Next-generation Human Machine Interaction (HMI) in Displays 2019
Yole’s methodology for building market forecasts is different from other market research companies:

- Our approach is to build a model where all the data from product shipments, module sales, sensor production, and player market share is collectively linked with detailed assumptions.

- We collect data from several sources, including:
  - Primary data from direct interviews and visits with key players;
  - Direct contact and surveys with equipment & materials suppliers;
  - Direct cost analysis from teardown reports conducted by System Plus Consulting;
  - Comparisons between publicly-available secondary data from WSTS, OICA, IFR, EMVA, AIA, etc.

- As a result, we can present synthetic market metrics intrinsic to a specific industry:
  - The main advantage of this approach is the delivery of homogeneous data, ranging from unit shipments and system sales to player market share.
  - We regularly update the market information presented in this report.
Yole Développement’s market forecast model is based on the matching of several sources:

**Top-to-bottom approach**
- Aggregate of market forecasts
  - @ System level

**Bottom-up approach**
- Ecosystem analysis
  - Aggregate of all players’ revenue
    - @ System level

**Top-to-bottom approach**
- Aggregate of market forecast
  - @ Semiconductor device level

**Bottom-up approach**
- Ecosystem analysis
  - Aggregate of key players’ revenues
    - @ Semiconductor device level

---

**Market**
- Volume (in Munits)
- ASP (in $)
- Revenue (in $M)

**Preexisting information**

**Primary data**
- Reverse costing
- Patent analysis
- Annual reports
- Direct interviews

**Secondary data**
- Press releases
- Industry organization reports
- Conferences

**Information Aggregation**

**Comparison with existing data**
- Monitoring of corporate communication
- Using other market research data
- Yole Développement analysis (consensus or not)

**Comparison with prior Yole Développement reports**
- Recursive improvement of dataset
- Customer feedback
About The Author

Biography & Contact

Dr. Zine Bouhamri

As a Technology & Market Analyst, Displays, Zine Bouhamri, PhD is a member of the Photonics, Sensing & Display division at Yole Développement (Yole). Zine manages the day to day production of technology & market reports, as well as custom consulting projects. He is also deeply involved in the business development of the Displays unit activities at Yole. Previously, Zine was in charge of numerous R&D programs at Aledia. During more than three years, he developed strong technical expertise as well as a detailed understanding of the display industry. Zine is author and co-author of several papers and patents. Zine Bouhamri holds an Electronics Engineering Degree from the National Polytechnic Institute of Grenoble (France), one from the Politecnico di Torino (Italy), and a Ph.D. in RF & Optoelectronics from Grenoble University (France).

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<tr>
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<td>5G</td>
<td>5th Generation wireless network</td>
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<tr>
<td>ADAS</td>
<td>Advanced Driver-Assistance Systems</td>
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<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
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<td>AIN</td>
<td>Aluminum Nitride</td>
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<td>ALS</td>
<td>Ambient Light Sensor</td>
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<td>AM</td>
<td>Active Matrix</td>
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<td>AOI</td>
<td>Automated Optical Inspection</td>
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<tr>
<td>AR</td>
<td>Augmented Reality</td>
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<td>ASIC</td>
<td>Application-Specific Integrated Circuit</td>
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<td>BLU</td>
<td>Backlight Unit</td>
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<td>Capex</td>
<td>Capital Expenditure</td>
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<td>CCD</td>
<td>Charge-Coupled Device</td>
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<td>CCM</td>
<td>CMOS Camera Module</td>
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<td>CMOS</td>
<td>Complementary Metal-Oxide-Semiconductor</td>
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<td>CSO</td>
<td>Crystal Sound OLED</td>
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<td>ELA</td>
<td>Excimer Laser Annealing</td>
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<td>GS</td>
<td>Global Shutter</td>
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<td>HD</td>
<td>High Definition</td>
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<td>HDR</td>
<td>High Dynamic Range</td>
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<td>HMI</td>
<td>Human Machine Interface</td>
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<td>IDM</td>
<td>Integrated Device Manufacturer</td>
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<td>IGZO</td>
<td>Indium Gallium Zinc Oxide</td>
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<td>ILD</td>
<td>Inter Layed Dielectric</td>
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<tr>
<td>IoT</td>
<td>Internet of Things</td>
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<tr>
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<td>ITO</td>
<td>Indium Tin Oxide</td>
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<td>KGD</td>
<td>Known Good Die</td>
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<td>LCD</td>
<td>Liquid Crystal Display</td>
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<td>LLO</td>
<td>Laser Lift Off</td>
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<td>LTPS</td>
<td>Low Temperature Poly Silicon</td>
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<td>LED</td>
<td>Light Emitting Diode</td>
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<tr>
<td>M&amp;A</td>
<td>Merger &amp; Acquisition</td>
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<tr>
<td>MEMS</td>
<td>MicroElectroMechanical Systems</td>
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<td>MOCVD</td>
<td>Metal-Organic Chemical Vapor Deposition</td>
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<td>Mixed Reality</td>
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<td>NIR</td>
<td>Near InfraRed</td>
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<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<td>Organic Semi-Conductors</td>
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<td>Phase Detection AutoFocus</td>
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<td>PI</td>
<td>Polymide</td>
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<td>PMUT</td>
<td>Piezoelectric Micromachined Ultrasonic Transducers</td>
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<td>PPI</td>
<td>Pixel Per Inch</td>
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<td>PR</td>
<td>Photoresist</td>
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<td>PZT</td>
<td>Lead Zirconate Titanate</td>
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<td>R2R</td>
<td>Roll to Roll</td>
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<td>RTA</td>
<td>Rapid Thermal Annealing</td>
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<td>TFT</td>
<td>Thin Film Transistor</td>
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<tr>
<td>VCSEL</td>
<td>Vertical-Cavity Surface-Emitting Laser</td>
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<tr>
<td>VR</td>
<td>Virtual Reality</td>
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COMPANIES CITED IN THE REPORT

A COLLABORATIVE EFFORT

This report would not have been possible without the collaborative effort from many other display, sensors and imaging reports from these esteemed colleagues.

