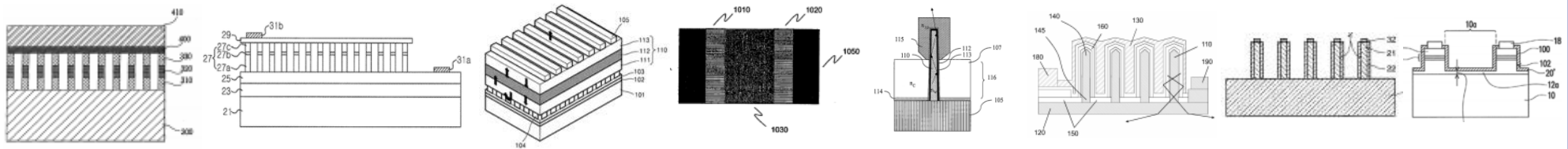


# Nanowire LED Patent Investigation



Le Quartz  
75 cours Emile Zola, F-69001 Lyon-Villeurbanne, France  
[www.yole.fr](http://www.yole.fr)

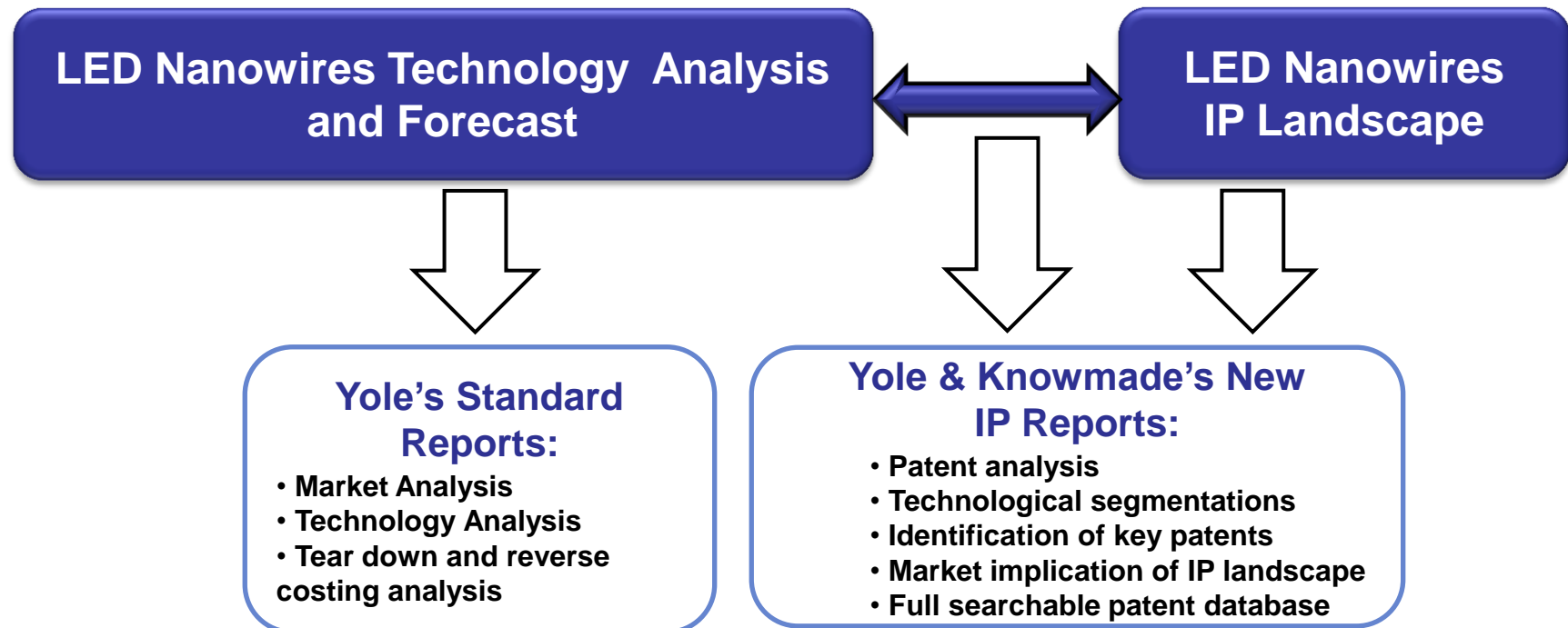


2405 route des Dolines  
06902 Sophia Antipolis, France  
[www.knowmade.com](http://www.knowmade.com)

# A New Type of Report Providing a Clear Link between IP Situation and Market Evolutions

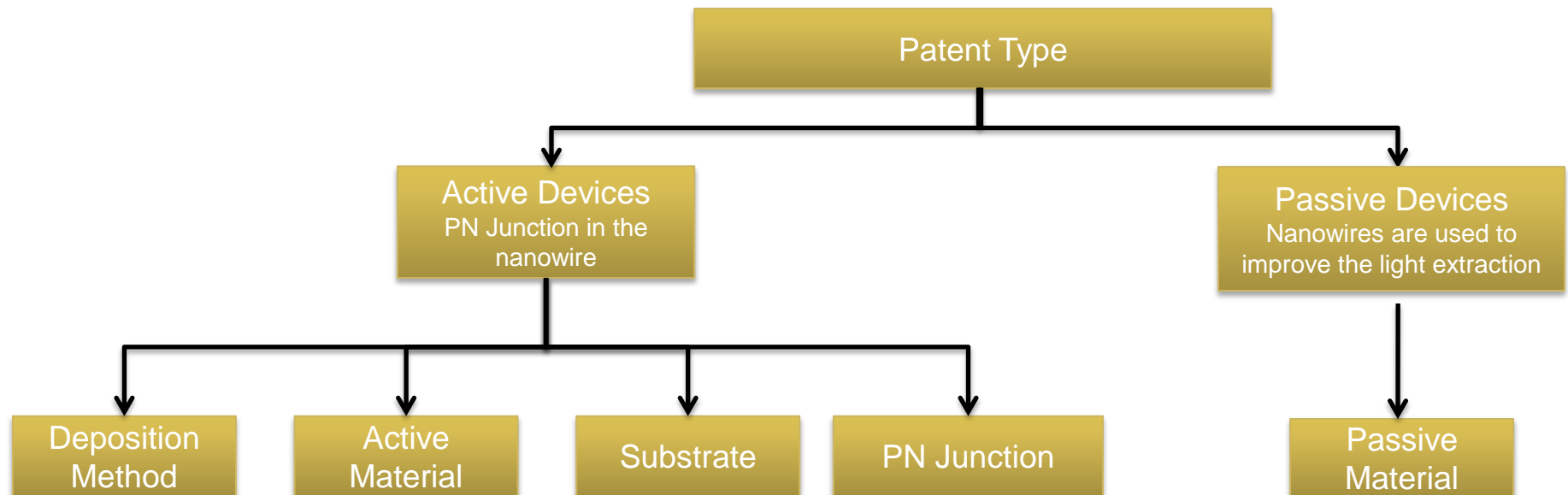
More than describing the status of the IP situation, this report provides a missing link between patented technological solutions and market, technological and business trends

