Challenges and Opportunities of Cree

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Cree in 2015

In 2015 Cree has reported:

- Flat revenue: $1.6 billion
- Decreased margin of 29%, compared with 38% 2014
- Net loss $64 million, compared with profit $124 million 2014

What happened with Cree?

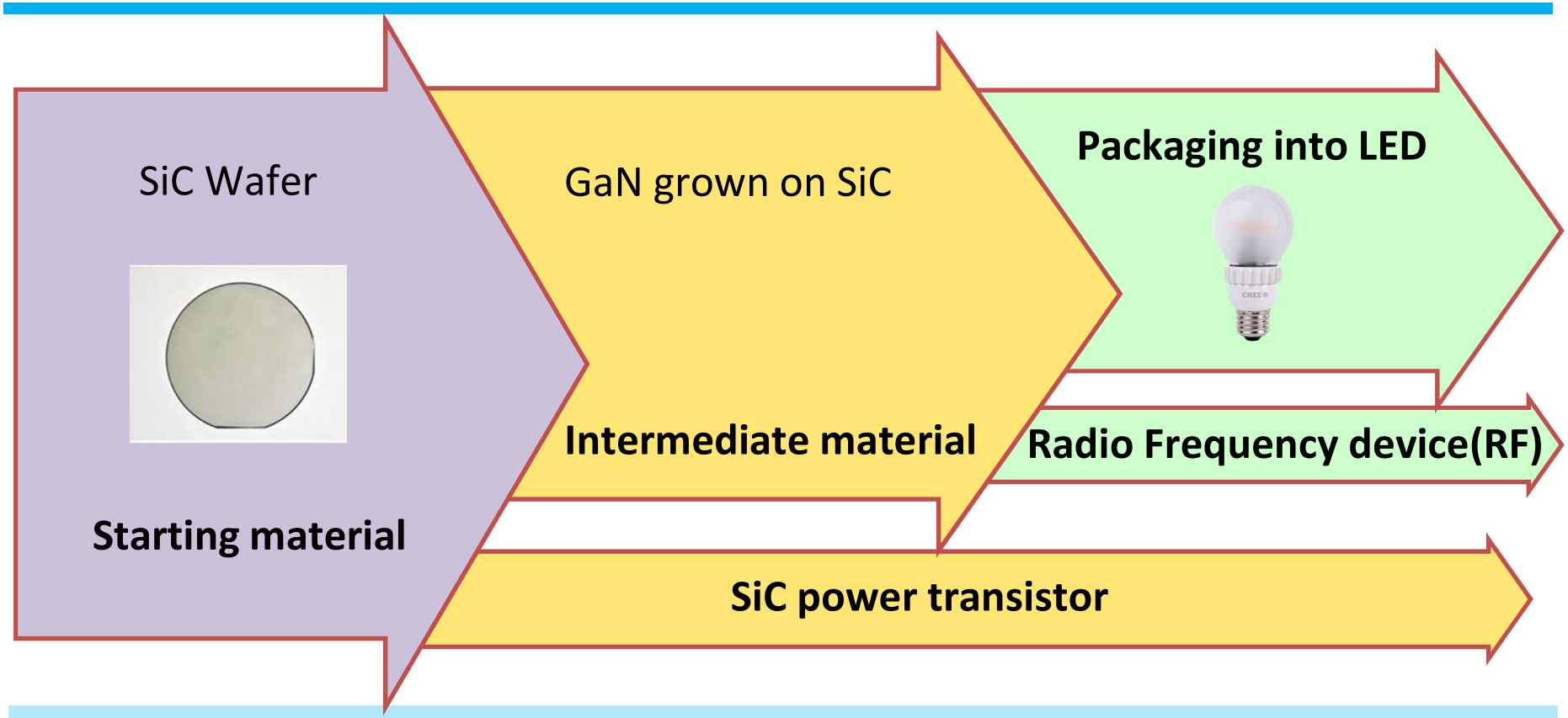
- **Background of Cree**
- Identify the challenges in LED
- Opportunity from power electronics
- Summary of Strategies and Risks

Cree: focusing on silicon carbide (SiC)

Startup	• 1987 Founded • 1991 world's first commercial SiC wafer • 1993 IPO in NASDAQ
Rapid Growth	• 1993~2000 Introducing disruptive white light LED • 1996~2006 Revenue CAGR ~40% • Major in producing LED components (intermediate)
Transform & Steady Growth	• 2008 entering into LED lighting product (end product) • 2011~2014 Revenue CAGR ~20%