Pierre Cambou
Eric Virey
Guillaume Girardin
Pierrick Boulay
Pars Mukish
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Cannot the display world follow the same path as Moore’s law?

There is a limit to enhancing the display in classical ways. Are we facing a new age?

- Better pixel
- Under-display features
- Form factor disruption
- In-display features

More Display

More than Display

- 8K
- 4K
- Full HD
- HD Ready
- Flat panel

Increase in resolution
Increase in image quality
Increase in functions?
Paradigm changes?

3D & holographic?

A mix for higher value systems
THE END GOAL FOR HMI FEATURES IN DISPLAYS

Integrating everything in the display to maximize the user experience

Towards 100% screen-to-body ratio but what to do with sensors and actuators?

As the display represents the part with which a user has the highest level of interaction, why not:

• increase its size;
• increase its screen-to-body ratio;
• integrate as many things as possible in it to avoid bezels.

Having all-in-one?
INTEGRATING FUNCTIONS IN THE DISPLAY
Innovating by integrating more functions under or in the display

• If bezels are to be removed, the functionalities that are built inside them (speakers, light sensors, cameras) need to be put somewhere. The push for OEMs is to integrate those directly within the display. Fingerprints, sensors (proximity, 3D sensing, cameras), haptics and even sound. This is already on their roadmaps.

The idea is to integrate as many functionalities as possible under or in the display.

Fingerprint on display

Under panel sensing

Haptics on display

Sound on display

Samsung's direction, illustrated at the 2018 Samsung OLED forum. (source: @UniverseIce)
The impact on the supply chain is probably the important point of this wished for trend.

**THE SUPPLY CHAINS**

Displays versus sensors and actuators: any disruption?

- Today there is a traditional supply chain for each kind of sensor:

  - Design
  - Foundry
  - Packaging & test
  - ASIC
  - Cover
  - Assembly
  - OEM/Device

- Now if we try to increase the screen-to-body ratio to 100%, by going toward an under-display or even an in-display integration of sensors, would it completely disrupt the value chain?

  - Can some blocks disappear, making the value absorbed by the panel maker? But what would be the costs on fabs?
  - Is there a technological reality in considering this? What are the market trends, technical trends, industry trends?
This report covers the main functions one could think of in terms of HMI in a display based device.

- **Fingerprint sensor**
- **Ambient light sensor**
- **Proximity sensor**
- **Camera**
- **Force sensing**
- **Microphone**
- **Haptic feedback**
- **Speaker**

**Touch sensing**

Not covered in this report: Touch is already commonly integrated in the display; though there is still a lot of innovation happening in this field, for clarity and length reasons, we do not tackle this topic (and associated ones, e.g. pen/stylus) here.
THE DRIVING APPLICATIONS

The applications driving progress are the ones with high volumes

-- Number of displays for principal applications

- Smartphones
- TVs
- Tablets
- Laptops/convertibles
- Wearables
- Monitors

Going to where the value is: smartphones and TVs. TVs represent a very large display surface.
THE MARKET DRIVERS

The tremendous importance of smartphones in the context

- For display makers, the main revenue drivers are linked to TVs and smartphones.
- TVs have relatively lower volumes compared to smartphones, but they represent a large area, contrary to smartphones which represent a small area but a very large volume.
- As sensors and actuators are most likely to be sensitive to volumes, we expect the smartphone market to be the main driver for HMI in displays innovation. Unless there are some specific application requirements (e.g. “eyes always up” in automotive).

<table>
<thead>
<tr>
<th></th>
<th>Smartphones</th>
<th>TVs</th>
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<tr>
<td>Area</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Volume</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

As the sensor and actuator market is likely more sensitive to volumes, smartphones represent the most important application driver.
Towards microLED displays to integrate all kinds of sensors?

- Sensors in pixels and other functionalities can be envisioned with microLED displays.
- But what is the added complexity for the layers to put on top at panel assembly level? Polarizers, films, etc.

A microLED display where discrete ICs positioned on the front face can drive groups of 36 subpixels featuring a 2x redundancy. (source: LuxVue patent US 9,318,475)

Fill factor (TV): < 1%

Fingerprint sensing embedded in a microLED display (source: LuxVue patent application US 20150348504A)
MICROLED TECHNOLOGY TRENDS

Process vs. Application Mapping
THE MOBILE MARKET TREND
Front-side cameras & sensors conundrum

Ultimately, the screen should take 100% of the body?

Screen-to-body ratio

Notch

Bars

Pop-up/slide-up

Under-display cameras and sensors?

Front appearance remains a key differentiator between main producers

<table>
<thead>
<tr>
<th>2017</th>
<th>2018</th>
<th>2019</th>
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<tbody>
<tr>
<td>Sony Z2</td>
<td>Meizu 15</td>
<td>VIVO V7</td>
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<tr>
<td>LG G6</td>
<td>Galaxy S9</td>
<td>Mi Mix 2</td>
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<tr>
<td>Essential</td>
<td>Huawei P20</td>
<td>iPhone X</td>
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<td>Zianne 5</td>
<td>LG G7</td>
<td>VIVO Nex</td>
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<tr>
<td>Oppo Find X</td>
<td>Huawei Magic 2</td>
<td>...</td>
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</tbody>
</table>
THE MARKET TRENDS

The push for sensor integration is driven by several aspects

- Several drivers are pushing for HMI integration in displays, even though everything mainly stems from the acute competition between OEMs. The search for new use cases lags behind as the targeted applications seem restricted.