- Knowmade has developed a unique methodology to define a technical segmentation of patent landscape and identify key patents.
- By combining their technical knowledge, business understanding and patent search, Yole and Knowmade are able to provide unique analysis and added value in this report.
- In-depth technological analysis of patents provided in this report will lead to understanding of strategic decisions and positioning of key players within the value chain.



# Scope of the Report

- This report provides a detailed picture of the patent landscape for LED with nanowires. Only patents related to nanowires for LED applications were considered: nanowires used as PN junction (“active devices”) and nanowires used for light extraction (“passive devices”). **This report does not include patents related to the fabrication of nanowires or for other applications (solar, detectors, laser ...).**
- More than 350 patent families relevant to the scope of this report have been analyzed. Those have been manually segmented by type and organized in various technology segments as described below.
- Market data from Yole Développement are also provided to add some context regarding business trends and metrics.



# Key Features of the Report

- The report provides essential patent data, technology analysis and forecast for LED Nanowires.
- It identifies more than 100 patent holders of LED Nanowires related intellectual property. It provides in-depth analysis of key technology segments and key players including:
  - Time evolution of patent publications and countries of patent filings
  - Current legal status of patents
  - Ranking of main patent applicants
  - Joint developments and IP collaboration network of main patent applicants
  - Key patents
  - Granted patents near expiration
  - Relative strength of main companies IP portfolio
  - Overview of patent litigations
  - Matrix applicants/technology issues for more than 30 companies
- A special focus is provided on key issues and approaches:
  - Materials: GaN, ZnO, GaAs, InP ...
  - Type of technology: active device (active layers), passive device (light extraction enhancement)
  - Type of PN junction: axial, radial (core-shell), axial/radial
- The “LED Nanowires IP” profiles of 6 companies is presented, with key patents, technological key approach, and partnerships.

# Key Features of the Report

- The report also provides an extensive Excel database with all patents analyzed in the report with technology segmentation. This database allows multi-criteria searches:
  - **Patent information**
    - Patent publication number
    - Hyperlinks to the original documents
    - Priority date
    - Title
    - Abstract
    - Patent Assignees
    - Technological segments
    - Legal status for each member of the patent family
  - **Technological segments**
    - Deposition Method
    - Substrate
    - Material
    - PN Junction
- **This report does not** provide any insight analyses or counsel regarding legal aspects or the validity of any individual patent: Knowmade and Yole Développement are research firms that provide market and technical analysis and opinions. The research, technical analysis and/or work contained herein is not a legal opinion and should not be construed as such.

# Methodology (1/2)

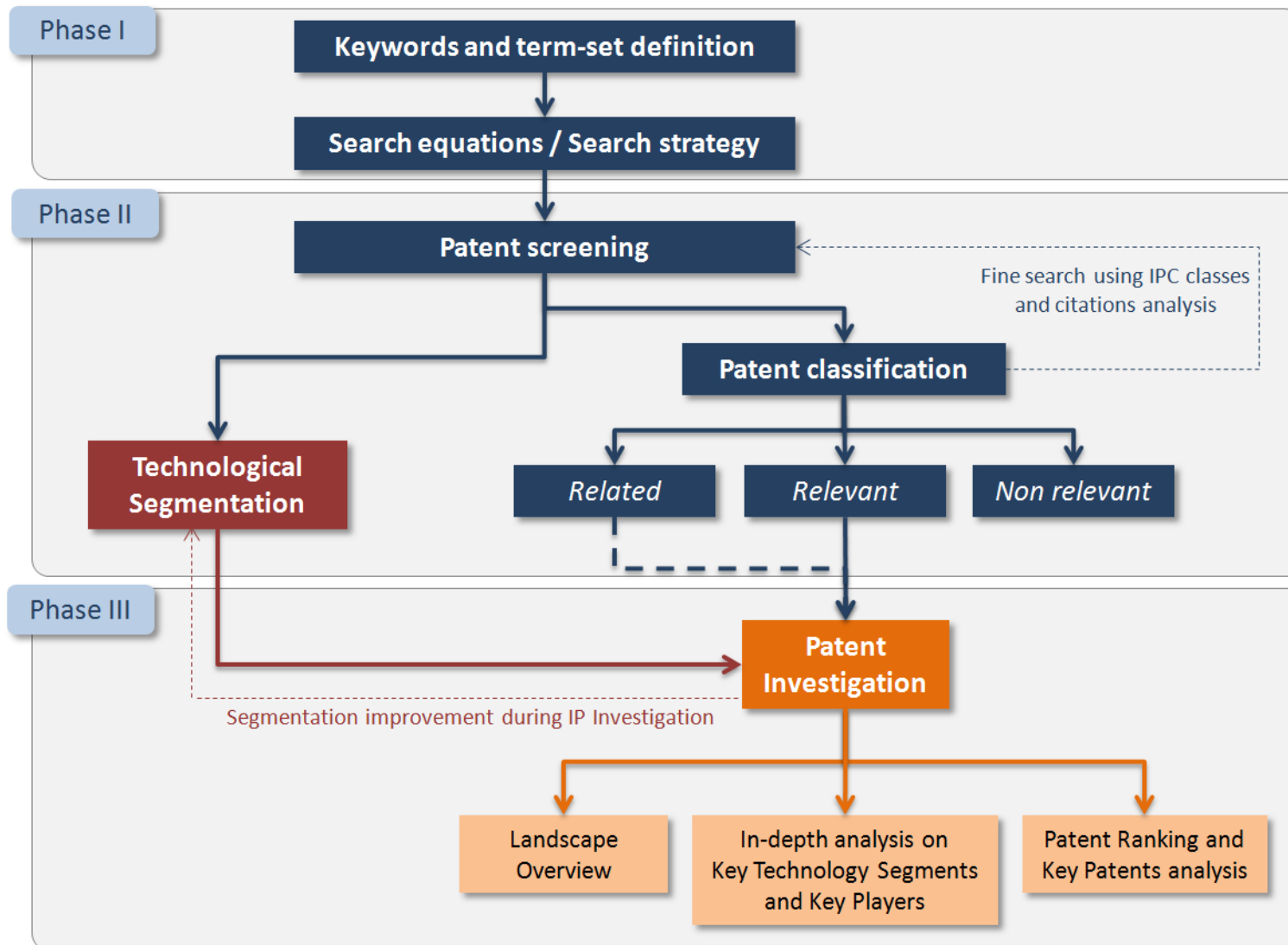
- The data were extracted from the FamPat worldwide database (Questel-ORBIT) which provides 80+ million patent documents from 95 offices.
- The patents search was performed in early February 2014, hence patents published after this date will not be available in this report.
- The patent selection is done both automatically and manually.