Source: www.cree.com

SiC: platform material for Cree

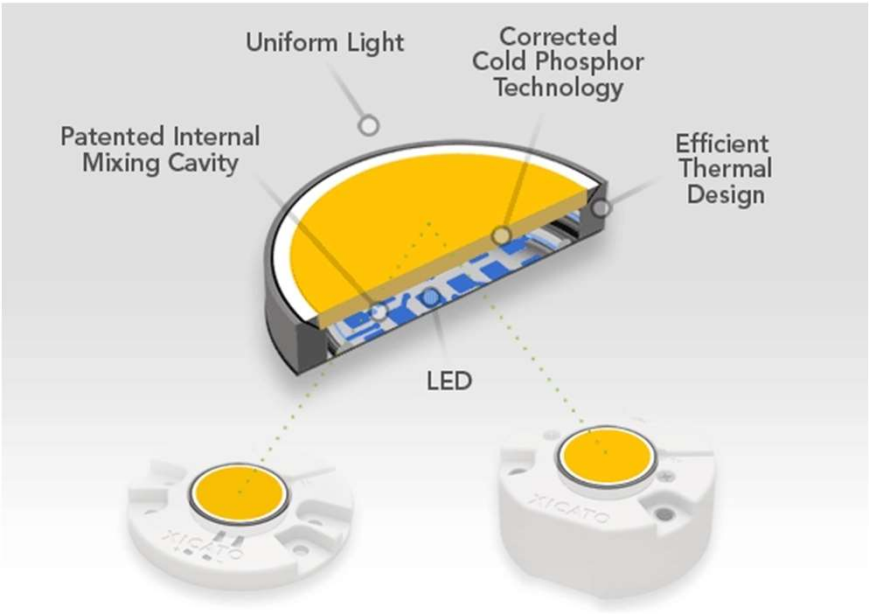


Source: Cree 2015 annual report

White light LED

	standard incandescent	CFL compact fluorescent lamp	LED
			
watts >>	60	18	10
lumens >>	840	825	800
life (years) >>	0.9	9.1	22.8
estimated annual energy cost >>*	$7.23	$5.18	$1.56
initial cost per bulb >>	$2.00	$8.00	$12.00

** based upon 3hrs/day and rate of $0.11 per kilowatt hour*



White light LED is generally more expensive but efficient

Source: Consumer Energy Solutions

Other competing technologies

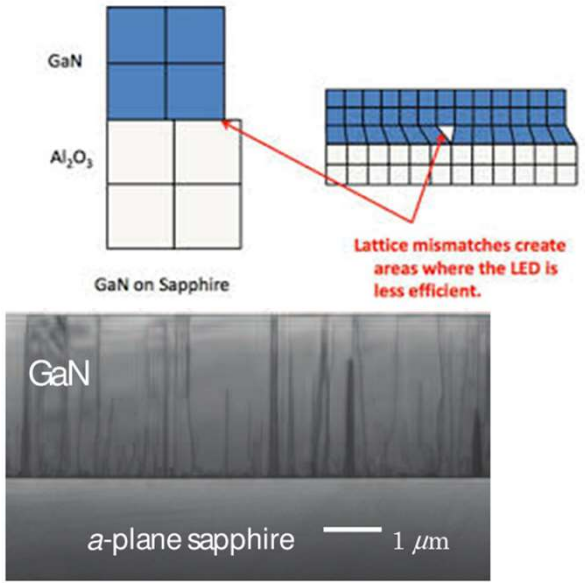
Comparison of three different substrates for GaN growth

Substrates	Lattice mismatch	Thermal conductivity	Representative company
SiC	3.5%	4.9 W/(cm K)	Cree
Sapphire	14%	0.3	Nichia
Si(111)	17%	1.5	Panasonic Azzuro

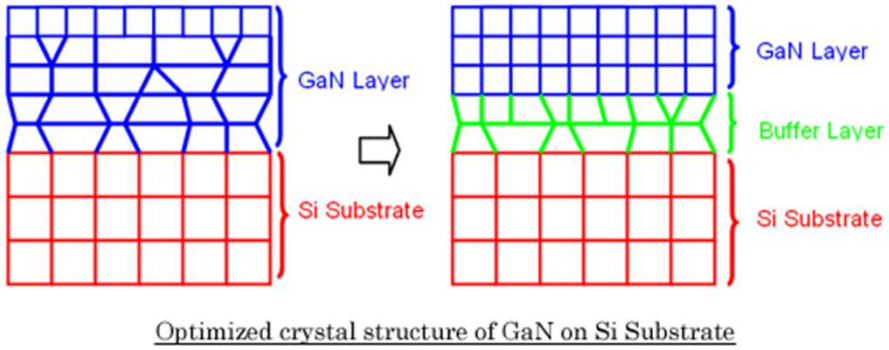
- The less mismatch, the easier to achieve epitaxy
- The higher thermal conductivity, the better stability

Why others still use sapphire?