As the competition is crazy between OEMs, there is a strong need for bringing something new to the table.
ABOUT THE DISPLAY

Modifying the backplane to directly integrate HMI s? – What purpose?

By adding sensing capability in the backplane, there is the possibility for either LCD or OLED to improve the display value.
The TFT process is long and complex.

ABOUT THE DISPLAY

Modifying the backplane to directly integrate HMIs? – Panel makers view
ABOUT THE DISPLAY

Modifying the backplane to directly integrate HMIs? – Panel makers view

• Nowadays, the typical required capex for a display panel maker is in the range of $4B to $11B.
• As illustrated, the TFT process is long and complex and requires several tens of steps.
• By changing even a few steps in this long process, the yield could dramatically decrease. This in a world where today, there is an overcapacity in terms of panels which tends to increase the pricing competition. By decreasing yields, even on fully depreciated fabs, the risk would be too great for display manufacturers. Hence little push towards intelligent backplanes in the short to mid term.
• So much so that at the end of the day, in the current display world (LCD or OLED), there is not a huge supply chain disruption to be expected for the sensor and actuator supply chain in terms of value absorption by display makers.
LTPS process flow – Overview
ABOUT THE DISPLAY

Modifying the backplane to directly integrate HMIs? – Disrupting the display

- To improve the idea of adding HMIs in displays, it appears that the problem stems from the backplane.
- Three possibilities stem from this observation:
  - change the display so that there is a possibility to push the screen-to-body ratio to 100% while keeping the interfaces;
  - make the display more transparent to allow for optical passage for most difficult optical sensors to put under the display;
  - remove the backplane or change the display technology to be able to integrate the interfaces in the backplane.
The pros outweigh the cons, so much so that there is little chance to see the rise of intelligent backplanes in the near future.

What to make of the idea of intelligent backplanes?

- Increased competition with low margins
- Long and complex LTPS process
- Wish to increase backplane value
- Wish to increase backplane value
- What to make of the idea of intelligent backplanes?
Since 2012, the dominant fingerprint technology has been capacitive detection. Late-2017 - 2018 was the period for the introduction of new principles for ultrasonic and optical fingerprint detection. This momentum should continue, with X% of fingerprint detection systems being based on these new principles by 2023.

Optical-detection module shipments should reach around XMu by 2023, with ultrasonic achieving XMu. Ultrasonic is considered a more high-end detection option, and therefore should be embedded on luxury phones (limited volume).
THE FINGERPRINT IN DISPLAY TREND

Fingerprint sensing trend is towards the integration in the display

• The evolution towards a full screen integration is the final step of this technology’s evolution.

This is the only way; either under or in-display, though the latter choice would give better use cases.
THE UNDER PANEL SENSING TREND

The main application of sensing: cameras

Sensing through cameras has become an essential part of the smartphone.

The front (selfie) camera transformation

Cameras

Biometric 3D sensing

Adding a new camera on front for IR sensing on top of RGB sensing

Woman taking 'selfie' picture (stock image). (source: Andrey Kiselev / Fotolia)
THE UNDER PANEL SENSING TREND

The mobile market trend and the idea of adding even more cameras

The clear conundrum linked to the idea of putting the frontside cameras beneath the display.

28,000 to 110,000 pixels will alter the image!
1 display pixel shuts off ~1,400 CIS pixels
VCSEL used to be used for datacom and other applications; but now 3D sensing for consumers has given birth to new players.
The possibilities for sound generation and integration?

There is a trade-off to accept for full total integration.
THE HAPTICS IN DISPLAY TREND

The haptics feedback application trend

Automotive to be an important driver?
OLED promises to be good enough for most integration but camera integration seems very unlikely.
Since the beginning of the smartphone era, we have observed a continuously-improving trend regarding screen-to-body ratio increase. This is true for any display one can think of: not just smartphones, but also televisions, laptops, smartwatches, etc. And the trend persists, so much so that new display technologies have been developed in order to facilitate the increase.

In parallel, since the beginning of the internet of things (IoT) age, billions of connected display-based devices are interacting with one another and acquiring even more sensors and actuators to help them interact with the world, and human beings. Since humans’ way of receiving information depends primarily on visual cues, it makes perfect sense to maximize a device’s screen-to-body ratio.

To ensure this ratio is maximized to its fullest, human machine interaction (HMI)-based sensors and actuators must be integrated underneath or on top of the display, within the panel stack. Today, some are, but arguably the most important sensors - front-side cameras that have completely changed the way people interact - are way too big and complex to be integrated simply. This prompts panel makers to cut their devices with “punch-holes” or “notches” that are not UI-friendly nor design savvy.

The question then becomes: can panel makers directly integrate some functions in their panels - and if so, will the supply chain be disrupted because of value absorption by these panel makers? Furthermore, how are these HMIs accomplished today, is there a trend for them to be easily integrated, and when?

This report presents a review of the trends in today’s sensors and actuators and the players involved (and their supply chains), and analyzes the possibility of integration directly under or in the display.

**OCCUPATIONAL FOR A LARGER SCREEN AREA IN DISPLAY-BASED DEVICES ARE HERE**

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**OPPORTUNITIES FOR A LARGER SCREEN AREA IN DISPLAY-BASED DEVICES ARE HERE**

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Another limiting factor is that for fabs which cost several billions of dollars, with several tens of steps to follow in order to produce a display panel, a single change in the process flow could drastically diminish the overall yield. And as the current environment is one of overproduction, price competition, and even growing fab capacity, this is not something desirable to panel makers.

Panel makers are hence reluctant to embrace the idea of “intelligent backplanes”, and though some are pursuing R&D efforts to try and integrate sensing functions in backplanes, the majority of panel makers and their associated OEMs are working towards the idea of integrating sensors under or on top of their displays, rather than inside the displays. So most HMIs will remain, under the condition that they can fight against the harsher conditions of being under the display.