Number of selected patent families for the LED Nanowires IP Investigation:  
361 over a number of returned results > 700

- The statistical analysis was performed with INTELLIXIR System.
- The patents were categorized using keyword analysis of patent title, abstract and claims, in conjunction with expert review of the subject-matter of inventions (details in next slides).
- The patents were organized according to FamPat's family rules (variation of EPO strict family): *A Patent Family* comprises patents linked by exactly same priority numbers (strict family), plus comparison of priority and application numbers, specific rules by country and information gathered from other sources (national files, legal status ...).

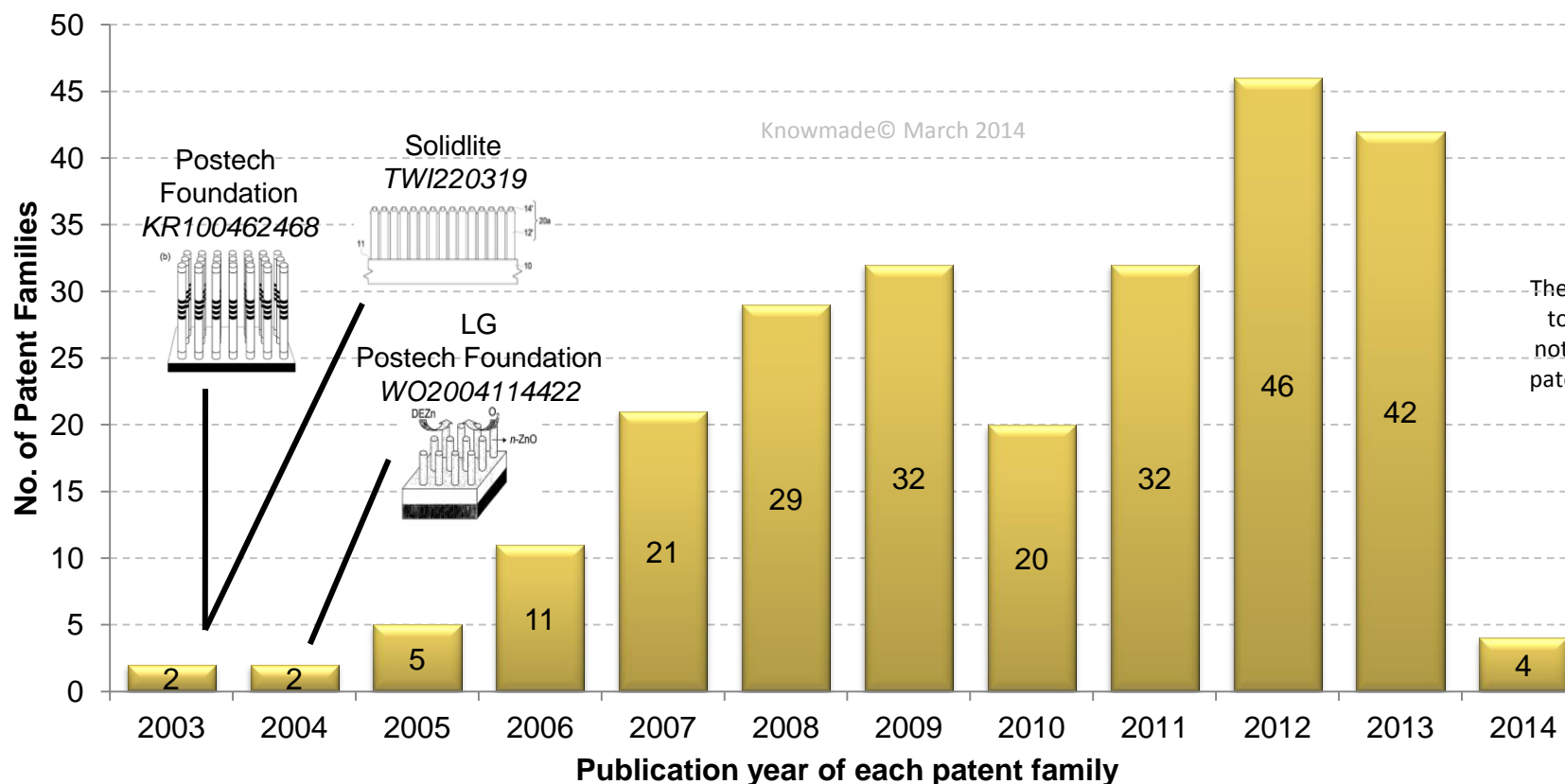
**Disclaimer:** Knowmade and Yole Développement are research firms that provides technical analysis and technical opinions. The research, technical analysis and/or work contained herein is not a legal opinion and should not be construed as such.

