Power Electronics for Electric & Hybrid Electric Vehicles 2020

Market and Technology Report 2020
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Dr. Hong Lin
Dr. Hong Lin has been Principal Technology and Market Analyst within the Power & Wireless division at Yole Développement (Yole) since 2013. She specializes in compound semiconductors for power electronics, RF and photonic applications. Dr. Hong Lin provides technical, marketing and strategy analysis, and, as a native Chinese speaker, she also follows market trends in China. Before joining Yole Développement, Dr. Hong Lin worked as R&D engineer at Newstep Technologies, where she was in charge of the development of cold cathodes by PECVD for visible and UV lamp applications based on nanotechnologies. She holds a Ph.D. in Physics and Chemistry of materials.

E-mail: lin@yole.fr
Society and global industrial environment being reshaped by battery revolution
EV/HEV and 21st century challenges
CASE: Connectivity, autonomous, shared, electric
EV/HEV business is entering a new era
Where does the acceleration of vehicle electrification come from?
How to take the right EV/HEV strategic decision?
Historical perspective of driving applications

Market forecast – take away
Main factors influencing the power devices demand for EV/HEV

Market trends – take away
Main drivers for electric mobility
Main EV/HEV driver: stricter CO₂ emission reduction targets for vehicles
How to reach CO₂ emission reduction targets?
Why is EV/HEV deployment faster then expected in the past?
Game changers pushing stronger vehicle electrification
What factors can slow down today’s EV/HEV boom?
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Why all car owners do not buy 100% electric?
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The report provides an in-depth analysis of the EV/HEV applications, power systems and devices, as well as technology trends and supply chain analysis.

**REPORT SCOPE**

Applications – Technology – Supply chain

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<td>FCEV</td>
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**Applications and technology trends**

**Supply chain analysis**

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EV/HEV BUSINESS IS ENTERING A NEW ERA

The EV/HEV “road” has been mainly paved by the efforts of a few EV/HEV pioneers. In the coming years historical automotive players might run easier and faster on an “already paved road” and strongly accelerate their vehicle fleet electrification.

**Milestones**

1. **Li-ion battery commercially available**
   - 1991

2. **Toyota Prius HEV (over 12 Mio hybrid vehicles sold since 1997)**
   - 2000
   - Mainly using NiMH battery

3. **Tesla BEV Nissan Leaf BEV**
   - 2012
   - ~20 years

4. **EV/HEV boom in China**
   - 2019

**Time**

1990 2000 2010 2020

**Vehicle long-driving range enabler**

**Boom in users’ interest in electrified vehicles**

**Boom in users’ interest in full electric vehicles**

**Massive fleet electrification by historical automotive OEMs**

10 years
WHERE DOES THE ACCELERATION OF VEHICLE ELECTRIFICATION COME FROM?

The initial strategic path for vehicle electrification has been accelerated by several singular events. This acceleration surprised most of the traditional automotive players who were not ready.

NEDC: New European Driving Cycle
WLTP: Worldwide Harmonized Light Duty Vehicles Test Procedure

Full-electric

Full-electric

Real evolution

As planned in the past

Source: Yole Développement
Any strategic decision concerning EV/HEV is a very difficult task due to a very complex and rapidly changing environment.

- What is my starting point?
- How difficult to develop?
- Do I have right partners & suppliers?
- Will end users buy my car?
- What is the car’s perceived value for them?
- What is the positioning of my competitors?
- CO₂ emission reduction?
- Additional cost for electrification (per vehicle)?
- Cost of gCO₂/km saved?
- With / without subsidies?
- Where to put most effort & money?
- Any raw material issues?
- Rapidly changing and region-dependent subsidies and incentive mechanisms
- Time to develop?
- How to accelerate the development?
- How big is the risk?
- Force quickly through innovation or move progressively?
- CO₂ credits vs. CO₂ fines

More information needed!
EV/HEV: CURRENT AND FUTURE MARKET OVERVIEW
ELECTRIC AND HYBRID VEHICLES: MARKET TRENDS

MARKET TRENDS – TAKE AWAY

- Global societal trends and limited fossil fuel resources require more mobility based on cleaner and more efficient power electronics.
- Electric vehicles are an ultimate solution for clean mobility.
- Electric vehicle smart charging using clean and renewable electricity generation, for example, by wind and photovoltaics enables "desirable" electric vehicles: no internal combustion engines, no pollution during electricity generation & no pollution during car operation.
- Electric vehicles become an integral part of Smart Grids of the future as generation/distribution/demand and consumption of electricity (and hydrogen for fuel-cell cars).