As for front-side cameras, given their size and sheer complexity there does not seem to be a possibility in the next few years to make them disappear - unless they are put into slide-up or pop-up mechanisms as can already be seen, but which raise questions concerning reliability.

This report presents a detailed analysis of display requirements, with a comprehensive overview of display structures and manufacturing, as well as HMIs, and through a thorough presentation of current and potential future solutions analyzes what can/cannot be done for their integration in the display.

### Push vs challenge for HMI integration in displays

#### Push for HMI in displays
- Luxury feel
- Wow effect
- New use cases

#### Challenge for HMI in displays
- Impact on manuf process
- Tech availability
- Required investment

### SOME FUTURE DISPLAY TECHNOLOGIES COULD ALLOW FOR EASIER INTEGRATION OF SENSORS AND ACTUATORS

The challenge of backplane integration will likely not be accepted by panel makers due to the way displays are made today. Now, is there a display technology that would allow for a way to circumvent this panel manufacturing issue, avoiding TFTs? MicroLED displays, being right around the corner, could be an opportunity. In fact, the excitement around MicroLED displays is real, even more so since Apple bought Luxvue in 2014.

### Display technologies vs HMI functions matrix for possible 2023 integration

<table>
<thead>
<tr>
<th>Technology</th>
<th>Fingerprint sensing</th>
<th>Under panel sensing</th>
<th>Sound on display</th>
<th>Haptics on display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under panel or in panel stack</td>
<td>Under</td>
<td>In</td>
<td>Under</td>
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<td>MicroLED</td>
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(Yole Développement, April 2019)
However, the challenge exists in how to assemble these panels. The assembly process appears to be one of critical steps that would allow the MicroLED display opportunity to materialize. Today, dozens of processes are being developed for microLED assembly. For each, multiple assembly strategies can be envisioned, i.e., small stamps, large stamps, interposers, etc. The spread in terms of the number of transfer cycles, for example, could be staggering. For instance, we can describe assembly strategies for TVs with more than a 200-fold spread in terms of the number of operations required.

But if the opportunity materializes, it could be a game-changer because, due to the low pixel fill-factor the microLED chips would exhibit per pixel, a tremendous space would exist for possible front-plane intelligent integration, and the possibility to add sensors for example. This may be the next big thing in terms of HMIs directly integrated in displays, even though the trend taken by OLED panel-user OEMs may seem good enough for everything, even if the most difficult sensors to integrate (i.e., camera modules) could be left aside.

This report offers an overview of microLED displays and discusses the challenges keeping them from disrupting the field, especially in terms of front-plane integration. This report also presents a comprehensive overview of optical structures, current challenges, and key research directions.

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As a Technology & Market Analyst, Displays, Zine Bouhamri, PhD is a member of the Photonics, Sensing & Display division at Yole Développement (Yole). Zine manages the day to day production of technology & market reports, as well as custom consulting projects. He is also deeply involved in the business development of the Displays unit activities at Yole. Previously, Zine was in charge of numerous R&D programs at Aledia. During more than three years, he developed strong technical expertise as well as a detailed understanding of the display industry. Zine is author and co-author of several papers and patents. Zine Bouhamri holds an Electronics Engineering Degree from the National Polytechnic Institute of Grenoble (France), one from the Politecnico di Torino (Italy), and a Ph.D. in RF & Optoelectronics from Grenoble University (France).
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ABOUT YOLE DEVELOPPEMENT

Founded in 1998, Yole Développement has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services and well as IP and patent analysis. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 80 collaborators worldwide covering MEMS and Image Sensors, Compound Semiconductors, RF Electronics, Solid-State Lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Nanomaterials, Power Electronics and Batteries & Energy Management.

The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and KnowMade, support industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

CONSULTING AND ANALYSIS

• Market data & research, marketing analysis
• Technology analysis
• Strategy consulting
• Reverse engineering & costing
• Patent analysis
• Design and characterization of innovative optical systems
• Financial services (due diligence, M&A with our partner)

More information on www.yole.fr

MEDIA & EVENTS

• i-Micronews.com website & related @Micronews e-newsletter
• Communication & webcast services
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More information on www.i-micronews.com

REPORTS

• Market & technology reports
• Patent investigation and patent infringement risk analysis
• Structure, process and cost analysis
• Cost simulation tool

More information on www.i-micronews.com/reports

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• Reports: David Jourdan (jourdan@yole.fr) Yole Group of Companies
• Press Relations & Corporate Communication: Sandrine Leroy (leroy@yole.fr)
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**Life Sciences & Healthcare**
- Microfluidics
- BioMEMS & Medical Microsystems
- Inkjet and accurate dispensing
- Solid-State Medical Imaging & BioPhotonics
- BioTechnologies

**Power & Wireless**
- RF Devices & Technologies
- Compound Semiconductors & Emerging Materials
- Power Electronics
- Batteries & Energy Management

**Semiconductor & Software**
- Package, Assembly & Substrates
- Semiconductor Manufacturing
- Memory
- Software & Computing

**Photonics, Sensing & Display**
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- Display
- MEMS, Sensors & Actuators
- Imaging
- Photonics & Optoelectronics
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- Consulting and Analysis
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  - Strategy consulting
  - Reverse engineering & costing
  - Patent analysis
  - Design and characterization of innovative optical systems
  - Financial services (due diligence, M&A with our partner)

- Syndicated reports
  - Market & technology reports
  - Patent investigation and patent infringement risk analysis
  - Teardowns & reverse costing analysis
  - Cost simulation tool