# Methodology (2/2)



# Time Evolution of Patent Publications

Active  
Devices



From 2003 to 2014, 246 patent families were published on nanowires as active layers for LED applications. Publications increase almost constantly over the past ten years except a decrease in 2010. The exact reason of the reduction in 2010 is unknown. It could be attributed to the economic crisis in 2008-2009, during which less patents were filed and thus less patents were published in 2010 (18 months after patent filing).



# Summary of Main Assignee Patent Portfolios

Active  
Devices

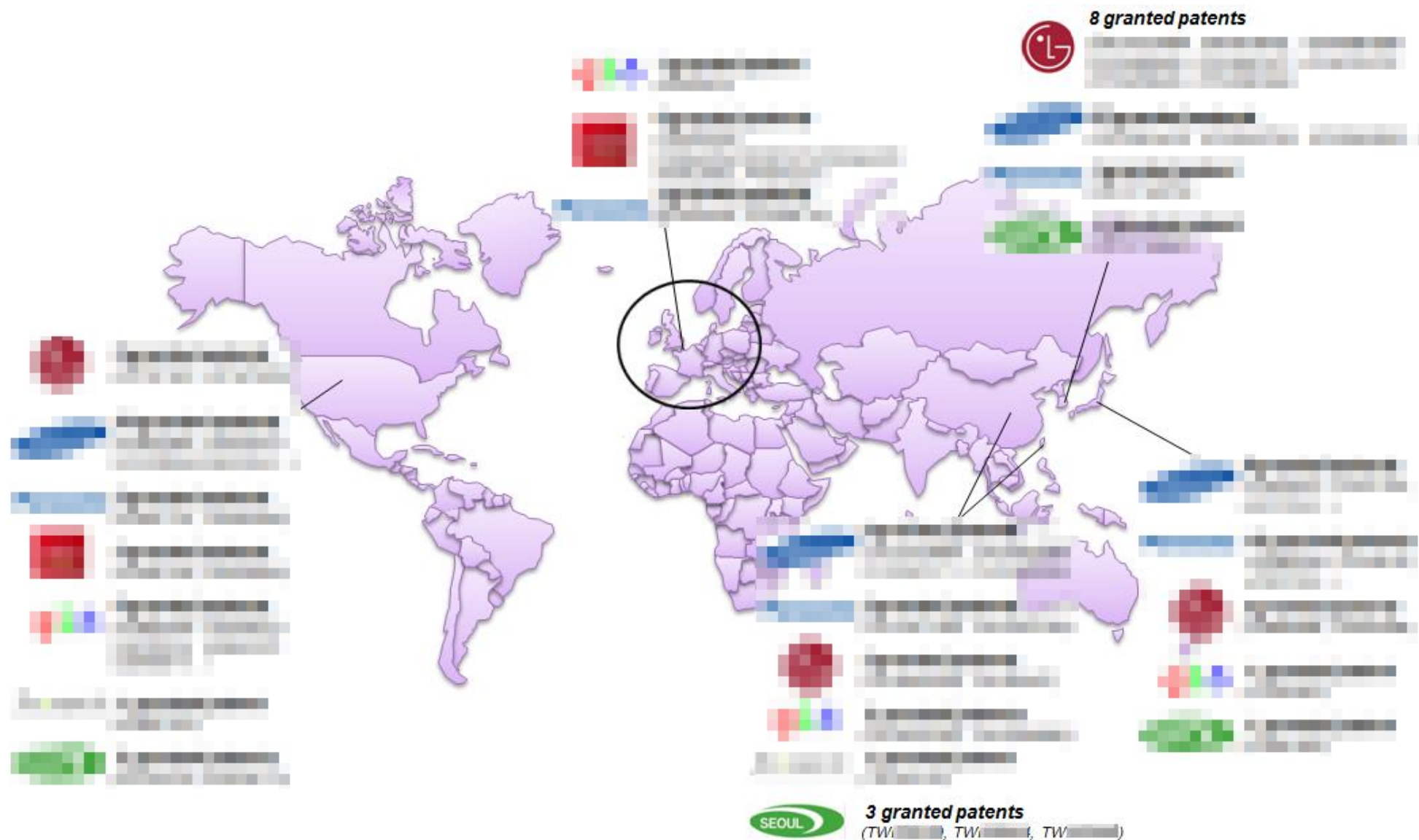
Assignee	No. of patent families	Oldest priority date of the patent portfolio (DD/MM/YYYY)	No. of patent families filed / yr (average)	No. Of patents	Patents average age (Y)	Granted patents (%)	Pending patents (%)	Dead patents (%)	No. of alive patents / family (granted, pending)	Country of filings (Number of Patent Documents)					
										KR	US	JP	WO	CN	FR
Company 1	XX	07/04/2004	6.0	134	3	54%	43%	2%	2.2	53	32	6		7	
Company 2	XX	14/07/2005	3.4	113	5	34%	7%	59%	1.5	2	2	28	5	2	
Company 3	XX	26/06/2003	1.6	31	6	52%	39%	10%	1.6	15	3	2	2	3	
Company 4	XX	09/06/2006	1.5	55	3	33%	62%	5%	4.3		7	3	8	2	10
Company 5	XX	31/03/2012	3.8	8	1	0%	100%	0%	1.0					8	
Company 6	XX	25/06/2005	0.8	35	5	40%	34%	26%	1.1	6	4	2	5	1	
Company 7	XX	19/12/2008	1.3	62	2	23%	76%	2%	1.1	4	7	4	6	4	