As the transition to full electric vehicles cannot be achieved overnight, different types of electrified vehicles (EV/HEVs) will still coexist in the coming years.

CHOOSING THE RIGHT ELECTRIFICATION APPROACH

Electrification cost per vehicle, split by electrification type

- Mild hybridization is the least costly approach to electrify an ICE vehicle costs are at $2,000 per vehicle.
- However, plug-in electric and hybrid electric (PEV, PHEV) vehicles are growing in popularity, thousands of which might eventually reach the market.
- More advanced systems include battery electric vehicles (BEV) that allow an increase in electric vehicle range.
- The electrification cost per vehicle strongly depends on the vehicle type as well as the electrification strategy.

CHOOSING THE RIGHT ELECTRIFICATION APPROACH

CO2 emission levels per vehicle, split by electrification type

- Mild and full hybridization results in small reduction of CO2 emissions only.
- To reach CO2 emission reduction targets, more defined BEV, plug-in HEV, PHEV, FCV, and electric mobility must be considered as well.

HOW TO REACH CO2 EMISSION REDUCTION TARGETS?

Many approaches, but with different potential

EV/HEV MARKET DRIVERS

Main EV/HEV driver: stricter CO2 emission reduction targets for vehicles

Europe is the largest market for selling plug-in hybrid vehicles. This trend is supported by other market trends with stricter CO2-emission controls.

Governments’ targets for average car fleet CO2 emission reduce below the 2020 levels.

USA 99 g/km (2025)

EU 81 g/km (2025)

China 117 g/km (2020)

Japan 122 g/km (2020)

India 113 g/km (2022)

90% of the fleet sales are EV/HEVs, with the exception of the USA where more than 90% of the ICE vehicles are sold.

China and India are the two largest markets for EVs, with the exception of the USA.
EV/HEV SUPPLY CHAIN ANALYSIS
ELECTRIC AND HYBRID VEHICLES: FOCUS ON CHINA

CHINESE AUTOMOTIVE MARKET OVERVIEW
- In 2018, China was the world's largest auto market, with 28% of all cars sold and was very important globally.
- Despite 2019 Chinese auto market declined double.

CHINESE NEV MARKET
- Passenger cars

IMPACT OF SUBSIDY CHANGE
- NEV sales decline in 2019
  - The notice as described in the previous slide came into effect on March 26th, 2019. March 26th to June 25th, 2019 was the transitional period.
  - All subsidies will be phased out by 2020.

REGULATION IN CHINA
- CAF&CNEV Credits (Dual-Credit) policy evolution
- The policy evolves very quickly!

CHINESE AUTOMOTIVE MARKET TRANSFORMATION
- NEV credit mandate is increased from 10% to 12%
ELECTRIC AND HYBRID VEHICLES: TECHNOLOGY TRENDS

Battery electric vehicle in 2019

What will be the positioning of full HEV in the future?

Toyota = more than 20 years of focus on HEV. Is it time to change?

Modular Electric Drive Matrix (MEB) Platform from Volkswagen

Trends towards higher system integration
Integration of different systems

E-axle - Toward fully integrated powertrain

Advantages of the two motor approach

800V Vehicles as of 2019

What future for 800V?

48V is more than about mild-hybrids

BEV vs. FCEV powertrain comparison

Technology roadmap of EV/HEV power device packaging

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Power SiC 2019: Materials, Devices, Applications and Technology Trends

Li-ion Battery Packs for Automotive and Stationary Storage Applications

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- Imaging
- Sensing & Actuating
- Display

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- Semiconductor Packaging and Substrates
- Semiconductor Manufacturing
- Memory
- Computing and Software

Power & Wireless
- RF Devices & Technologies
- Compound Semiconductors & Emerging Materials
- Power Electronics
- Batteries & Energy Management
4 BUSINESS MODELS

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  - Technology analysis
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  - Reverse engineering & costing
  - Patent analysis
  - Design and characterization of innovative optical systems
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  - Yole Korea
    - Seoul
  - Yole Japan
    - Greater China office
      - Hsinchu

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

From A to Z…
Over 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 as well as intellectual property (IP) and patent analysis. Together, our group of companies is collaborating ever more closely. In 2020, we therefore will offer a collection of over 125 syndicated reports, 11 monitors and 160 teardowns. Combining the respective expertise and methodologies from the three companies, our products cover:

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

Our team of analysts, including PhD and MBA qualified industry experts from Yole Développement, System Plus Consulting and KnowMade, collect and analyse 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 2,300 projects, interacting with technology professionals and high-level opinion makers from the main players in their industries and completed more than 5,000 interviews per year.

