon carbide wafer is limited. That means the company that are in production at the moment, you have Rohm, you have Wolfspeed, then you have a few. But a number of companies that are really manufacturing wafers is less than 10 companies. So, in addition to the one I mentioned you have Dow Corning, you have II-VI, for example, you have [*indiscernible*] for example, and you have a bunch of Chinese companies SICC, TankeBlue, Norstel, which is a Swedish company, which has been acquired by a Chinese investor and others that are fairly new developed entrance. So, at the moment the ability to add internally wafer manufacturing is key because we are able to play with the margin of your price more easily compared to Infineon and STMicro, for example, or Mitsubishi Electric.

But on the long-term when other companies that are developing that kind of wafer will be available to put them on the market with reliability, this advantage will really disappear because of the wider supplier landscape at the wafer level.

Yes, today, it's a key advantage and Wolfspeed and Rohm have taken full benefit of this advantage on the medium-term.

David Mulholland: That's clear and then maybe if we extend onto the slide 9 in the presentation and how you see the outlook for who will be the leaders out to 2022. How do you think we should envisage changes in terms of the market share environment from where we are today?

Jean-Christophe Eloy: So, what is really significant that we will move for the next five years from companies that are in the device business or wafer and device business, which is the case of Infineon, Wolfspeed, Rohm, STMicro to companies and the leadership will certainly grow in the end of the companies that have module activity because silicon carbide can reap the benefit of the silicon carbide, so redeveloping module and not so many players has this ability to have module developments because it's quite complex.

And we think that more and more companies will move to this module and sell the modules integrating silicon carbide diode and transistor. I think it will benefit from that. These companies will have very significant advantage on the market step by step because they will be able to take the extra cost of the silicon carbide in the module, be able to lower the manufacturing cost of the module itself because of the savings you can have into the passive, into the cooling and so on and so on and be able to deliver higher performance at the module level. That means better margin, strong added value to the customer with the ability to have the product, which is not a single device, but a complete module that are selling to a company.

So, when we see this evolution happening step by step, which Mitsubishi is fully involved on that. Infineon is developing since there have now one year transistor to develop such modules. Wolfspeed has started to do that and we think that this module makers will have very significant market advantage. The GE Electric has made an agreement with EV on that and there are multiple agreements that are underway in order for the module maker to take full benefit of the silicon carbide devices.

And I think this is what could change the structure of the market for the next five years. This is related to the growth of this module that is very significant and much higher compared to older applications. The company that will be able to jump on this growth—and there are modules for various applications for PV and so on and so on will be the clear winner on that, and it will be restructuring the market.

So, the companies that are only at device level at the moment like Infineon and ST will have to move on this module level. Infineon has already done that for other power electronics, so they have strong knowledge on that. ST is a bit behind in these modules, Rohm has already done that. Mitsubishi is fully involved on that and Wolfspeed is pushing the process. So most of the players have the ability to do so, but we have to look at the speed that they are pushing that and the way the competitors could take benefit of this module approach in order to get market share.

David Mulholland: Okay, maybe if we just touch on ST specifically for a moment. Over the last 6 to 12 months they've been talking a lot about their silicon carbide capabilities and design that they've had on that. How much credibility do you give them as a competitor in this space and the position they might be able to take in silicon carbide longer term? Is that something that could be game changing in

2018 as those design wins ramp? I don't know if you have any insights today on how big the ramps might be.

Jean-Christophe Eloy: Well, difficult to evaluate the ramp and the benefit we can take for 2018. So, they have increased their market share last year and they are strong number, five players, Mitsubishi, Rohm, so on and so on. They are at the same level compared to Mitsubishi. They are more involved at the device level, and Mitsubishi more involved at the module level. So, my feeling at the moment that we'll see step by step and get more information about the design wins to get from silicon carbide is that they are able to maintain their market share, so around 10% maybe move to 11% or 12% due to the design they get, which is okay.

If they want to really move to higher market share they will have to either to team up with module makers in order to be able to not to deliver only devices, but to be able to be involved in the module business as of by their own or through partnership and the key evolution that has to happen at the ST level. Are they willing to do so? Are they working on it? I have no insight on the company, but they could stay at this 10% to 12% market share for the next three years.

I think it's totally achievable for them because they have good outflows and they are really active in the power electronic business so no question on that. But if they want to move to higher level market share the module approach has to be implemented either internally or through partnership. And we don't have any information on that at the moment. They are working on that. Certainly, they are working on it, but there is no data on the company about when it could happen and what will be the biggest model behind.

David Mulholland: The other standouts that you see, people like Fuji Electric, SEMIKRON, and On Semi are in the IGBT role today, but not as visible in silicon carbides. What do you think they need to do over the next four to five years? Is it too late to be a big player or are you seeing investments, aggressive investments, there in silicon carbide as well?

Jean-Christophe Eloy: For me all these companies Fuji Electric, On Semi and more—it's more a defensive approach in order to be involved on that as well as they are involved in IGBT in order to be able to understand the market traction on that and be able at one point if the silicon carbide is really significant as a market, push the silicon carbide in order to maintain the market share on this overall silicon carbide and IGBT business. So, this is the slide 14 when we have the market share or the different IGBT maker based on the volt and range, so typically for silicon carbide we have to involve 1,200 volts mainly. So, number 1 Infineon, then Mitsubishi Electric and then it's Fuji Electric, again ABB. ABB has in agreement with GM on this on that. You have Hitachi and you have also other companies like Ixys, and so on.

So, I think Mitsubishi Electric, Fuji Electric are here and also Toshiba for part of market are here really to understand what's happening on silicon carbide compared to IGBT in order to be able at one point to put more effort on silicon carbide if it's really happening as a market.

Will they do that on time or not? Well, we'll see. My feeling is that these companies, Fuji Electric and Toshiba and Mitsubishi Electric, they are very strong module business. My guess is that they get a foot in silicon carbide to see what's happening, and at one point to move to modules, introduce silicon carbide devices and get their market share at the module level. And I feel this is a really the

strategy of this company. So, at one point—well the only fear at the device level could be a challenge to compete with Infineon, Cree or ROM. But if they're using the silicon carbide IGBT to develop the module business they could be the strong players within five years.

David Mulholland: That's great and thanks. I think at this point, operator, could you possibly poll for questions and then come back to me and I have a couple of more that I'll ask while we queue?

David Mulholland: That's great. So, while we poll just one more from me then. One of the questions we get on silicon carbide and what it means over the next four or five years is how profitable those products might be compared to what people have in the IGBT environment today. Obviously, you've mentioned a bit already around the wafer production, but what do you think the opportunity in terms of the gross margin profitability of a silicon carbide product relative to what they—it's quite a good market in IGBT today.

Jean-Christophe Eloy: Well, IGBT is a quite competitive business. We think that silicon carbide transistor could be much higher in term of margin. There are two things. One thing is that the same price of silicon carbide transistor is higher, so you're able to expect better margin on that. The price increase is there, of course, as always in the semiconductor industry for new technology, but we think that the intrinsic price of the silicon carbide transistor was to have much better margin. It's the first one.

The second point is that as the significant part of the market is moving to the module business the ability to increase the margin at the module is really, really significant. First because you're able to save a lot of cost at the module level and embed the higher cost and the added value for the silicon carbide in the module. And, you are able to at the module where you are making a lot of savings for the multiple elements of the module in terms, as I said, cooling, but also passive devices, lower side of the modules and so on and so on, you're able to define the price, which is adapted for the application where you can take the full increase of the price of the silicon carbide here, but save a lot in the cost of the module around that. So, it could be very significant.