- Monitors
  - Monthly and/or Quarterly update
  - Excel database covering supply, demand, and technology
  - Price, market, demand and production forecasts
  - Supplier market shares

- Media
  - i-Micronews.com website
  - @Micronews e-newsletter
  - Communication & webcast services
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  - Teardown and reverse engineering
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  - Patent assessment
  - [www.knowmade.fr](http://www.knowmade.fr)

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  - [www.piseo.fr](http://www.piseo.fr)

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  - Innovation and business maker
  - [www.blumorpho.com](http://www.blumorpho.com)

- **Yole Finance**
  - Due diligence
  - [www.yole.fr](http://www.yole.fr)
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ANALYSIS SERVICES - CONTENT COMPARISON

Depth of the analysis

Breadth of the analysis

High

Low

Technology and Market Report

Leadership Meeting

Q&A Service

Meet the Analyst

Custom Analysis

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SERVING THE ENTIRE SUPPLY CHAIN

Integrators, end-users and software developers

Device manufacturers

Suppliers: material, equipment, OSAT, foundries...

Financial investors, R&D centers

Our analysts provide market analysis, technology evaluation, and business plans along the entire supply chain.
SERVING MULTIPLE INDUSTRIAL FIELDS

We work across multiples industries to understand the impact of More-than-Moore technologies from device to system.

From A to Z...

Industrial and defense

Medical systems

Energy management

Automotive

Transportation makers

Mobile phone and consumer electronics
Over the course of more than 20 years, Yole Développement has grown to become a group of companies. Together with System Plus Consulting and KnowMade, we now provide marketing, technology and strategy consulting, media and corporate finance services, reverse costing, structure, process and cost analysis services and well as intellectual property (IP) and patent analysis. Together, our group of companies is collaborating ever closer and therefore will offer, in 2019, a collection of over 125 reports and 10 new monitors. Combining respective expertise and methodologies from the three companies, they cover:

- MEMS & Sensors
- RF devices & technologies
- Medical technologies
- Semiconductor Manufacturing
- Advanced packaging
- Memory
- Batteries and energy management
- Power electronics
- Compound semiconductors
- Solid state lighting
- Displays
- Software
- Imaging
- Photonics

If you are looking for:
- An analysis of your product market and technology
- A review of how your competitors are evolving
- An understanding of your manufacturing and production costs
- An understanding of your industry’s technology roadmap and related IPs
- A clear view supply chain evolution

Our reports and monitors are for you!

Our team of over 70 analysts, including PhD and MBA qualified industry veterans from Yole Développement, System Plus Consulting and KnowMade, collect information, identify trends, challenges, emerging markets, and competitive environments. They turn that information into results and give you a complete picture of your industry’s landscape. In the past 20 years, we have worked on more than 2,000 projects, interacting with technology professionals and high-level opinion makers from the main players of their industries and realized more than 5,000 interviews per year.

WHAT TO EXPECT IN 2019?
In 2019 we will extend our offering with a new ‘monitor’ product which provides more updates on your industry during the year. The Yole Group of Companies is also building on and expanding its investigations of the memory industry. Moreover, in parallel, the Yole Group reaffirms its commitment to a new collection of reports mixing software and hardware and is increasing its involvement in displays, radio-frequency (RF) technology, advanced substrates, batteries and compound semiconductors. Discover our 2019 program right now, and ensure you get a true vision of the industry. Stay tuned!
OUR 2019 REPORTS COLLECTION (1/4)

18 fields of excellence combined with six markets to provide a complete picture of your industry landscape

**Market – Technology – Strategy – by Yole Développement**
Yole Développement (Yole) offers market reports including quantitative market forecasts, technology trends, company strategy evaluation and in-depth application analyses. Yole will publish more than 55 reports in 2019, with our partner PISEO contributing to some of the lighting reports.

The Reverse Costing® report developed by System Plus Consulting provides full teardowns, including detailed photos, precise measurements, material analyses, manufacturing process flows, supply chain evaluations, manufacturing cost analyses and selling price estimations. The reports listed below are comparisons of several analyzed components from System Plus Consulting. More reports are however available, and over 60 reports will be released in 2019. The complete list is available at www.systemplus.fr.

**Patent Reports – by KnowMade**
More than describing the status of the IP situation, these analyses provide a missing link between patented technologies and market, technological and business trends. They offer an understanding of the competitive landscape and technology developments from a patent perspective. They include key insights into key IP players, key patents and future technology trends. For 2019 KnowMade will release over 15 reports.

**The markets targeted are:**
- Mobile & Consumer
- Automotive & Transportation
- Medical
- Industrial
- Telecom & Infrastructure
- Defense & Aerospace

Linked reports are dealing with the same topic to provide a more detailed analysis.
OUR 2019 REPORTS COLLECTION (1/5)

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MEMS & SENSORS
- MARKET AND TECHNOLOGY REPORT
  - Status of the MEMS Industry 2019 - Update
  - Status of the Audio Industry 2019 - New
  - Uncooled Infrared Imagers and Detectors 2019 – Update
  - Consumer Biometrics: Technologies and Market Trends 2018
  - MEMS Pressure Sensor Market and Technologies 2018
  - Gas & Particle Sensors 2018
- STRUCTURE, PROCESS & COST REPORT
  - MEMS & Sensors Comparison 2019
  - MEMS Pressure Sensor Comparison 2018
  - Particle Sensors Comparison 2019
  - Miniaturized Gas Sensors Comparison 2018
- PATENT REPORT
  - MEMS Foundry Business Portfolio 2019 - New
  - Miniaturized Gas Sensors 2019 - New

PHOTONIC AND OPTOELECTRONICS
- MARKET AND TECHNOLOGY REPORT
  - Photonic Integrated Circuit 2019 - New
  - LiDARs for Automotive and Industrial Applications 2019 - Update
  - Silicon Photonics 2018
- PATENT REPORT
  - Silicon Photonics for Data Centers: Optical Transceiver 2019 - New
  - LiDAR for Automotive 2018