Sapphire and Silicon technology improvement



Direct GaN growth on Sapphire



Optimized crystal structure of GaN on Si Substrate

Buffered GaN growth

Buffer technology makes Sapphire and Silicon substitutes to SiC

Current market position of Cree

- The only SiC based LED producer.
- Record setting LED efficiency 303 lm/W (theoretical limit 683 lm/W).
- Takes ~6% of world's LED market (6th largest manufacture)
- World's 2nd largest manufacture of SiC power devices. Takes ~29% world's market share.

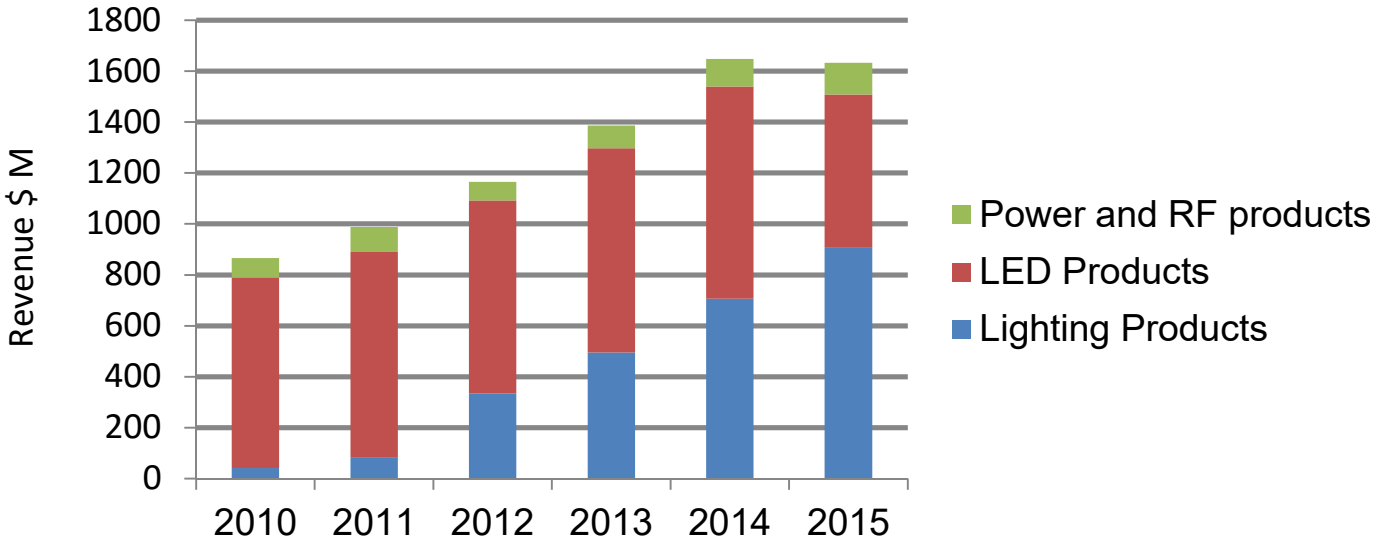
Source: Cree 2015 annual report & Yole Development 2015

- Background of Cree
- **Identify the challenges**

1. LED product short term: threat from China
2. LED product long term: Sapphire and Si substitution
3. Lighting product: steady growth