So, the increase of margin for silicon carbide I think is very significant because of the higher price that lead to that. And the second point is moving to the module business will increase the margin of the module maker based on silicon carbide devices. And this is exactly what is happening for example if you're looking at Mitsubishi and the growth of GP. They have been pushing the rail business in the last year using silicon carbide and what we get from the company is that the margins into that was really much more important, and it should be exactly the same for all the different companies.

And here where we see also an increase of the market growth, as I said, moving the component of growth rates from 28% to 30% a year in the next two years. Because if you have modules that are taking full benefit of the silicon carbide transistors and diode in terms of performance, you are helping a lot of your customers that don't want to be involved in adaption modules for the application could benefit from silicon carbide, and deliver of module with respect of silicon carbide. We're looking at time of the development of it will really increase the market adoption and shorten all the issues leaning to the redevelopment of modules based on silicon carbide.

So, this ability will be embedded in the modules, will help to increase the margins and will help to increase market adoption. And this is exactly what's happening at the moment. So, we are forecasting the silicon carbide markets since more than ten years. We're deeply involved on that. We have reported a year on that and we have increased the forecast. So, in the last two years we have increased the forecast of the year because there is more adoption because it's simpler to use the devices or the module based on that. There are more and more applications where the efficiency of the silicon carbide devices is really important and help to drive return on investment of the devices because you're saving electricity and you're saving on the power consumption into the system itself and it's a huge benefit. And this is really helping to increase the markets and increase the margin because if you are helping your customer to have a return on investment you need the product they are buying, but great for them and you can implement that in your pricing.

David Mulholland: That's great. Thanks very much. I guess one thing it wouldn't be a discussion on par semi if we didn't question the outlook for gallium nitride as well. I don't know if you can comment on how you see the GaN market developing. Is it where are we in the cycle? It's been fairly clear the ramp we're starting to see on silicon carbides. Where are we and when could we start seeing something similar for GaN?

Jean-Christophe Eloy: So, gallium nitride is in terms of applications we are below 600 volts so it's much lower voltage applications, where the price is really, really important because at that level the silicon is really good, very cheap and gallium nitride is bringing devices that are two times, three times higher in term of price, but with better performance. So, the only applications today that we see market adoption into gallium nitride is really two applications that needs the gallium nitride specification. And there are two main applications that are really driving gallium nitride, one is LiDAR application because of the switching capability; there is fast switching. This is the market that is emerging with autonomous vehicles and we see more and more adoption of the gallium nitride for the LiDAR modules. But starting volume production at the moment it will be starting certainly within two years in terms of very large volume for automotive, but it's coming. Okay, so it's one of the application that's driving the adoption of gallium nitride.

The other application, which could be much more significant in terms of size is the wireless charging and other wireless power applications. Gallium nitride devices are really totally adapted for that. In the same way we've seen the first application in consumer for mobile phone wireless charging for example, the developments and significant projects for electric vehicles, also to have wireless charging. There are multiple other applications that could really, really happen, and we are just at the beginning of it. Its specific applications that can drive, in fact, the adoption of the devices of this technology gallium nitride transistors, and that means once it's adopted it will be very helpful because it will help to step—all what the semiconductor industry is really good at—be able to step by step decrease the manufacturing cost and decrease the price because the price will be more marketable.

This is exactly what happened with silicon carbide devices in 2001 with the introduction of Infineon. Where at that time Infineon was the only one to produce laser, it was very interesting for PFC applications and it was a self-application. Then the photovoltaic industry came in and helped to drive the growth, helped to decrease the price and then more applications come in. And it happened 10 to 15

years ago for the silicon carbide device and we think it will happen in the next five years for gallium nitride. So, today it's a small market. Last year I think gallium nitride device last year 2016 market size was around $14 million, so very small, but the growth rate could be really significant in the next five years with the adoption of the very specific application of LiDAR and power and wireless charging.

Today, the companies that are leading are more smaller companies. It's a company named EPC, GaN Systems, that are sharing that market, with all the big players including Infineon, On Semi, including Mitsubishi and other large companies, involving power electronics. They are looking at the gallium nitride for this lower voltage applications and especially for very specific application that take full benefit of the characteristic of gallium nitride, wireless charging and LiDAR.

So, in the same way we are monitoring these applications. It's a market that is just starting. The inflection point will happen within two years or three years with these two applications getting more momentum and growth, but it will happen. It will not compete against silicon carbide because most of the applications we are away in terms of voltage range and spec of the device, but gallium nitride is certainly focussing on applications where silicon is established at the moment and could step by step remove silicon from these specific applications. So, it's not a massive adoption of gallium nitride, just very specific adoption on key applications that will drive further adoption in next five to ten years.

David Mulholland: That's clear. Operator, is there anyone in the queue?

Operator: Yes, you do have two questions. Please go ahead.

Questioner 1: Hi, thanks so much for doing the call and definitely answered one of my questions on the last response here. But just one from left field, I'm curious if China has any sort of domestic interest in building up any silicon carbide capabilities just given there's so much interest in growing their semiconductor industry natively. I just don't know if that's a vector where you've seen any interest or any growth coming from them. It doesn't seem like it, but I did just want to ask. Thanks.

Jean-Christophe Eloy: So, silicon carbide in China has been very active in fact at two levels. One is on the material. There are six companies that have developments and investments in order to grow the silicon carbide and make the silicon carbide wafers. Few are in volume production at the moment, but there is a significant growth there, sorry investment there, very significant. And there is some interest at the power device level. There are few companies that are developing that, but it's really just the beginning. The very strong interest is coming from the system maker. I was mentioning BYD and also CRRC. So, BYD this is for the electric cars, electric bus, charging station, and so on. All the electric transportation that they are developing, silicon carbide as a key material and device for the optimisation of the modules and they have started to use silicon carbide for on charging modules in electric vehicles last year. So it has been the first one to do that. So, before Toyota before the different players, so strong push at BYD level. There are other carmakers, electric carmakers in China that are looking at that.

And the other one is CRRC, which is the train, the national train manufacture company. That is also pushing a lot the development and the adoption of silicon carbide in rail traction for silicon carbide module and they are really pushing the adoption on that. And at the moment they are buying the device module from

outside, but there is a willingness of those agreements and these players to have the silicon carbide complete supply chain in China.

It's not that simple because there is a lot of knowledge that is linked to the development of such device and industry, but investment is there. If they be able to succeed we'll see. So Norstel, which is a Swedish silicon carbide manufacturer, has been acquired last year, one year ago by Chinese investor. There is also two other wafer makers for power electronics on silicon that has been bought so this right here in Denmark, and [*indiscernible*] in Finland that has been acquired by a chain of investors in order to get access to the wafers for the power electronics.

So, the silicon carbide wafers will not be an issue in the next two to three years then they have to build on top of that the device manufacturing and it's taking more time on that. So, supply in China, at one point will be supplies in China, but I think there is still five years of developments before seeing really significant things on that at this time. But adoption of silicon carbide at the system level is already happening and happening very fast because of the specification of the silicon carbide and because the companies there don't have silicon history. They are jumping on the technology that is the most adapted, I believe, and they have been trading on silicon carbide when it's useful.

So, supply chain will take time. That adoption at the module level is happening already now and will be a key driver for the growth of the silicon carbide device market.

Questioner 1: Thanks.

Operator: And your next question comes from hidden. Please go ahead.

Questioner 2: Hi, good evening, everybody, just a quick question regarding the phase acquisition of Wolfspeed by Infineon, whether you could foresee other strategic partnership or players in terms of this acquisition among the smaller players.