■ : highest value in column

■ : lowest value in column

# Mapping of Current IP Holders

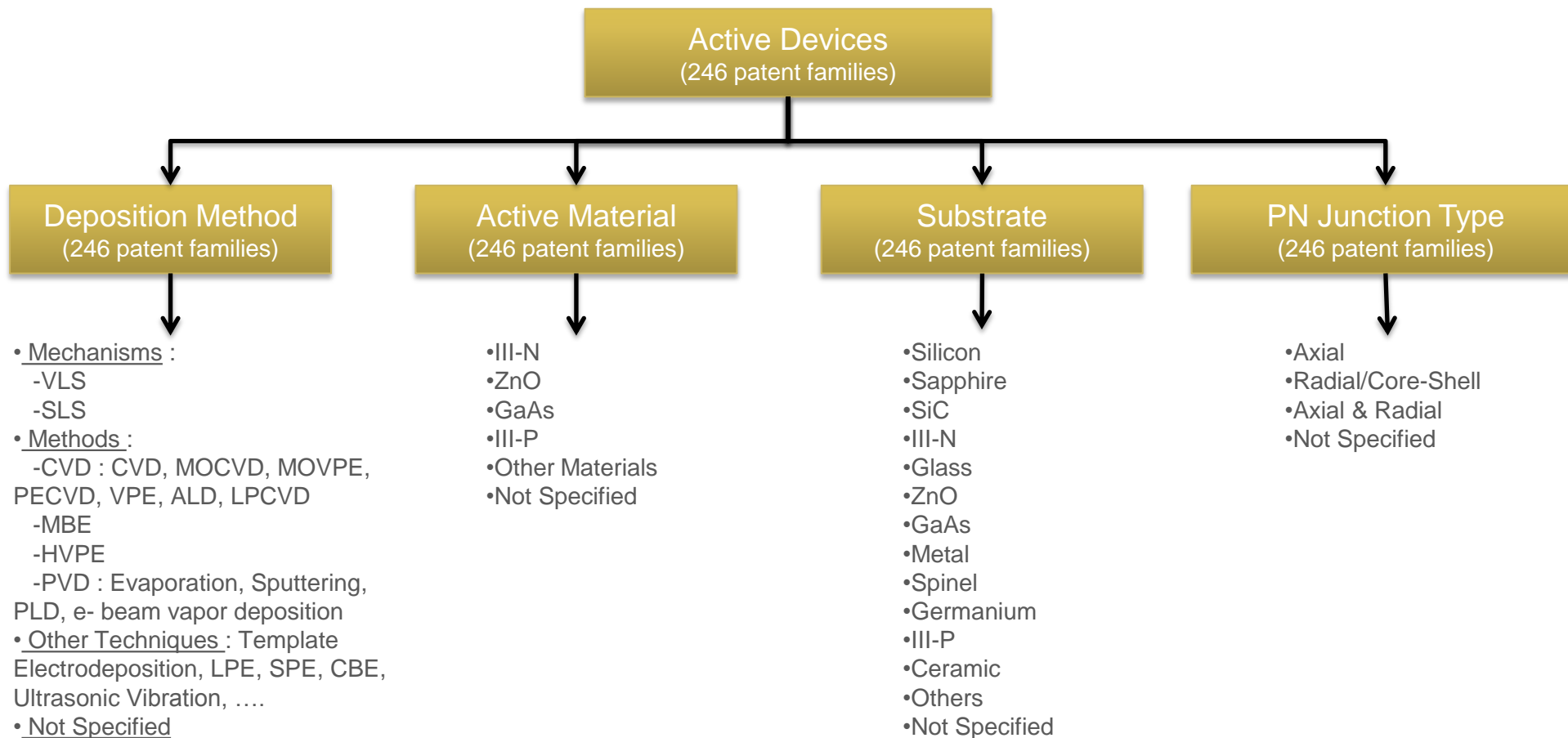
Active  
Devices



# Technology Segmentation

## Active Devices

Patents belonging to the group **Active Devices** have been manually categorized by technology segments as described below. In brackets is the corresponding number of patent families. Note that a patent can be found in several categories.



# Segmentation by Active Material Type

Active  
Devices

Patent Applicants	No. of Patent Families	III-N	ZnO	GaAs	III-P	Other Materials	Not Specified
Company 1	XX	47	20	10	10	5	5
Company 2	XX	30	9				
Company 3	XX	15	4	2	2		
Company 4	XX	11	7	4	3	1	
Company 5	XX	7	1				
Company 6	XX	6	5				
Company 7	XX	7		6	6		
Company 8	XX	5	1		1		
Company 9	XX	4					
Company 10	XX	3	4	4	4	4	
Company 11	XX	4					
Company 12	XX						4
Company 13	XX	4		4	4		
Company 14	XX	3					
Company 15	XX	3	3	2	2	2	
Company 16	XX	2		3	2	1	
Company 17	XX	3	1				
Company 18	XX	3					
Company 19	XX	1	2				
Company 20	XX	1	2				
Company 21	XX	2	3	1			
Company 22	XX	3	1		1	1	