- Opportunity from power electronics
- Summary of Strategies and Risks

Segmented revenue of Cree

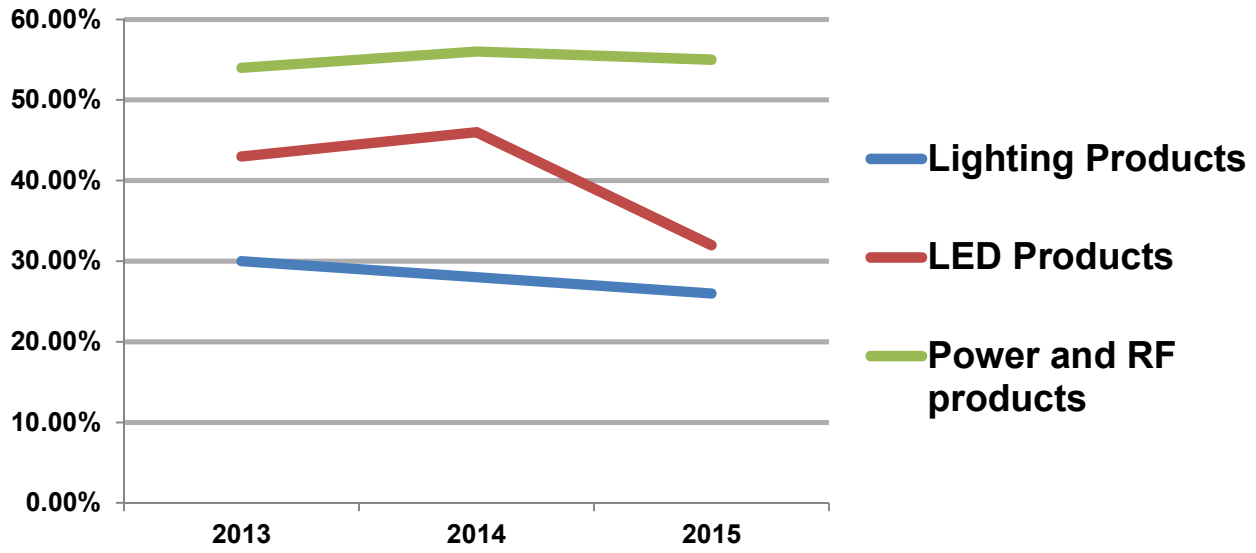


- Lighting product increased 28%
- LED product decreased 28%
- Power and RF has increased 15%

What about margins?

Source: Cree annual report 2015

Gross margin is decreasing for LED segment

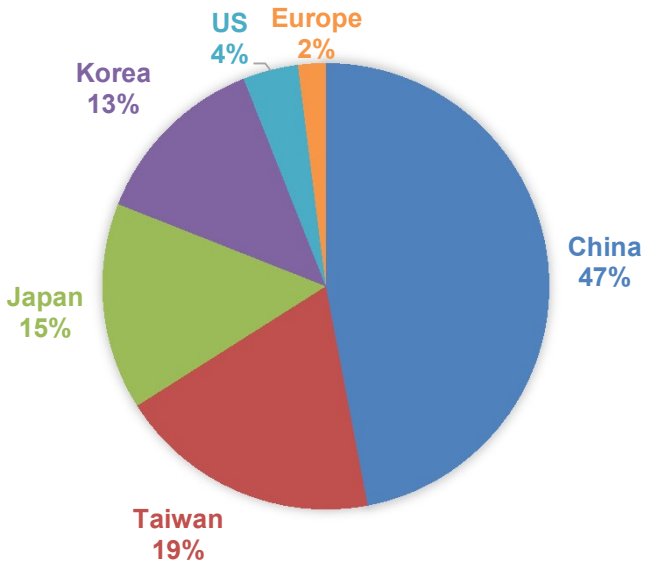


LED products has a declined margin last year. Is it from competition?

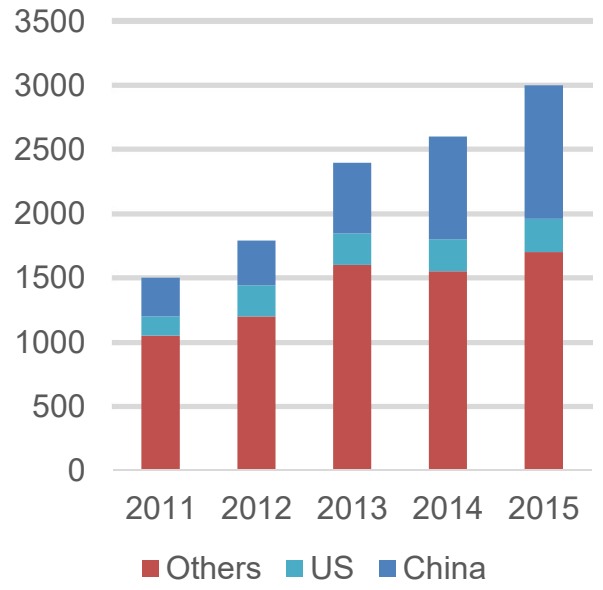
Source: Cree annual report 2015

LED product supply: threat from China in LED products

World's MOCVD installation 2015



World's LED chip capacity
(thousand 4" wafer equivalent)