Jean-Christophe Eloy: Well difficult to forecast because the number of small players involved initially is limited. So when we are talking about Infineon, Rohm, Mitsubishi, ST, Fuji, Toshiba and so on, we are really talking about the big players. I think the acquisition of Wolfspeed by Infineon will not happen, not that much because of the silicon carbide, but more on the—Wolfspeed is also doing devices based on silicon carbide and gallium nitride, and these devices most of the applications are linked to other applications in radar.

One of the reason of this acquisition that be able to happen that Wolfspeed has key technologies that lead to silicon carbide, but for other applications, which cannot be owned by none of these companies. So, I think Wolfspeed it's not clear at the moment—what is clear is that Wolfspeed is moving its way alone. Is there a chance something internally in order to separate the US business compared to the other parts? There is no sign that they are doing that. Maybe it could happen at one point, but at least today there is no sign that they're able to do that.

And from the other players, I think the acquisition will not occur either to on much smaller companies that develops specific transistors or diodes. There is a lot of small companies that have IP knowledge of transistor or to the diodes. There is a bunch of companies in Sweden. There is [*indiscernible*]. There is several others in Germany, few in UK also, which are small, but 10%, 20%, 30% strong knowledge, strong IP, and at one point it could be a way for the players that have

used the silicon carbide activity in order to get key IP and development and manufacturing power in order to move the device on the market.

So, what we see more it will be much smaller acquisition that could happen in order to get access to knowledge, and as I said there is minimum 20 or companies, below 30%, that are on the field working for the development of such devices. So, yes it could happen for that, but in terms of big deals involving Wolfspeed or the others we don't see that because Wolfspeed seems to be staying within the Cree activity. As I said I think there is no sign that there is changes around that at the moment, and for the others silicon carbide is part of the total activities and there is no interest for them to sell it because of the [*indiscernible*]. We don't see major acquisition there, much more technical strategic acquisition in order to get an IP position, get a team, get the knowledge, but no big deal around that.

Questioner 2: Okay, thank you.

Operator: Thank you. There are no more questions.

David Mulholland: Maybe just one more from me then. Obviously there's a few, and Cree is probably the only significant US player in silicon carbide today. Do you think we should be keeping an eye on any of the other US players to make more of a move beyond, I guess we've already discussed on Semi a little bit, but are there any of the other ones you think worth keeping an eye on?

Jean-Christophe Eloy: Well, ON Semi was a small player in the power device business and with the acquisition of Fairchild are becoming the number 4 of the market, global total market of power electronics. Silicon carbide and gallium nitrite has to be on the roadmap. So, they are developing internally and they may become significant players on that market in the next year because they need to have that kind of activity internally. Outside of that there is not that much big players on power electronics in the US.

What's happening at the moment because of the acquisition by Infineon of International Rectifier two years ago, Infineon is almost three times bigger, number 1 in power electronic business compared to number 2, which is Mitsubishi Electric. I think so from the top of my head Infineon is $3 billion in power electronics and Mitsubishi Electric is $1 billion something like that, approximately.

And then you have a lot of Japanese companies which are between $500 million and $1 billion, a few European and a few US companies there, but a lot of Japanese companies. And to have a leader, which is three times bigger compared to the number 2, it's a digital market position for all the different companies. So, we think that there will be again a major acquisition in this power electronic business between the number 2 and the number 10.

Which company will be involved, what kind of deal will happen and so on? I don't know, and we are not in the secrets of that kind of deal happening, but you cannot stay in a business where number 1 is three times bigger compared to number 2. That means they have a competitive advantage with price, power and ability in terms of investment, in terms of technology development that is huge, huge compared to all their competitors. At one point the competitors will have to combine their forces in order to be able to compete with them.

As I said we have not seen any movement on that, but from a strategic point of view something will happen in the next two years.

David Mulholland: I guess taking a step back from that then when you look at Infineon and the position that it does have and that leadership position in the broader par semi space, do you think that is a strength and an opportunity for them over the next five years, or given potential consolidation elsewhere is that actually a risk for them?

Jean-Christophe Eloy No, I don't think there is a risk for Infineon. They are more in the growth path at the moment, which is really, really good. And I don't think there is risk because the competitors, at least in the next three years—because for the competitors will be able to merge, be able to get the synergies and so on and so on, it takes time. Infineon with the acquisition of International Rectifier have already done that two years ago. So they have momentum, the portfolio of product and activity in the automotive business that helps them to take full benefit of what's happening in the electronic vehicles area, and so on and so on. So, they are in a momentum at the moment, which I don't see any way to stop it in the next three years.

After that, yes, if there are competitors that are able to merge and grow the activity, make the good investment in terms of technology and products to take the full benefit of the growth of the different markets at the moment, well, yes, the competitive advantage of Infineon could really decrease in the next four, or five, or six from now. But the next three years, well I think from my analogy it will be really, really tough to compete head to head with Infineon. An acquisition has to happen for that, I think.

David Mulholland: Operator, are there any more questions?

Operator: There are no more questions.

David Mulholland: That's great. Thank you very much, Jean-Christophe, for your time today and thanks, everyone, for joining us. I think with that we'll probably call it a day there. So, thanks, everyone, for joining us. If you have any follow-up questions feel free to get in touch with myself, David Mulholland at UBS or your relevant sales contact is happy to follow-up on the topic. But, as I say, thanks very much for your time, Jean-Christophe. It's been incredibly helpful, and I hope it's been helpful for all of our clients today.

Jean-Christophe Eloy: Thank you, have a good day. Good bye.

Valuation Method and Risk Statement

The upside risks to the semiconductor sector include stronger end demand from OEMs and tightness of supply due to the financial distress of competitors. Downside risks include macro-economic factors, over-capacity in times of peaking demand and poor yields. The semiconductor sector is high cyclical and vulnerable to sudden shifts in customer sentiment while many companies also have high cost bases meaning they can go loss-making in the downturn. Valuations are DCF and multiple derived.

Required Disclosures

This report has been prepared by UBS Limited, an affiliate of UBS AG. UBS AG, its subsidiaries, branches and affiliates are referred to herein as UBS.

For information on the ways in which UBS manages conflicts and maintains independence of its research product; historical performance information; and certain additional disclosures concerning UBS research recommendations, please visit www.ubs.com/disclosures. The figures contained in performance charts refer to the past; past performance is not a reliable indicator of future results. Additional information will be made available upon request. UBS Securities Co. Limited is licensed to conduct securities investment consultancy businesses by the China Securities Regulatory Commission. UBS acts or may act as principal in the debt securities (or in related derivatives) that may be the subject of this report. This recommendation was finalized on: 30 August 2017 08:00 PM GMT.

Analyst Certification: Each research analyst primarily responsible for the content of this research report, in whole or in part, certifies that with respect to each security or issuer that the analyst covered in this report: (1) all of the views expressed accurately reflect his or her personal views about those securities or issuers and were prepared in an independent manner, including with respect to UBS, and (2) no part of his or her compensation was, is, or will be, directly or indirectly, related to the specific recommendations or views expressed by that research analyst in the research report.

UBS Investment Research: Global Equity Rating Definitions

12-Month Rating	Definition	Coverage[1]	IB Services[2]
Buy	FSR is > 6% above the MRA.	45%	28%
Neutral	FSR is between -6% and 6% of the MRA.	38%	27%
Sell	FSR is > 6% below the MRA.	17%	11%
Short-Term Rating	**Definition**	**Coverage[3]**	**IB Services[4]**
Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 30 June 2017.
1:Percentage of companies under coverage globally within the 12-month rating category.
2:Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months.
3:Percentage of companies under coverage globally within the Short-Term rating category.
4:Percentage of companies within the Short-Term rating category for which investment banking (IB) services were provided within the past 12 months.