RF DEVICES AND TECHNOLOGIES
- MARKET AND TECHNOLOGY REPORT
  - 5G's Impact on RF Front-End Module and Connectivity for Cell Phones 2019 – Update
  - Radar and Wireless for Automotive: Market and Technology Trends 2019 - Update
  - Advanced RF Antenna Market & Technology 2019 - New
  - RF Standards and Technologies for Connected Objects 2018
- STRUCTURE, PROCESS & COST REPORT
  - RF Front-End Module Comparison 2019 - Update
  - Automotive Radar RF Chipset Comparison 2018
- PATENT REPORT
  - Antenna for 5G Wireless Communications 2019 - New
  - RF Front End Modules for Cellphones 2018
  - RF Filter for 5G Wireless Communications: Materials and Technologies 2019
  - RF GaN : Materials, Devices and Modules 2018

Update : 2018 version still available

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OUR 2019 REPORTS COLLECTION (2/5)

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IMAGING
- MARKET AND TECHNOLOGY REPORT
  - Status of the CIS Industry 2019: Technology and Foundry Business - Update ✴️
  - Imaging for Automotive 2019 - Update ✴️
  - Neuromorphic Technologies for Sensing 2019 - Update ✴️
  - Status of the CCM and WLO Industry 2019 – Update ✴️
  - 3D Imaging & Sensing 2018 ✴️
  - Machine Vision for Industry and Automation 2018 ✴️
  - Sensors for Robotic Vehicles 2018 ✴️
- STRUCTURE, PROCESS & COST REPORT
  - Compact Camera Modules Comparison 2019 ✴️
  - CMOS Image Sensors Comparison 2019 ✴️
- PATENT REPORT
  - Facial & Gesture Recognition Technologies in Mobile Devices 2019 - New ✴️
  - Apple iPhone X Proximity Sensor & Flood Illuminator 2018 ✴️

MEDICAL IMAGING AND BIOPHOTONICS
- MARKET AND TECHNOLOGY REPORT
  - X-Ray Detectors for Medical, Industrial and Security Applications 2019 - New ✴️
  - Microscopy Life Science Cameras: Market and Technology Analysis 2019 ✴️
  - Ultrasound technologies for Medical, Industrial and Consumer Applications 2018 ✴️
- PATENT REPORT
  - Optical Coherence Tomography Medical Imaging 2018 ✴️

MICROFLUIDICS
- MARKET AND TECHNOLOGY REPORT
  - Status of the Microfluidics Industry 2019 - Update ✴️
  - Organ-on-a-Chip Market & Technology Landscape 2019 - Update ✴️
  - Point-of-Need Testing Application of Microfluidic Technologies 2018 ✴️
  - Liquid Biopsy: from Isolation to Downstream Applications 2018 ✴️
  - Chinese Microfluidics Industry 2018 ✴️
- PATENT REPORT
  - Microfluidic Manufacturing Technologies 2019 – New ✴️

INKJET AND ACCURATE DISPENSING
- MARKET AND TECHNOLOGY REPORT
  - Inkjet Printheads - Dispensing Technologies & Market Landscape 2019 - Update ✴️
  - Emerging Printing Technologies for Microsystem Manufacturing 2019 - New ✴️
  - Piezoelectric Materials from Bulk to Thin Film 2019 - New ✴️
  - Inkjet Functional and Additive Manufacturing for Electronics 2018 ✴️
- STRUCTURE, PROCESS & COST REPORT
  - Piezoelectric Materials from Bulk to Thin Film Comparison 2019 ✴️
OUR 2019 REPORTS COLLECTION (3/5)

18 fields of excellence combined with six markets to provide a complete picture of your industry landscape

BIOTECHNOLOGIES
- MARKET AND TECHNOLOGY REPORT
  - CRISPR-Cas9 Technology: From Lab to Industries 2018
- PATENT REPORT
  - Personalized Medicine 2019 – New

BIOMEMS & MEDICAL MICROSYSTEMS
- MARKET AND TECHNOLOGY REPORT
  - Medical Wearables: Market & Technology Analysis 2019 - New
  - Neurotechnologies and Brain Computer Interface 2018
  - BioMEMS & Non-Invasive Sensors: Microsystems for Life Sciences & Healthcare 2018
- PATENT REPORT
  - 3D Cell Printing 2019 - New
  - Circulating Tumor Cells Isolation 2019 - New
  - Nanopore Sequencing 2019 - New

SOFTWARE AND COMPUTING
- MARKET AND TECHNOLOGY REPORT
  - Artificial Intelligence Computing For Automotive 2019 - New
  - Hardware and Software for Artificial Intelligence (AI) in Consumer Applications 2019 - Update
  - From Image Processing to Deep Learning 2019 - Update
  - xPU (Processing Units) for Cryptocurrency, Blockchain, HPC and Gaming 2019 – New

MEMORY
- MARKET AND TECHNOLOGY REPORT
  - Status of the Memory Business 2019 - New
  - MRAM Technology and Business 2019 - New
  - Emerging Non-Volatile Memory 2018
- STRUCTURE, PROCESS & COST REPORT
  - Memory Comparison 2019

ADVANCED PACKAGING
- MARKET AND TECHNOLOGY REPORT
  - Fan Out Packaging Technologies and Market Trends 2019 - Update
  - 3D TSV Integration and Monolithic Business Update 2019 - Update
  - Advanced RF SiP for Cellphones 2019 - Update
  - Status of Advanced Packaging 2019 - Update
  - Status of Advanced Substrates 2019 - Update
  - Panel Level Packaging Trends 2019 - Update
  - System in Package (SiP) Technology and Market Trends 2019 - New
  - Trends in Automotive Packaging 2018
  - Thin-Film Integrated Passive Devices 2018
- STRUCTURE, PROCESS & COST REPORT
  - Advanced RF SiP for Cellphones Comparison 2019
OUR 2019 REPORTS COLLECTION (4/5)
18 fields of excellence combined with six markets to provide a complete picture of your industry landscape