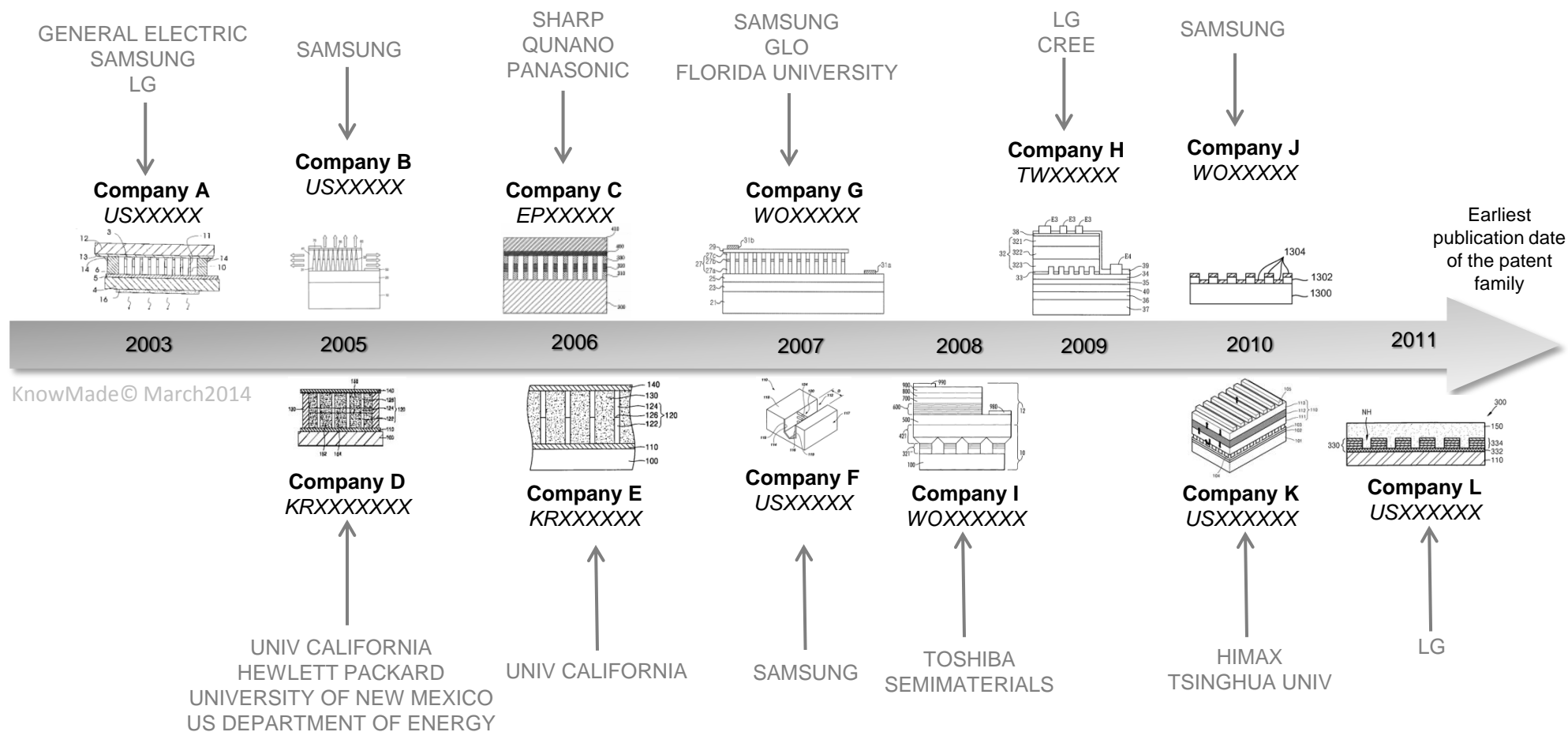
Knowmade© May 2014

# Key Patent Families for Axial PN Junction

Active Devices  
PN Junction :  
Axial

The selection of key patent families is based on citations analysis, family size, current legal status of patents, and impact on the LED Nanowires technology.

The corresponding main citing applicants are given for each key patent family.



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## Patenting activity in Active Devices

- XX Patents within XX Patent Families
- Oldest priority date: 200X-XX
- Patent average age: X
- Main countries of patent filings: XX, XX
- XX granted patents (main countries: XX, XX)
- XX patent families granted in XX and XX
- XX pending patents

## Patenting activity in Passive Devices

- XX Patents within XX Patent Families
- Oldest priority date: 200X-XX
- Patent average age: X
- Main countries of patent filings: XX, XX
- XX granted patents (main countries: XX, XX)
- XX patent families granted in XX and XX
- XX pending patents

## Technological Segmentation

- **Active Material:** III-N (XX patent families), ■■■■ (XX patent families)
- **PN Junction:** Radial (XX patent families), Axial (XX patent families)
- **Passive Material:** ■■■■ (XX patent families), III-N (X patent families)

## IP Collaborations

- **Company X**
  - Active Devices GaN, Radial: KRXXXXXX (20XX, co-filing)
  - Active Devices ZnO/GaN, Radial: KRXXXXXX (20XX, co-filing)
  - Passive Devices: EPXXXXXX (200X, co-filing)
- **Company X**
  - Passive Devices: JPXXXXXX (200X, co-filing)
  - Passive Devices: USXXXXXX (200X, co-filing)

## Key Patent Families in Active Devices

- KRXXXXXX (200X, Axial, ■■■■)
- KRXXXXXX (200X, ■■■■)
- USXXXXXX (20XX, Axial)
- USXXXXXX (20XX, ■■■■)
- KRXXXXXX (200X, Radial)
- KRXXXXXX (20XX, ■■■■ ■■■■)

## Granted Patents Near Expiration Date - Active Devices

- KRXXXXXX (exp. date ■■■■)
- KRXXXXXX (exp. date 2024-04-07)
- KRXXXXXX (exp. date ■■■■)
- KRXXXXXX (exp. date ■■■■)

## Granted Patents Near Expiration Date - Passive Devices

- KRXXXXXX (exp. date 2024-12-04)