KEY DEFINITIONS:Forecast Stock Return (FSR) is defined as expected percentage price appreciation plus gross dividend yield over the next 12 months. **Market Return Assumption (MRA)** is defined as the one-year local market interest rate plus 5% (a proxy for, and not a forecast of, the equity risk premium). **Under Review (UR)** Stocks may be flagged as UR by the analyst, indicating that the stock's price target and/or rating are subject to possible change in the near term, usually in response to an event that may affect the investment case or valuation. **Short-Term Ratings** reflect the expected near-term (up to three months) performance of the stock and do not reflect any change in the fundamental view or investment case. **Equity Price Targets** have an investment horizon of 12 months.

EXCEPTIONS AND SPECIAL CASES:UK and European Investment Fund ratings and definitions are: Buy: Positive on factors such as structure, management, performance record, discount; **Neutral:** Neutral on factors such as structure, management, performance record, discount; **Sell:** Negative on factors such as structure, management, performance record, discount. **Core Banding Exceptions (CBE):** Exceptions to the standard +/-6% bands may be granted by the Investment Review Committee (IRC). Factors considered by the IRC include the stock's volatility and the credit spread of the respective company's debt. As a result, stocks deemed to be very high or low risk may be subject to higher or lower bands as they relate to the rating. When such exceptions apply, they will be identified in the Company Disclosures table in the relevant research piece.

Research analysts contributing to this report who are employed by any non-US affiliate of UBS Securities LLC are not registered/qualified as research analysts with FINRA. Such analysts may not be associated persons of UBS Securities LLC and therefore are not subject to the FINRA restrictions on communications with a subject company, public appearances, and trading securities held by a research analyst account. The name of each affiliate and analyst employed by that affiliate contributing to this report, if any, follows.

UBS Limited: David Mulholland, CFA; Francois-Xavier Bouvignies. **UBS Securities Japan Co., Ltd.:** Shingo Hirata; Kenji Yasui. **UBS AG Hong Kong Branch:** Bill Lu; Nicolas Gaudois. **UBS Securities LLC:** Stephen Chin; Steven Chin.

Company Disclosures

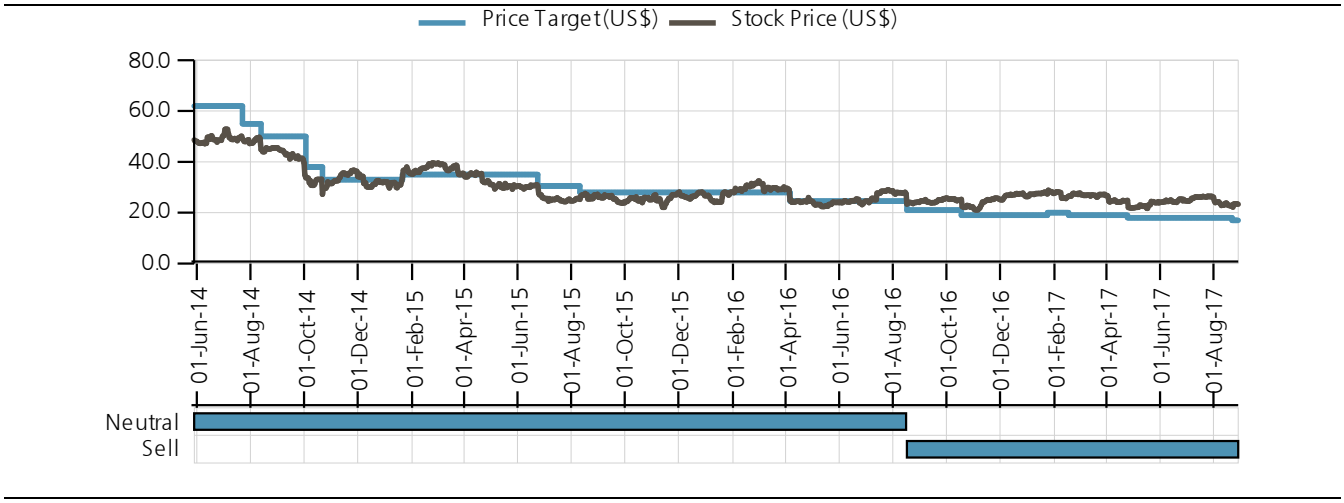
Company Name	Reuters	12-month rating	Short-term rating	Price	Price date
Cree Inc.[16, 26]	CREE.O	Sell	N/A	US$23.29	29 Aug 2017
Infineon Technologies AG[7]	IFXGn.DE	Buy	N/A	€18.95	29 Aug 2017
Mitsubishi Electric[7, 14]	6503.T	Buy	N/A	¥1,642.0	30 Aug 2017
Rohm	6963.T	Neutral	N/A	¥8,530	30 Aug 2017
STMicroelectronics[5, 7, 16]	STM.PA	Sell	N/A	€14.10	29 Aug 2017

Source: UBS. All prices as of local market close.
Ratings in this table are the most current published ratings prior to this report. They may be more recent than the stock pricing date

5. UBS AG, its affiliates or subsidiaries expect to receive or intend to seek compensation for investment banking services from this company/entity within the next three months.
7. Within the past 12 months, UBS Securities LLC and/or its affiliates have received compensation for products and services other than investment banking services from this company/entity.
14. UBS Limited acts as broker to this company.
16. UBS Securities LLC makes a market in the securities and/or ADRs of this company.
26. A U.S.-based global equity strategist, a member of his team, or one of their household members has a long common stock position in Cree Inc.

Unless otherwise indicated, please refer to the Valuation and Risk sections within the body of this report. For a complete set of disclosure statements associated with the companies discussed in this report, including information on valuation and risk, please contact UBS Securities LLC, 1285 Avenue of Americas, New York, NY 10019, USA, Attention: Investment Research.

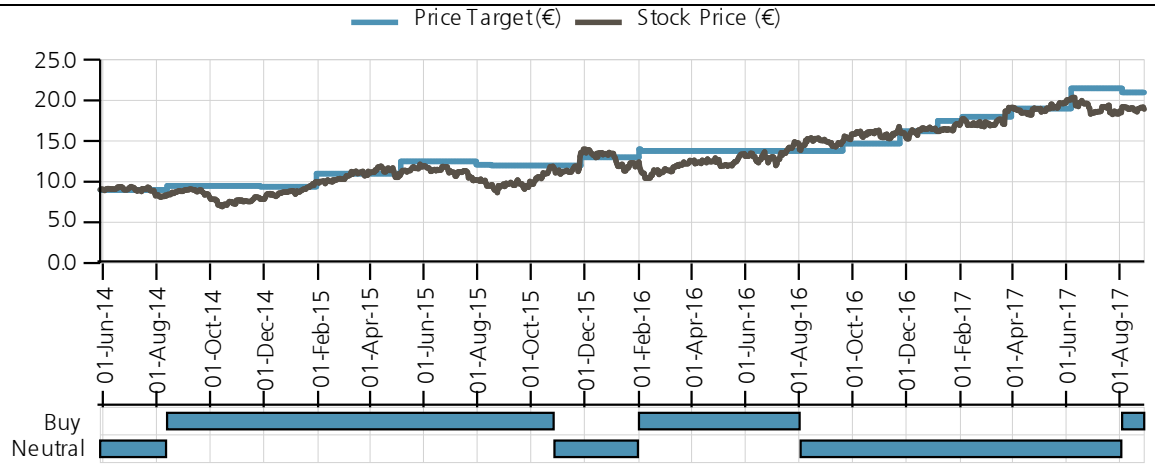
Cree Inc. (US$)