**SEMICONDUCTOR MANUFACTURING**

- **MARKET AND TECHNOLOGY REPORT**
  - Nano Imprint Lithography 2019 - New
  - Equipment and Materials for Fan Out Packaging 2019 - Update
  - Equipment for More than Moore: Thin Film Deposition & Etching 2019 - New
  - Wafer Starts for More Than Moore Applications 2018
  - Polymeric Materials at Wafer-Level for Advanced Packaging 2018
  - Bonding and Lithography Equipment Market for More than Moore Devices 2018

- **STRUCTURE, PROCESS & COST REPORT**
  - Wafer Bonding Comparison 2018

- **PATENT REPORT**
  - Hybrid Bonding for 3D Stack 2019 – New

**SOLID STATE LIGHTING**

- **MARKET AND TECHNOLOGY REPORT**
  - Status of the Solid State Light Source Industry 2019 - New
  - Edge Emitting Lasers (EELS) 2019 - New
  - Light Shaping Technologies 2019 - New
  - Automotive Advanced Front Lighting Systems 2019 - New
  - VCSELs - Technology, Industry and Market Trends 2019 - Update
  - IR LEDs and Laser Diodes – Technology, Applications, and Industry Trends 2018
  - UV LEDs - Technology, Manufacturing and Application Trends 2018
  - LiFi: Technology, Industry and Market Trends 2018

- **STRUCTURE, PROCESS & COST REPORT**
  - VCSEL Comparison 2019

- **PATENT REPORT**
  - VCSELs 2018

**DISPLAY**

- **MARKET AND TECHNOLOGY REPORT**
  - Next Generation 3D Display 2019 - New
  - Next Generation Human Machine Interaction (HMI) in Displays 2019 - New
  - Micro-and Mini-LED Displays 2019 - Update
  - Technologies And Markets for Next Generation Televisions
  - Displays & Optical Vision Systems for VR, AR & MR 2018

- **PATENT REPORT**
  - MicroLED Displays : Intellectual Property Landscape 2018

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OUR 2019 REPORTS COLLECTION (5/5)

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**POWER ELECTRONICS**
- **MARKET AND TECHNOLOGY REPORT**
  - Power SiC: Materials, Devices and Applications 2019 - Update
  - Power Electronics for EV/HEV and e-mobility: Market, Innovations and Trends 2019 - Update
  - Status of the Power Electronics Industry 2019 - Update
  - Discrete Power Packaging: Material Market and Technology Trends 2019 - New
  - Status of the Power ICs Industry 2019 - Update
  - Status of the Passive Components for the Power Electronics Industry 2019 - Update
  - Status of the Inverter Industry 2019 - Update
  - Status of the Power Module Packaging Industry 2019 - Update
  - Wireless Charging Market Expectations and Technology Trends 2018
  - Power GaN 2018: Epitaxy, Devices, Applications and Technology Trends

- **STRUCTURE, PROCESS & COST REPORT**
  - Automotive Power Module Packaging Comparison 2018
  - GaN-on-Silicon Transistor Comparison 2019
  - SiC Transistor Comparison 2019

- **PATENT REPORT**
  - Power SiC: Materials, Devices and Modules 2019 - New
  - Power GaN: Materials, Devices and Modules 2019 – Update

**BATTERY & ENERGY MANAGEMENT**
- **MARKET AND TECHNOLOGY REPORT**
  - Status of the Rechargeable Li-ion Battery Industry 2019 - New
  - Li-ion Battery Packs for Automotive and Stationary Storage Applications 2019 - Update

- **PATENT REPORT**
  - Battery Energy Density Increase: Materials and Emerging Technologies 2019 - New
  - Solid-State Batteries 2019 - New
  - Status of the Battery Patents 2018

**COMPOUNDS SEMI.**
- **MARKET AND TECHNOLOGY REPORT**
  - Emerging Compound Semiconductor Market & Technology Trends 2019 - New
  - Status of the Compound Semiconductor Industry 2019 - New
  - InP Materials, Devices and Applications 2019 - New
  - GaAs Wafer and Epitwfer Market: RF, Photonics, LED and PV Applications 2018

- **PATENT REPORT**
  - GaN-on-Silicon Substrate: Materials, Devices and Applications 2019 - Update

Update: 2018 version still available

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OUR 2019 MONITORS COLLECTION (1/2)

Get the most updated overview of your market to monitor your strategy

Yole Développement, System Plus Consulting and KnowMade, all part of the Yole Group of Companies, are launching a collection of 10 monitors in 2019. The monitors aim to provide updated market, technology and patent data as well dedicated quarterly analyses of the evolution in your industry over the previous 12 months. Furthermore, you can benefit from direct access to the analyst for an on-demand Q&A and discussion session regarding trend analyses, forecasts and breaking news.

Topics covered will be compact camera modules (CCMs), advanced packaging, compound semiconductors, microfluidics, batteries, RF and memory.

MARKET MONITOR by Yole Développement

A FULL PACKAGE:
The monitors will provide the evolution of the market in units, wafer area and revenues. They will also offer insights into what is driving the business and a close look at what is happening will also be covered in it.