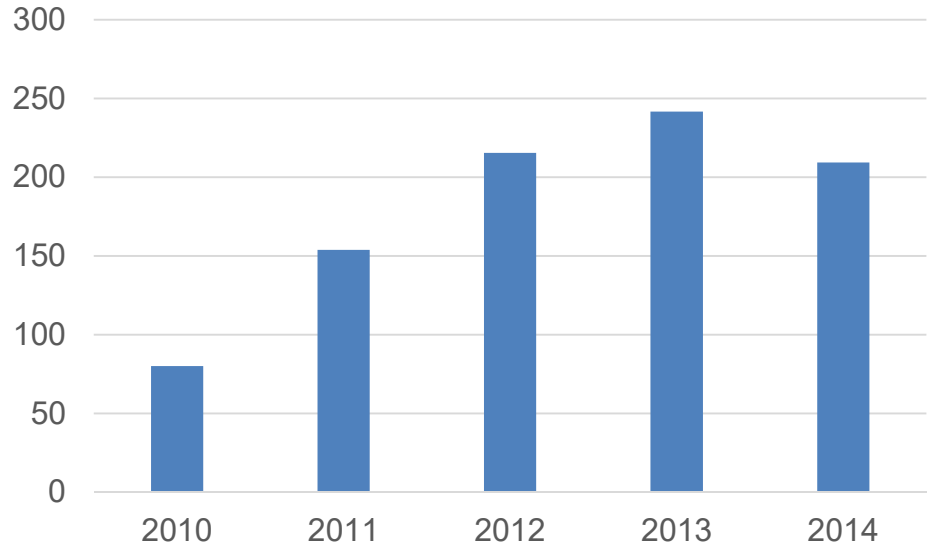


- Over supply by 16-19%
- Why China is booming in LED Chip capacity?

Source: LEDinside 2015 & Semi 2015 & Solid state technology

Subsidy in China

Government subsidy received by San An Inc (M$)



San An has reported 2015 revenue of $3 billion, ~8% from subsidy

50% to 100% subsidy is reported on new MOCVD installation

Source: WIND

Will oversupply continue?

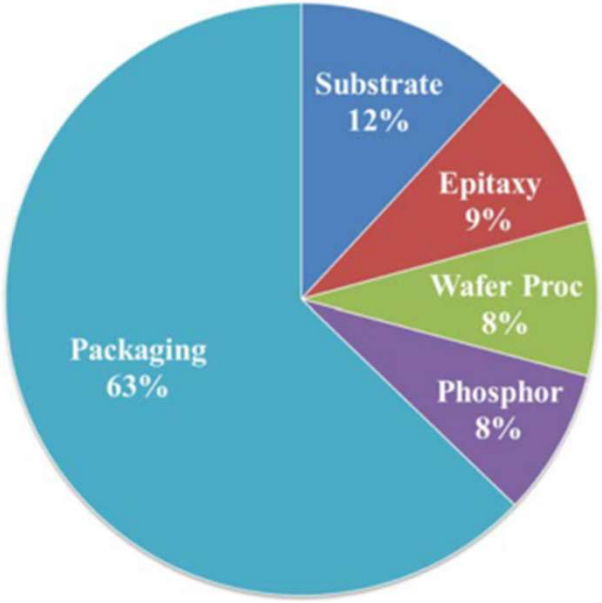
Over supply of LED would continue in short term (2-3y)

- **Trend:** Capacity is increasing at similar rate with demand
- **Lowered entry barrier**: subsidy on MOCVD installation
- **Lack of exit**: Subsidized producer with lower efficiency would survive for a while.