Date	Stock Price (US$)	Price Target (US$)	Rating
2014-05-29	48.63	62.0	Neutral
2014-07-23	48.95	55.0	Neutral
2014-08-13	44.82	50.0	Neutral
2014-10-03	33.73	38.0	Neutral
2014-10-22	27.28	33.0	Neutral
2015-01-21	33.88	35.0	Neutral
2015-06-24	30.56	30.5	Neutral
2015-08-11	25.2	28.0	Neutral
2016-04-06	24.81	24.5	Neutral
2016-08-17	23.38	21.0	Sell
2016-10-18	25.2	19.0	Sell
2017-01-24	27.41	20.0	Sell
2017-02-17	26.49	19.0	Sell
2017-04-25	24.82	18.0	Sell
2017-08-22	23.03	17.0	Sell

Source: UBS; as of 29 Aug 2017

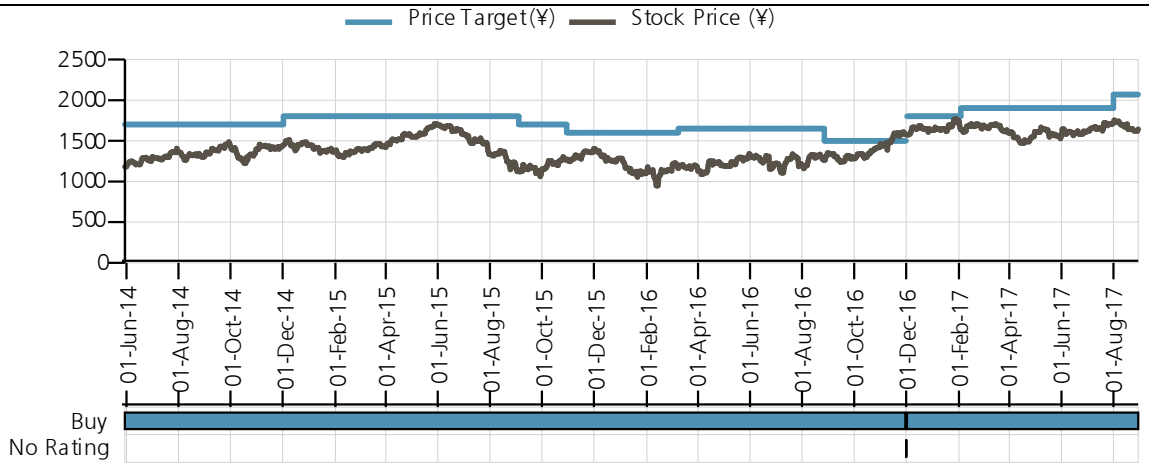
Infineon Technologies AG (€)



Date	Stock Price (€)	Price Target (€)	Rating
2014-05-29	9.04	9.0	Neutral
2014-08-13	8.34	9.5	Buy
2014-11-27	7.88	9.4	Buy
2015-01-30	9.98	11.0	Buy
2015-05-06	10.98	12.5	Buy
2015-07-31	10.21	12.1	Buy
2015-08-17	9.62	12.0	Buy
2015-10-28	11.61	12.0	Neutral
2015-11-27	13.6	13.0	Neutral
2016-02-01	12.44	14.0	Buy
2016-02-03	11.48	13.8	Buy
2016-08-03	13.91	13.8	Neutral
2016-09-20	14.96	14.7	Neutral
2016-11-24	16.37	16.2	Neutral
2017-01-06	16.22	17.5	Neutral
2017-02-03	17.76	18.0	Neutral
2017-03-31	19.15	19.0	Neutral
2017-06-07	20.31	21.5	Neutral
2017-08-04	19.23	21.0	Buy

Source: UBS; as of 29 Aug 2017

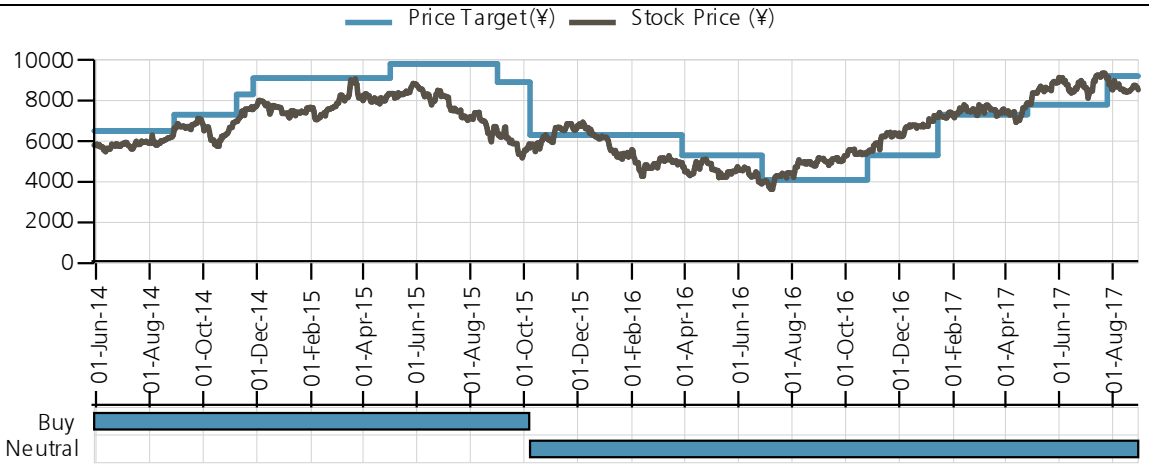
Mitsubishi Electric (¥)



Date	Stock Price (¥)	Price Target (¥)	Rating
2014-05-30	1181.0	1700.0	Buy
2014-12-02	1447.0	1800.0	Buy
2015-09-04	1123.0	1700.0	Buy
2015-10-30	1270.0	1600.0	Buy
2016-03-09	1162.0	1650.0	Buy
2016-08-27	1264.0	1500.0	Buy
2016-12-01	1578.0	-	No Rating
2016-12-02	1575.0	1800.0	Buy
2017-02-03	1637.0	1900.0	Buy
2017-08-01	1719.0	2070.0	Buy

Source: UBS; as of 30 Aug 2017

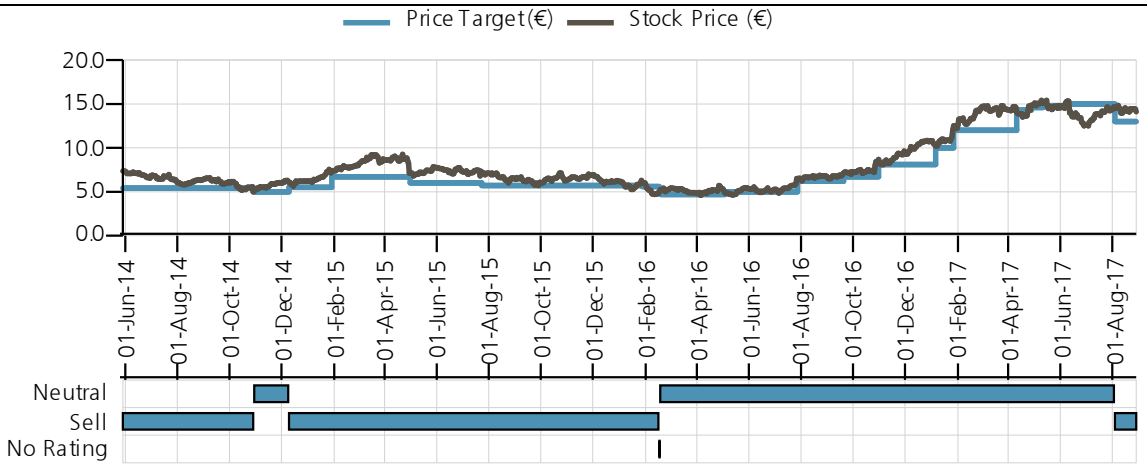
Rohm (¥)