# Excel Database

with all patents analyzed in the report with technology segmentation



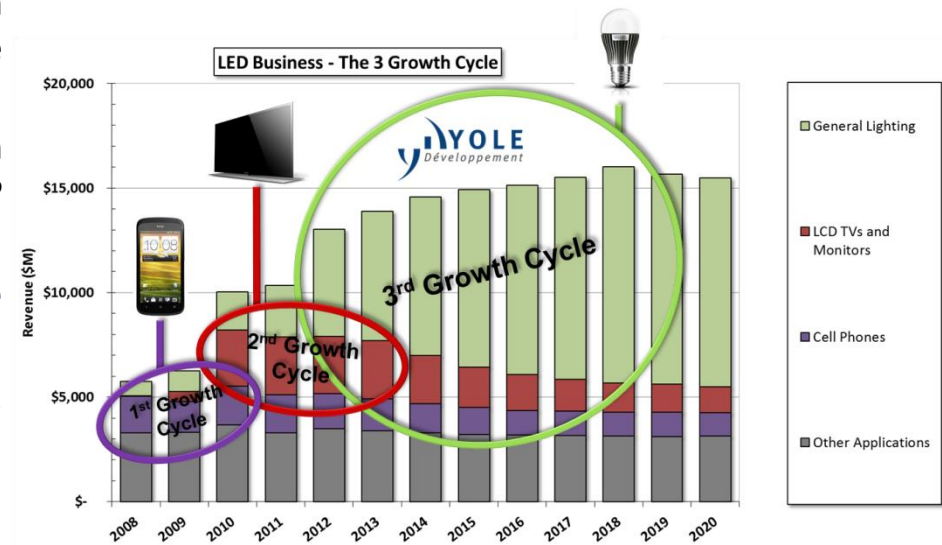
This database allows multi-criteria searches and includes patent publication number, hyperlinks to the original documents, priority date, title, abstract, patent assignees, technological segments, legal status for each member of the patent family.

							Segmentation																								
							Relevance		Type of Device		Deposition Method						Substrate														

# History of LED Industry

## LED Industry is Entering its 3<sup>rd</sup> Growth Cycle

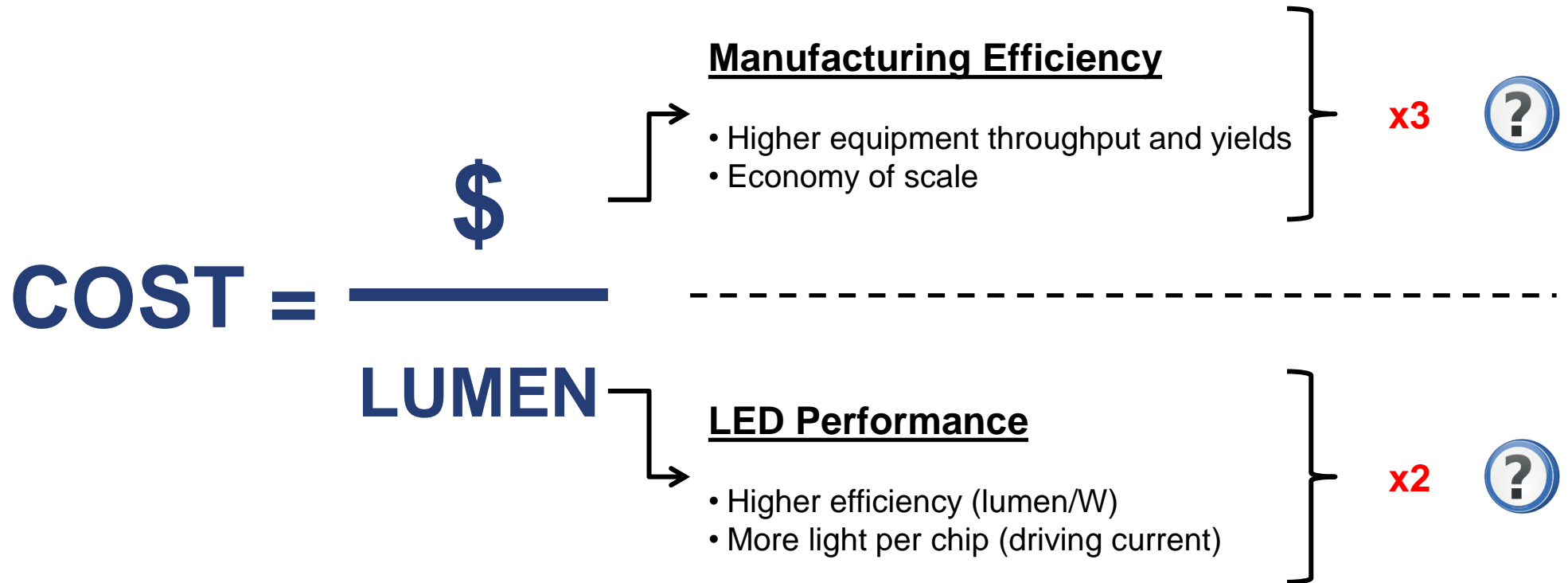
1. Growth of the LED industry came initially from small LCD displays and keypad backlighting applications.
2. And was driven forward by the LCD display application.
  - LED TV was expected to be the LED industry driver for 2011, but the reality was quite different due to lower sales of LCD TVs, lower than expected adoption rate of LED and lower number of LEDs per TV set. This situation, mixed with the entry of several new Asian players, created a climate of overcapacity, price pressure, and strong competition.
  - Packaged LED volumes were about 30% lower than expected and revenue shrank due to strong ASP pressure.
3. In 2012, most companies have started to move to the new “El Dorado” of the LED business: General Lighting, which represents the next killer application. In 2013, LED technology has really spread beyond general lighting with the LED penetration rate > 4% in some applications. However, to enable massive adoption of the technology, LED-products still require a cost decrease.





# The Path to Cost Reduction

Need for a cost reduction by a factor of 5 - 6 at system level.



# Pure Players Overview

**Several pure Nanowire players developing LED have emerged.  
All of them are spins off from academic institutions.**

Company name	Country	Material	Substrate	NW fabrication technique
Aledia	XXXXXX	XXXXXXXX	Si	MOCVD
glō	Sweden / USA	III-V nanowires	Sapphire, Si	XXXXXX
XXXXX	Taiwan	GaN nanowires	XXXXX	MOCVD
Ecospark	Sweden	ZnO nanowires	XXXXX	XXXXX
XXXXXX	XXXXX	GaAs nanowires	Graphene	MBE

- **Several academic players are also working on nanowire technology:**
  - Gwangju Institute of Science and Technology - GIST (KR)
  - University of California Los Angeles - UCLA (USA)
  - University of Illinois (USA)

# Order Form

## SHIP TO

Name (Mr/Ms/Dr/Pr):

Job Title:

Company:

Address:

City:

State:

Postcode/Zip:

Country:

VAT ID Number for EU members:

Tel:

Email:

Date:

## PAYMENT METHODS

### Check

To pay your invoice using a check, please mail your check to the following address:

KnowMade S.A.R.L.