The following deliverables will be included in the monitors:

- An Excel database with all historical and forecast data
- A PDF slide deck with graphs and comments/analyses covering the expected evolutions

ADVANCED PACKAGING – NEW
This monitor will provide the evolution of the advanced packaging platforms. It will cover Fan-Out Wafer Level Packaging (WLP), Fan-Out Panel Level Packaging (PLP), Wafer-Level Chip Scale Packaging (WLCSP), Flip Chip packaging platforms, and 2.5D and 3D Through Silicon Via (TSV) integration. Frequency: Quarterly, starting from Q3 2019

COMPOUND SEMI. – NEW
This monitor will describe how the compound semiconductor industry is evolving. It will offer a close look at GaAs, InP, SiC, GaN and other compounds of interest providing wafer volumes, revenues, application breakdowns and momentum. Frequency: Quarterly, starting from Q3 2019

CAMERA MODULE – NEW
This monitor will provide the evolution of the imaging industry, with a close look at image sensor, camera module, lens and VCM. Volumes, revenues and momentum of companies like Sony, Samsung, Omnivision and OnSemi will thus be analysed. Frequency: Quarterly, starting from Q3 2019

MEMORY – UPDATE
For the memory industry you can have access to a quarterly monitor, as well as an additional service, a monthly pricing. Both services can be bought separately:

- DRAM Service: Including a quarterly monitor and monthly pricing.
- NAND Service: Including a quarterly monitor and monthly pricing.

REVERSE TECHNOLOGY MONITOR by System Plus Consulting

SMARTPHONES – NEW
To stay updated on the latest components, packaging and silicon chip choices of the smartphone makers, System Plus Consulting has created its first Smartphone Reverse Technology monitor. This year, get access to the packaging and silicon content database of at least 20 different flagship smartphones – more than five per quarter. Starting at the beginning of 2019, the monitor will include an Excel database report for each phone and a quarterly comparison.
OUR 2019 MONITORS COLLECTION (2/2)

Get the most updated overview of your market to monitor your strategy

PATENT MONITOR by KnowMade

A FULL PACKAGE:
Starting at the beginning of the year, the KnowMade monitors include the following deliverables:

• An Excel file including the monthly IP database of:
  • New patent applications
  • Newly granted patents
  • Expired or abandoned patents
  • Transfer of IP rights through re-assignment and licensing
  • Patent litigation and opposition

• Quarterly report including a PDF slide deck with the key facts & figures of the quarter: IP trends over the three last months, with a close look to key IP players and key patented technologies.

○ GaN for Power & RF Electronics
  Wafers and epiwafers, GaN-on-SiC, silicon, sapphire or diamond, semiconductor devices such as transistors, and diodes, devices and applications including converters, rectifiers, switches, amplifiers, filters, and Monolithic Microwave Integrated Circuits (MMICs), packaging, modules and systems.

○ GaN for Optoelectronics & Photonics
  Wafers and epiwafers, GaN-on-sapphire, SiC or silicon; semiconductor devices such as LEDs and lasers; and applications including lighting, display, visible communication, photonics, packaging, modules and systems.

○ Li-ion Batteries
  Anodes made of lithium metal, silicon, and lithium titanate (LTO); cathodes made of Lithium Iron Phosphate (LFP), Nickel-Manganese-Cobalt (NMC), Lithium Nickel Cobalt Aluminium Oxide (NCA), Lithium Nickel Metal Dioxide (LiNiM02), Lithium Metal Phosphate (LiMPO4), and Lithium Metal Tetroxide (LiMO4); electrolytes including liquid, polymer/gel, and solid inorganics; ceramic and other separators; battery cells including thin film/microbattery, flexible, cylindrical and prismatic; and battery packs and systems.

○ Post Li-ion Batteries
  Battery technologies including redox-flow batteries, sodium-ion, lithiumsulfur, lithium-air, and magnesium-ion, and their supply chains, including electrodes, electrolytes, battery cells and battery packs/systems.

○ Solid-State Batteries
  Supply chain including electrodes, battery cells, battery packs/systems and electrolytes, including polymer, inorganic and inorganic/polymer, inorganic materials, including argyrodites, Lithium Super Ionic CONductor, (LISICONs), Thio-LISICONs, sulfide glasses, oxide glasses, perovskites, anti-perovskites and garnets.

○ RF Acoustic Wave Filters
  Including Surface Acoustic Wave (SAW), Temperature Compensated (TC)- SAW, Bulk Acoustic Wave- Free-standing Bulk Acoustic Resonator (BAWFBAR), BAW-Solidly-Mounted Resonator (BAW-SMR), and Packaging.

○ RF Power Amplifiers
  Including Low Noise Amplifiers, Doherty Amplifiers, Packaging, and Millimeter-Wave technology.

○ RF Front-End Modules

○ Microfluidics
  From components to chips and systems, including all applications.
MICRONEWS MEDIA

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To meet the growing demand for market, technological and business information, Micronews Media integrates several tools able to reach each individual contact within its network. We will ensure you benefit from this.

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Online display advertising campaigns are great strategies for improving your product/brand visibility. They are also an efficient way to adapt with the demands of the times and to evolve an effective marketing plan and strategy.

ONSITE
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Brand visibility, networking opportunities
Today’s technology makes it easy for us to communicate regularly, quickly, and inexpensively – but when understanding each other is critical, there is no substitute for meeting in-person. Events are the best way to exchange ideas with your customers, partners, prospects while increasing your brand/product visibility.

INPERSON
Webcasts
Targeted audience involvement equals clear, concise perception of your company’s message. Webcasts are a smart, innovative way of communicating to a wider targeted audience. Webcasts create very useful, dynamic reference material for attendees and also for absentees, thanks to the recording technology.

Benefit from the i-Micronews.com traffic generated by the 11,200+ monthly unique visitors, the 10,500+ weekly readers of @Micronews e-newsletter
Several key events planned for 2018 on different topics to attract 120 attendees on average
Gain new leads for your business from an average of 340 registrants per webcast

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