Date	Stock Price (¥)	Price Target (¥)	Rating
2014-05-30	5800.0	6500.0	Buy
2014-08-29	6640.0	7300.0	Buy
2014-11-08	6970.0	8300.0	Buy
2014-11-27	7560.0	9100.0	Buy
2015-05-02	8340.0	9800.0	Buy
2015-09-01	6370.0	8900.0	Buy
2015-10-08	5670.0	6300.0	Neutral
2016-03-29	4935.0	5300.0	Neutral
2016-06-28	3905.0	4100.0	Neutral
2016-10-26	5440.0	5300.0	Neutral
2017-01-14	7180.0	7300.0	Neutral
2017-04-26	7890.0	7800.0	Neutral
2017-07-26	9050.0	9200.0	Neutral

Source: UBS; as of 30 Aug 2017

STMicroelectronics (€)



Date	Stock Price (€)	Price Target (€)	Rating
2014-05-29	7.36	5.4	Sell
2014-10-30	5.06	5.0	Neutral
2014-12-10	6.09	5.5	Sell
2015-01-29	7.39	6.7	Sell
2015-05-01	7.12	6.0	Sell
2015-07-24	7.15	5.7	Sell
2016-01-28	6.1	5.6	Sell
2016-02-17	4.98	-	No Rating
2016-02-18	5.24	4.7	Neutral
2016-05-04	4.85	5.0	Neutral
2016-07-28	6.44	6.2	Neutral
2016-09-20	7.13	6.7	Neutral
2016-10-31	8.69	8.1	Neutral
2017-01-06	10.21	10.0	Neutral
2017-01-27	12.5	12.0	Neutral
2017-04-11	14.05	14.3	Neutral
2017-04-28	14.85	14.6	Neutral
2017-05-12	15.17	14.8	Neutral
2017-06-07	15.05	15.0	Neutral
2017-08-04	14.56	13.0	Sell

Source: UBS; as of 29 Aug 2017

Global Disclaimer

This document has been prepared by UBS Limited, an affiliate of UBS AG. UBS AG, its subsidiaries, branches and affiliates are referred to herein as UBS.

Global Research is provided to our clients through UBS Neo, in certain instances, UBS.com and any other system, or distribution method specifically identified in one or more communications distributed through UBS Neo or UBS.com as an approved means for distributing Global Research (each a "System"). It may also be made available through third party vendors and distributed by UBS and/or third parties via e-mail or alternative electronic means. The level and types of services provided by Global Research to a client may vary depending upon various factors such as a client's individual preferences as to the frequency and manner of receiving communications, a client's risk profile and investment focus and perspective (e.g., market wide, sector specific, long-term, short-term, etc.), the size and scope of the overall client relationship with UBS and legal and regulatory constraints.

All Global Research is available on UBS Neo. Please contact your UBS sales representative if you wish to discuss your access to UBS Neo.

When you receive Global Research through a System, your access and/or use of such Global Research is subject to this Global Research Disclaimer and to the terms of use governing the applicable System.

When you receive Global Research via a third party vendor, e-mail or other electronic means, your use shall be subject to this Global Research Disclaimer and to UBS's Terms of Use/Disclaimer (http://www.ubs.com/global/en/legalinfo2/disclaimer.html). By accessing and/or using Global Research in this manner, you are indicating that you have read and agree to be bound by our Terms of Use/Disclaimer. In addition, you consent to UBS processing your personal data and using cookies in accordance with our Privacy Statement (http://www.ubs.com/global/en/legalinfo2/privacy.html) and cookie notice (http://www.ubs.com/global/en/homepage/cookies/cookie-management.html).

If you receive Global Research, whether through a System or by any other means, you agree that you shall not copy, revise, amend, create a derivative work, transfer to any third party, or in any way commercially exploit any UBS research provided via Global Research or otherwise, and that you shall not extract data from any research or estimates provided to you via Global Research or otherwise, without the prior written consent of UBS.

This document is for distribution only as may be permitted by law. It is not directed to, or intended for distribution to or use by, any person or entity who is a citizen or resident of or located in any locality, state, country or other jurisdiction where such distribution, publication, availability or use would be contrary to law or regulation or would subject UBS to any registration or licensing requirement within such jurisdiction. It is published solely for information purposes; it is not an advertisement nor is it a solicitation or an offer to buy or sell any financial instruments or to participate in any particular trading strategy. No representation or warranty, either expressed or implied, is provided in relation to the accuracy, completeness or reliability of the information contained in any materials to which this document relates (the "Information"), except with respect to Information concerning UBS. The Information is not intended to be a complete statement or summary of the securities, markets or developments referred to in the document. UBS does not undertake to update or keep current the Information. Any opinions expressed in this document may change without notice and may differ or be contrary to opinions expressed by other business areas or groups, personnel or other representative of UBS. Any statements contained in this report attributed to a third party represent UBS's interpretation of the data, information and/or opinions provided by that third party either publicly or through a subscription service, and such use and interpretation have not been reviewed by the third party.

This document is a general communication and is educational in nature. Nothing in this document constitutes a representation that any investment strategy or recommendation is suitable or appropriate to an investor's individual circumstances or otherwise constitutes a personal recommendation. By providing this document, none of UBS or its representatives has any responsibility or authority to provide or have provided investment advice in a fiduciary capacity or otherwise. Investments involve risks, and investors should exercise prudence and their own judgement in making their investment decisions. None of UBS or its representatives is suggesting that the recipient or any other person take a specific course of action or any action at all. By receiving this document, the recipient acknowledges and agrees with the intended purpose described above and further disclaims any expectation or belief that the information constitutes investment advice to the recipient or otherwise purports to meet the investment objectives of the recipient. The financial instruments described in the document may not be eligible for sale in all jurisdictions or to certain categories of investors. Options, derivative products and futures are not suitable for all investors, and trading in these instruments is considered risky. Mortgage and asset-backed securities may involve a high degree of risk and may be highly volatile in response to fluctuations in interest rates or other market conditions. Foreign currency rates of exchange may adversely affect the value, price or income of any security or related instrument referred to in the document. For investment advice, trade execution or other enquiries, clients should contact their local sales representative.

The value of any investment or income may go down as well as up, and investors may not get back the full (or any) amount invested. Past performance is not necessarily a guide to future performance. Neither UBS nor any of its directors, employees or agents accepts any liability for any loss (including investment loss) or damage arising out of the use of all or any of the Information.

Any prices stated in this document are for information purposes only and do not represent valuations for individual securities or other financial instruments. There is no representation that any transaction can or could have been effected at those prices, and any prices do not necessarily reflect UBS's internal books and records or theoretical model-based valuations and may be based on certain assumptions. Different assumptions by UBS or any other source may yield substantially different results.

This document and the Information are produced by UBS as part of its research function and are provided to you solely for general background information. UBS has no regard to the specific investment objectives, financial situation or particular needs of any specific recipient. In no circumstances may this document or any of the Information be used for any of the following purposes:

(i) valuation or accounting purposes;

(ii) to determine the amounts due or payable, the price or the value of any financial instrument or financial contract; or

(iii) to measure the performance of any financial instrument.