Source: Solid State technology

Long term trend: Cost of different technology

LED chip cost break down (4” Sapphire sub)



Price of different substrates

	4”	6”	8”
Sapphire	~$50	~$150	NA
Si	NA	NA	~$40
SiC	~$150	~$450	NA

- Sapphire and Si are generally cheaper than SiC
- Substrate cost takes only 12%
- Further analysis on overall cost is needed

Source: Department of Energy 2015

Estimate relative variable cost of LED chip manufacture

Assumptions:

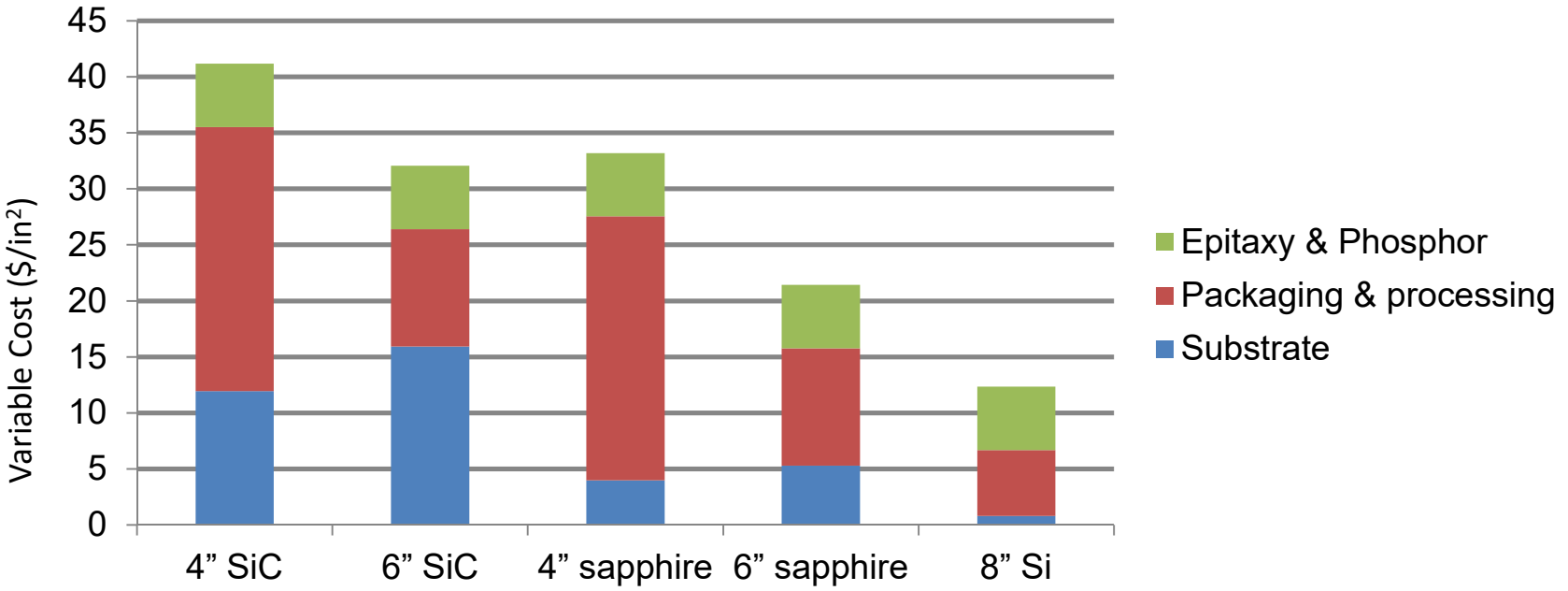
- The cost of epitaxy growth is proportional to the area of wafer
- The cost of wafer processing and packaging are proportional to the wafer number, regardless wafer type
- Yields remained same for all substrates

Estimate variable cost of LED chip manufacture

Total cost = substrate + Packaging & processing + Epitaxy & phosphor

	Substrate	Packaging & processing	Epitaxy & Phosphor	Total cost per wafer	Total cost per square inch
4” sapphire	$50	$296	$71	$417	$33
6” sapphire	$150	$296	$160	$606	$21
4” SiC	$150	$296	$71	$517	$41
6” SiC	$450	$296	$160	$456	$32
8” Si	$40	$296	$284	$620	$12