2405 route des Dolines, BP 65

06902 Valbonne Sophia Antipolis

FRANCE

### Money Transfer

To pay your invoice using a bank money wire transfer please contact your bank to complete this process.

Here is the information that you will need to submit the payment:

Payee: KnowMade S.A.R.L.

Bank: Banque populaire St Laurent du Var CAP 3000 - Quartier du lac- 06700 St Laurent du Var

IBAN: FR76 1560 7000 6360 6214 5695 126

BIC/SWIFT: CCBPFRPPNCE

### Paypal

In order to pay your invoice via PAYPAL, you must first register at [www.paypal.com](http://www.paypal.com). Then you can send money to the KnowMade S.A.R.L. by entering our E-mail address [contact@knowmade.fr](mailto:contact@knowmade.fr) as the recipient and entering the invoice amount.

## RETURN ORDER BY

**E-mail:** [contact@knowmade.fr](mailto:contact@knowmade.fr)

**Mail:** KnowMade S.A.R.L. 2405 route des Dolines, BP 65 06902 Sophia Antipolis FRANCE

## PRODUCT ORDER

☐ Single user license EURO 3,990

☐ Corporate license EURO 5,990

For price in dollars, please use the day's exchange rate. For French customer, add 20% for VAT.

All reports are delivered electronically in pdf format

### Signature:

*I hereby accept Knowmade's Terms and Conditions of Sale*

# Terms and Conditions of Sales

## Definitions

“Acceptance”: Action by which the Buyer accepts the terms and conditions of sale in their entirety. It is done by signing the purchase order which mentions “I hereby accept Knowmade’s Terms and Conditions of Sale”.

“Buyer”: Any business user (i.e. any person acting in the course of its business activities, for its business needs) entering into the following general conditions to the exclusion of consumers acting in their personal interests.

“Contracting Parties” or “Parties”: The Seller on the one hand and the Buyer on the other hand.

“Intellectual Property Rights” (“IPR”) means any rights held by the Seller in its Products, including any patents, trademarks, registered models, designs, copyrights, inventions, commercial secrets and know-how, technical information, company or trading names and any other intellectual property rights or similar in any part of the world, notwithstanding the fact that they have been registered or not and including any pending registration of one of the above mentioned rights.

“License”: For the reports and databases, 2 different licenses are proposed. The buyer has to choose one license:

1. Single user license: a single individual at the company can use the report.
2. Corporate license: the report can be used by unlimited users within the company. Subsidiaries are not included.

“Products”: Reports are established in PowerPoint and delivered on a PDF format and the database may include Excel files.

“Seller”: Based in Sophia Antipolis (France headquarters), Knowmade is a technology intelligence company specialized in the research and analysis of scientific and technical information. We provide patent landscapes and scientific state of the art with high added value to businesses and research laboratories. Our intelligence digests play a key role to define your innovation and development strategy.

## 1. Scope

1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the Buyer and the Seller. ANY ADDITIONAL, DIFFERENT, OR CONFLICTING TERMS AND CONDITIONS IN ANY OTHER DOCUMENTS ISSUED BY THE BUYER AT ANY TIME ARE HEREBY OBJECTED TO BY THE SELLER, SHALL BE WHOLLY INAPPLICABLE TO ANY SALE MADE HEREUNDER AND SHALL NOT BE BINDING IN ANY WAY ON THE SELLER.

1.2 This agreement becomes valid and enforceable between the Contracting Parties after clear and non-equivocal consent by any duly authorized person representing the Buyer. For these purposes, the Buyer accepts these conditions of sales when signing the purchase order which mentions “I hereby accept Knowmade’s Terms and Conditions of Sale”. This results in acceptance by the Buyer.

1.3 Orders are deemed to be accepted only upon written acceptance and confirmation by the Seller, within [7 days] from the date of order, to be sent either by email or to the Buyer’s address. In the absence of any confirmation in writing, orders shall be deemed to have been accepted.

## 2. Mailing of the Products

2.1 Products are sent by email to the Buyer:

- within [1] month from the order for Products already released; or
- within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.

2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer.

The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including in cases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.

2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in article 3.

2.4 The mailing is operated through electronic means either by email via the sales department. If the Product’s electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that it is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects.

2.6 No return of Products shall be accepted without prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information to the Seller as required under article 2.5 shall remain at the Buyer’s risk.

# Terms and Conditions of Sales

## 3. Price, invoicing and payment

3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.

3.2 Payments due by the Buyer shall be sent by cheque payable to Knowmade, PayPal or by electronic transfer to the following account:

Banque populaire St Laurent du Var CAP 3000 - Quartier du lac- 06700 St Laurent du Var

BIC or SWIFT code: CCBPFRPPNCE

IBAN: : FR76 1560 7000 6360 6214 5695 126

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

## 4. Liabilities

4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement

4.3 In no event shall the Seller be liable for:

- a) damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or information) arising out of the use of or inability to use the Seller's website or the Products, or any information provided on the website, or in the Products;
- b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.

4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non-acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

## 5. Force majeure

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

# Terms and Conditions of Sales

## 6. Protection of the Seller's IPR

6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;
- Recordings and re-transmittals over any network (including any local area network);
- use in any timesharing, service bureau, bulletin board or similar arrangement or public display;
- Posting any Product to any other online service (including bulletin boards or the Internet);
- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

## 7. Termination

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

## 8. Miscellaneous

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

## 9. Governing law and jurisdiction

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Grasse, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.