By receiving this document and the Information you will be deemed to represent and warrant to UBS that you will not use this document or any of the Information for any of the above purposes or otherwise rely upon this document or any of the Information. Prior to making any investment or financial decisions, any recipient of this document or the information should seek individualized advice from his or her personal financial, legal, tax and other professional advisors that takes into account all the particular facts and circumstances of his or her investment objectives.

UBS has policies and procedures, which include, without limitation, independence policies and permanent information barriers, that are intended, and upon which UBS relies, to manage potential conflicts of interest and control the flow of information within divisions of UBS and among its subsidiaries, branches and affiliates. For further information on the ways in which UBS manages conflicts and maintains independence of its research products, historical performance information and certain additional disclosures concerning UBS research recommendations, please visit www.ubs.com/disclosures.

Research will initiate, update and cease coverage solely at the discretion of UBS Research Management, which will also have sole discretion on the timing and frequency of any published research product. The analysis contained in this document is based on numerous assumptions. All material information in relation to published research reports, such as valuation methodology, risk statements, underlying assumptions (including sensitivity analysis of those assumptions), ratings history etc. as required by the Market Abuse Regulation, can be found on NEO. Different assumptions could result in materially different results.

The analyst(s) responsible for the preparation of this document may interact with trading desk personnel, sales personnel and other parties for the purpose of gathering, applying and interpreting market information. UBS relies on information barriers to control the flow of information contained in one or more areas within UBS into other areas, units, groups or affiliates of UBS. The compensation of the analyst who prepared this document is determined exclusively by research management and senior management (not including investment banking). Analyst compensation is not based on investment banking revenues; however, compensation may relate to the revenues of UBS and/or its divisions as a whole, of which investment banking, sales and trading are a part, and UBS's subsidiaries, branches and affiliates as a whole.

For financial instruments admitted to trading on an EU regulated market: UBS AG, its affiliates or subsidiaries (excluding UBS Securities LLC) acts as a market maker or liquidity provider (in accordance with the interpretation of these terms in the UK) in the financial instruments of the issuer save that where the activity of liquidity provider is carried out in accordance with the definition given to it by the laws and regulations of any other EU jurisdictions, such information is separately disclosed in this document. For financial instruments admitted to trading on a non-EU regulated market: UBS may act as a market maker save that where this activity is carried out in the US in accordance with the definition given to it by the relevant laws and regulations, such activity will be specifically disclosed in this document. UBS may have issued a warrant the value of which is based on one or more of the financial instruments referred to in the document. UBS and its affiliates and employees may have long or short positions, trade as principal and buy and sell in instruments or derivatives identified herein; such transactions or positions may be inconsistent with the opinions expressed in this document.