Estimate variable cost of LED chip manufacture



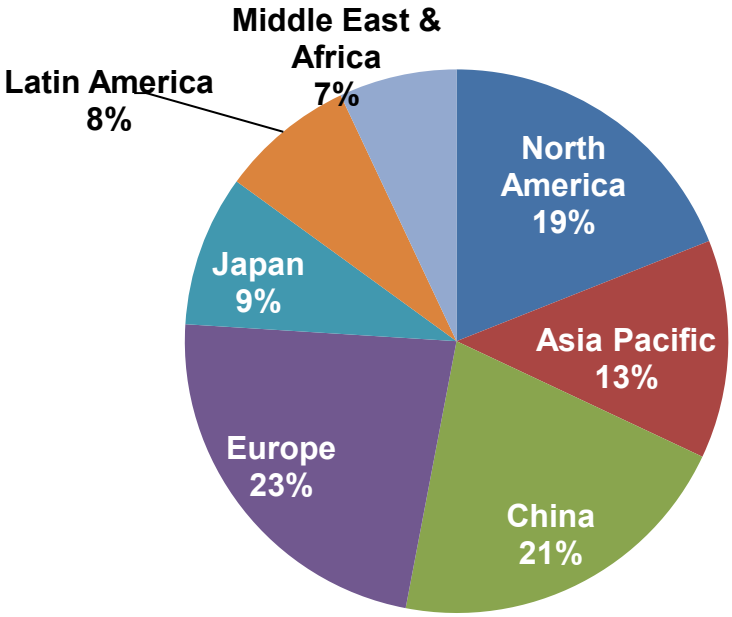
6” sapphire is partially adopted in industry
6” SiC process is not available yet
8” Si process is in R&D

Long term trend: Cree is disadvantageous in cost

According to the previous analysis

- Cree has fall behind in terms of wafer scaling
- SiC wafer is more expensive than sapphire and Si
- 8” Si process might revolutionize LED industry in long run

Downstream: lighting product trend



- Total market size in 2015 is $25B
- CAGR 30% in US, 12% world wide, Cree growth rate 28%-30%.
- Cree takes 4% in world market and 20% in North America. One of the largest.

How is Cree's product comparing with others?

Source; LEDinside

Comparison of SiC and Sapphire LED product

100W replacement LED

	Cree	Philips
Price ($)	20.00	9.00
Power(W)	18	14.5
Substrate	SiC	Sapphire
Brightness(lm)	1600	1500

Sapphire technology showed similar quality with price

Source: Amazon

Potential reason for Cree's higher price in lighting product

- **Better distribution channel ?**

1. No significant difference among competitors
2. Large retailers take only 20% of Cree's sales

- **Better reliability ?**

1. Technical reviews show similar reliability
2. Heat sink technique guaranteed sapphire LED good reliability

- **Better customer service**

1. Longer warranty(10y compared with 3y)
2. Headquartered in US

- **Better brand recognition: Obama's influence**

Source: Amazon

Obama’s visited Cree twice during his presidency

- Bring jobs back to US
- CO2 reduction plan

Source: Amazon

Continuous grow in lighting product

- **Expecting moderate growth in short term(2-3y)**

1. No significant new entrants
2. Steady growth of LED lighting market is expected
3. Good brand recognition helps maintain market share

- **Optimistic scenario:** remain 26% margin by 2018

1. Growth of revenue continue to be 30%
2. By 2018, revenue $2B, gross profit $520M

- **Pessimistic scenario:** decreased margin to 20% by 2018

1. Price war to keep market share.
2. By 2018, revenue still $2B, gross profit $400M (fully offset current chip sector)

Source: Amazon

Potential strategy for lighting product

- **Out source chip manufacture to China and switch to sapphire**

1. Cheaper overall cost than SiC
2. Subsidy may help improve the profit margin
3. Save the time to develop sapphire or Si technology

- **Maintain brand recognition in North America market.**

1. Potentially further lower price
2. Keeps improving customer service.

- **Risks:**

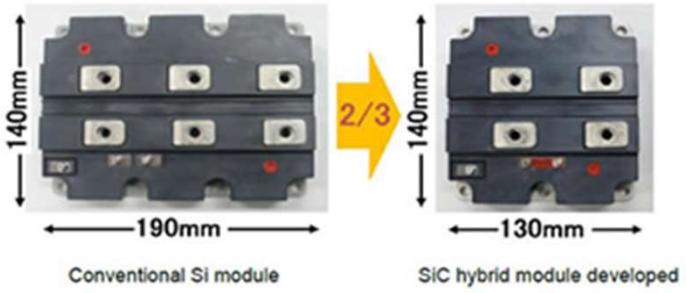
1. Uncertainty about Chinese subsidiary policy
2. Difficulty to find a partner or establish factory in China