United Kingdom and the rest of Europe: Except as otherwise specified herein, this material is distributed by UBS Limited to persons who are eligible counterparties or professional clients. UBS Limited is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. **France:** Prepared by UBS Limited and distributed by UBS Limited and UBS Securities France S.A. UBS Securities France S.A. is regulated by the ACPR (Autorité de Contrôle Prudentiel et de Résolution) and the Autorité des Marchés Financiers (AMF). Where an analyst of UBS Securities France S.A. has contributed to this document, the document is also deemed to have been prepared by UBS Securities France S.A. **Germany:** Prepared by UBS Limited and distributed by UBS Limited and UBS Europe SE. UBS Europe SE is regulated by the Bundesanstalt fur Finanzdienstleistungsaufsicht (BaFin). **Spain:** Prepared by UBS Limited and distributed by UBS Limited and UBS Securities España SV, SA. UBS Securities España SV, SA is regulated by the Comisión Nacional del Mercado de Valores (CNMV). **Turkey:** Distributed by UBS Limited. No information in this document is provided for the purpose of offering, marketing and sale by any means of any capital market instruments and services in the Republic of Turkey. Therefore, this document may not be considered as an offer made or to be made to residents of the Republic of Turkey. UBS Limited is not licensed by the Turkish Capital Market Board under the provisions of the Capital Market Law (Law No. 6362). Accordingly, neither this document nor any other offering material related to the instruments/services may be utilized in connection with providing any capital market services to persons within the Republic of Turkey without the prior approval of the Capital Market Board. However, according to article 15 (d) (ii) of the Decree No. 32, there is no restriction on the purchase or sale of the securities abroad by residents of the Republic of Turkey. **Poland:** Distributed by UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce regulated by the Polish Financial Supervision Authority. Where an analyst of UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce has contributed to this document, the document is also deemed to have been prepared by UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce. **Russia:** Prepared and distributed by UBS Bank (OOO). **Switzerland:** Distributed by UBS AG to persons who are institutional investors only. UBS AG is regulated by the Swiss Financial Market Supervisory Authority (FINMA). **Italy:** Prepared by UBS Limited and distributed by UBS Limited and UBS Limited, Italy Branch. Where an analyst of UBS Limited, Italy Branch has contributed to this document, the document is also deemed to have been prepared by UBS Limited, Italy Branch. **South Africa:** Distributed by UBS South Africa (Pty) Limited (Registration No. 1995/011140/07), an authorised user of the JSE and an authorised Financial Services Provider (FSP 7328). **Israel:** This material is distributed by UBS Limited. UBS Limited is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. UBS Securities Israel Ltd is a licensed Investment Marketer that is supervised by the Israel Securities Authority (ISA). UBS Limited and its affiliates incorporated outside Israel are not licensed under the Israeli Advisory Law. UBS Limited is not covered by insurance as required from a licensee under the Israeli Advisory Law. UBS may engage among others in issuance of Financial Assets or in distribution of Financial Assets of other issuers for fees or other benefits. UBS Limited and its affiliates may prefer various Financial Assets to which they have or may have Affiliation (as such term is defined under the Israeli Advisory Law). Nothing in this Material should be considered as investment advice under the Israeli Advisory Law. This Material is being issued only to and/or is directed only at persons who are Eligible Clients within the meaning of the Israeli Advisory Law, and this material must not be relied on or acted upon by any other persons. **Saudi Arabia:** This document has been issued by UBS AG (and/or any of its subsidiaries, branches or affiliates), a public company limited by shares, incorporated in Switzerland with its registered offices at Aeschenvorstadt 1, CH-4051 Basel and Bahnhofstrasse 45, CH-8001 Zurich. This publication has been approved by UBS Saudi Arabia (a subsidiary of UBS AG), a Saudi closed joint stock company incorporated in the Kingdom of Saudi Arabia under commercial register number 1010257812 having its registered office at Tatweer Towers, P.O. Box 75724, Riyadh 11588, Kingdom of Saudi Arabia. UBS Saudi Arabia is authorized and regulated by the Capital Market Authority to conduct securities business under license number 08113-37. **UAE / Dubai:** The information distributed by UBS AG Dubai Branch is only intended for Professional Clients and/or Market Counterparties, as classified under the DFSA rulebook. No other person should act upon this material/communication. The information is not for further distribution within the United Arab Emirates. UBS AG Dubai Branch is regulated by the DFSA in the DIFC. UBS is not licensed to provide banking services in the UAE by the Central Bank of the UAE, nor is it licensed by the UAE Securities and Commodities Authority. **United States:** Distributed to US persons by either UBS Securities LLC or by UBS Financial Services Inc., subsidiaries of UBS AG; or by a group, subsidiary or affiliate of UBS AG that is not registered as a US broker-dealer (a **'non-US affiliate'**) to major US institutional investors only. UBS Securities LLC or UBS Financial Services Inc. accepts responsibility for the content of a document prepared by another non-US affiliate when distributed to US persons by UBS Securities LLC or UBS Financial Services Inc. All transactions by a US person in the securities mentioned in this document must be effected through UBS Securities LLC or UBS Financial Services Inc., and not through a non-US affiliate. UBS Securities LLC is not acting as a municipal advisor to any municipal entity or obligated person within the meaning of Section 15B of the Securities Exchange Act (the "Municipal Advisor Rule"), and the opinions or views contained herein are not intended to be, and do not constitute, advice within the meaning of the Municipal Advisor Rule. **Canada:** Distributed by UBS Securities Canada Inc., a registered investment dealer in Canada and a Member-Canadian Investor Protection Fund, or by another affiliate of UBS AG that is registered to conduct business in Canada or is otherwise exempt from registration. **Mexico:** This report has been distributed and prepared by UBS Casa de Bolsa, S.A. de C.V., UBS Grupo Financiero, an entity that is part of UBS Grupo Financiero, S.A. de C.V. and is an affiliate of UBS AG. This document is intended for distribution to institutional or sophisticated investors only. Research reports only reflect the views of the analysts responsible for the reports. Analysts do not receive any compensation from persons or entities different from UBS Casa de Bolsa, S.A. de C.V., UBS Grupo Financiero, or different from entities belonging to the same financial group or business group of such. For Spanish translations of applicable disclosures, please see www.ubs.com/disclosures. **Brazil:** Except as otherwise specified herein, this material is prepared by UBS Brasil CCTVM S.A. to persons who are eligible investors residing in Brazil, which are considered to be: (i) financial institutions, (ii) insurance firms and investment capital companies, (iii) supplementary pension entities, (iv) entities that hold financial investments higher than R$300,000.00 and that confirm the status of qualified investors in written, (v) investment funds, (vi) securities portfolio managers and securities consultants duly authorized by Comissão de Valores Mobiliários (CVM), regarding their own investments, and (vii) social security systems created by the Federal Government, States, and Municipalities. **Hong Kong:** Distributed by UBS Securities Asia Limited and/or UBS AG, Hong Kong Branch. **Singapore:** Distributed by UBS Securities Pte. Ltd. [MCI (P) 007/09/2016 and Co. Reg. No.: 198500648C] or UBS AG, Singapore Branch. Please contact UBS Securities Pte. Ltd., an exempt financial adviser under the Singapore Financial Advisers Act (Cap. 110); or UBS AG, Singapore Branch, an exempt financial adviser under the Singapore Financial Advisers Act (Cap. 110) and a wholesale bank licensed under the Singapore Banking Act (Cap. 19) regulated by the Monetary Authority of Singapore, in respect of any matters arising from, or in connection with, the analysis or document. The recipients of this document represent and warrant that they are accredited and institutional investors as defined in the Securities and Futures Act (Cap. 289). **Japan:** Distributed by UBS Securities Japan Co., Ltd. to professional investors (except as otherwise permitted). Where this document has been prepared by UBS Securities Japan Co., Ltd., UBS Securities Japan Co., Ltd. is the author, publisher and distributor of the document. Distributed by UBS AG, Tokyo Branch to Professional Investors (except as otherwise permitted) in relation to foreign exchange and other banking businesses when relevant. **Australia:** Clients of UBS AG: Distributed by UBS AG (ABN 47 088 129 613 and holder of Australian Financial Services License No. 231087). Clients of UBS Securities Australia Ltd: Distributed by UBS Securities Australia Ltd (ABN 62 008 586 481 and holder of Australian Financial Services License No. 231098). This Document contains general information and/or general advice only and does not constitute personal financial product advice. As such, the Information in this document has been prepared without taking into account any investor's objectives, financial situation or needs, and investors should, before acting on the Information, consider the appropriateness of the Information, having regard to their objectives, financial situation and needs. If the Information contained in this document relates to the acquisition, or potential acquisition of a particular financial product by a 'Retail' client as defined by section 761G of the Corporations Act 2001 where a Product Disclosure Statement would be required, the retail client should obtain and consider the Product Disclosure Statement relating to the product before making any decision about whether to acquire the product. The UBS Securities Australia Limited Financial Services Guide is available at: www.ubs.com/ecs-research-fsg. **New Zealand:** Distributed by UBS New Zealand Ltd. UBS New Zealand Ltd is not a registered bank in New Zealand. You are being provided with this UBS publication or material because you have indicated to UBS that you are a "wholesale client" within the meaning of section 5C of the Financial Advisers Act 2008 of New Zealand (Permitted Client). This publication or material is not intended for clients who are not Permitted Clients (non-permitted Clients). If you are a non-permitted Client you must not rely on this publication or material. If despite this warning you nevertheless rely on this publication or material, you hereby (i) acknowledge that you may not rely on the content of this publication or material and that any recommendations or opinions in such this publication or material are not made or provided to you, and (ii) to the maximum extent permitted by law (a) indemnify UBS and its associates or related entities (and their respective Directors, officers, agents and Advisors) (each a 'Relevant Person') for any loss, damage, liability or claim any of them may incur or suffer as a result of, or in connection with, your unauthorised reliance on this publication or material and (b) waive any rights or remedies you may have against any Relevant Person for (or in respect of) any loss, damage, liability or claim you may incur or suffer as a result of, or in connection with, your unauthorised reliance on this publication or material. **Korea:** Distributed in Korea by UBS Securities Pte. Ltd., Seoul Branch. This document may have been edited or contributed to from time to time by affiliates of UBS Securities Pte. Ltd., Seoul Branch. This material is intended for professional/institutional clients only and not for distribution to any retail clients. **Malaysia:** This material is authorized to be distributed in Malaysia by UBS Securities Malaysia Sdn. Bhd (Capital Markets Services License No.: CMSL/A0063/2007). This material is intended for professional/institutional clients only and not for distribution to any retail clients. **India:** Distributed by UBS Securities India Private Ltd. (Corporate Identity Number U67120MH1996PTC097299) 2/F, 2 North Avenue, Maker Maxity, Bandra Kurla Complex, Bandra (East), Mumbai (India) 400051. Phone: +912261556000. It provides brokerage services bearing SEBI Registration Numbers: NSE (Capital Market Segment): INB230951431, NSE (F&O Segment) INF230951431, NSE (Currency Derivatives Segment) INE230951431, BSE (Capital Market Segment) INB010951437; merchant banking services bearing SEBI Registration Number: INM000010809 and Research Analyst services bearing SEBI Registration Number: INH000001204. UBS AG, its affiliates or subsidiaries may have debt holdings or positions in the subject Indian company/companies. Within the past 12 months, UBS AG, its affiliates or subsidiaries may have received compensation for non-investment banking securities-related services and/or non-securities services from the subject Indian company/companies. The subject company/companies may have been a client/clients of UBS AG, its affiliates or subsidiaries during the 12 months preceding the date of distribution of the research report with respect to investment banking and/or non-investment banking securities-related services and/or non-securities services. With regard to information on associates, please refer to the Annual Report at: http://www.ubs.com/global/en/about_ubs/investor_relations/annualreporting.html

The disclosures contained in research documents produced by UBS Limited shall be governed by and construed in accordance with English law.

UBS specifically prohibits the redistribution of this document in whole or in part without the written permission of UBS and UBS accepts no liability whatsoever for the actions of third parties in this respect. Images may depict objects or elements that are protected by third party copyright, trademarks and other intellectual property rights. © UBS 2017. The key symbol and UBS are among the registered and unregistered trademarks of UBS. All rights reserved.