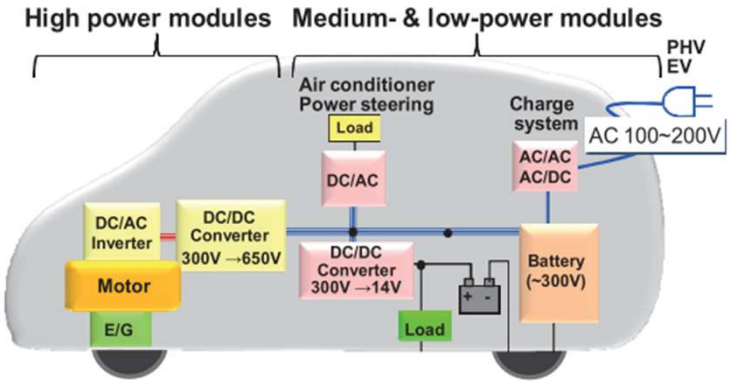
Source: Amazon

- Background of Cree
- Identify the challenges
- **Opportunity from power electronics**
- Summary of Strategies and Risks

Cree's opportunity in power electronics

Current SiC power module size

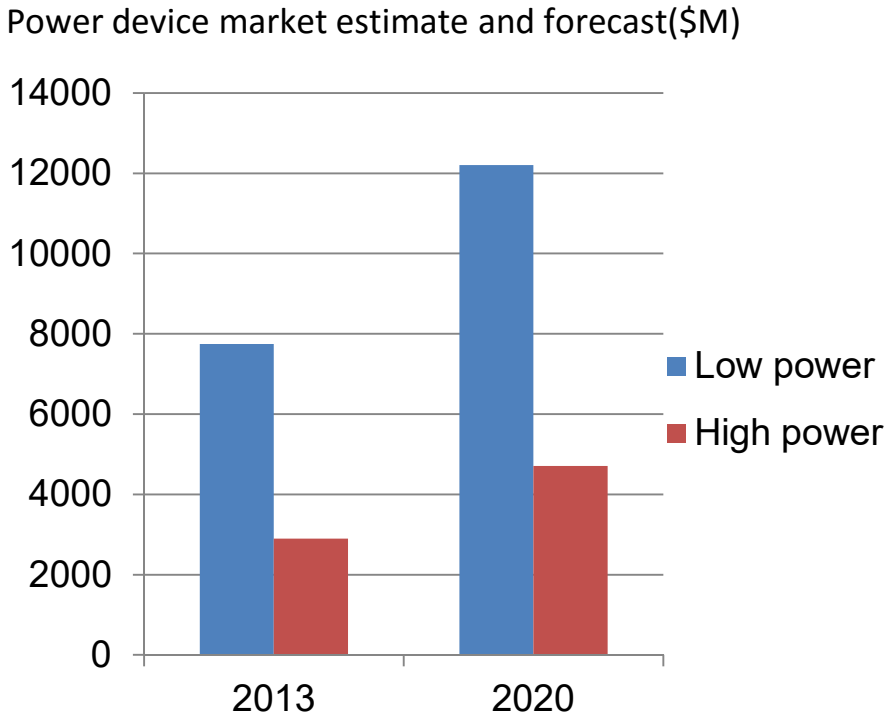




- Smaller size: a quarter of Si counterparts
- Higher efficiency (98% compared with 80% of silicon device) under high voltage
- Higher working temperature(200^{o}C)
- Bottle Neck: Currently ten times more expensive than Si device

Source: Toyota

Cree potential SiC power device market estimate



Assumptions:

- By 2020, high power device revenue can reach $4.7B

- High power (>600V) penetration rate:

1. Optimistic: 20% (CAGR 40%)
2. Pessimistic: 10% (CAGR 25%)

- Cree takes about 29% currently, profit margin 50%

Estimate for 2020:

Revenue: 300M(opt) 150M (pes)

Profit: 150M(opt), 75M(pes)

Source: Yole Development

Potential strategy for power device sector

- **R&D**: Invest in developing 6” and above technique to reduce cost

- **Marketing**: Focus on devices for high power purpose

1. Electrical vehicle
2. Solar farm
3. High speed train

- **Risks**: Low oil price may reduce the adoption rate of EV and solar, in turns reduce the penetration rate of SiC device.

Strategy for Cree

- **LED chip**: Reduce excessive LED chip capacity (only keep for internal use)
- **Lighting product**: Improve marketing and out sourcing
- **Power electronics**: continue R&D and marketing for future growth

Potential risks

- LED chip: fast adoption of 8” Si technology may take over SiC technology in LED.
- Lighting product: Price war from other brands may reduce margin faster than expected.
- Power device: low energy price might hinder the development of EV and solar, which in turns reduce high power device demand.


Brain