**WHAT TO EXPECT IN 2020?**

During 2019 we introduced new additions to our “monitor” product offering, which provides continual updates on your industry during the year, and we will be expanding this offering during 2020. In addition to the monitors, we also developed “teardown tracks” that provide you online visibility into the latest consumer technology product designs and the suppliers within them. In 2020, an automotive track will be launched, further expanding our research focused on emerging technologies. On our traditional report side of our business, the Yole Group continues our commitment to a new collection of reports addressing six key markets: Mobile & Consumer, Automotive & Transportation, Telecom & Infrastructure, Medical, Industrial, and Defense & Aerospace. Discover our 2020 program right now, and ensure you get a true vision.
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- Status of Rechargeable Li-ion Battery Industry 2019

PATENT LANDSCAPE REPORT
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- Silicon Anode for Li-ion Batteries 2020

COMPOUND SEMICONDUCTORS AND EMERGING MATERIALS

MARKET AND TECHNOLOGY REPORT
- GaAs Wafer and Epiwafer Market: RF, Photonics, LED and PV Applications 2020
- InP Wafer and Epiwafer Market – Photonic and RF Applications 2020
- Power SiC: Materials, Devices and Applications 2020
- Power GaN: Epitaxy, Devices, Applications, and Technology Trends 2020
- RF GaN Market: Applications, Players, Technology, and Substrates 2020
- Status of SOI and Innovative Engineered Substrates: Players, Applications and Technology Trends 2020
- Emerging Semiconductor Substrates: Market & Technology Trends 2019

STRUCTURE, PROCESS & COST REPORT
- GaN Transistors Comparison 2020
- SiC Diodes Comparison 2020
- SiC Transistors Comparison 2020
- GaN-Based Wall Charger Comparison 2019
- GaN-on-Si HEMT vs Superjunction MOSFET Comparison 2019

PATENT LANDSCAPE REPORT
- Power GaN 2019
- Power SiC: MOSFETs, SBDs and Modules 2019

COMPUTING AND SOFTWARE

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- Artificial Intelligence for Surveillance & Security 2020
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• Front-End Equipment and Materials for Memory: Focus on Market Forecast & Shares 2020
• Memory for Artificial Intelligence Applications 2020: Embedded, Standalone …
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• MRAM Technology and Business 2019

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• Status of the Advanced Packaging Industry 2020
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• Wafer-Level Chip Scale Packaging 2020
• 2.5D/3D TSV & Wafer-Level Stacking: Technology & Market Updates 2019
• Advanced RF System-in-Package for Cellphones 2019
• Automotive Packaging: Market and Tech. Trends 2019
• Die Attach Equipment Market 2019
• Status of Advanced Substrates 2019

STRUCTURE, PROCESS & COST REPORT
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• Fan Out Packaging Comparison 2020

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• Fan-Out Wafer/Panel Level Packaging 2020

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• Quantum Technologies 2020
• LiDAR for Automotive and Industrial Applications 2020
• Silicon Photonics 2020
• Optical Transceivers for Data and Telecom 2020

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• Silicon Photonics and Photonic Integrated Circuits 2020

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  • Power Electronics for Electric & Hybrid Electric Vehicles 2020
• Status of the Power Electronics Industry 2020
• Status of the Power Module Packaging Industry 2020
• Discrete Power Device Packaging: Materials Market and Technology Trends 2019
• Power Management IC: Technology, Industry and Trends 2019
• Status of the Inverter Industry 2019

STRUCTURE, PROCESS & COST REPORT
• Power Module Packaging Comparison 2020
• Si IGBT Comparison 2020
• Smartphone RF FEM Comparison 2020

PATENT LANDSCAPE REPORT
• Wide Band Gap Power Modules 2020

RF DEVICES & TECHNOLOGIES
MARKET & TECHNOLOGY REPORT
• 5G’s Impact on RF Front-End for Telecom Infrastructure 2020
• 5G’s Impact on RF Front-End Module and Connectivity for Consumer Applications 2020
• Status of the Radar Industry: Players, Applications and Technology Trends 2020
• Status of the Thin-Film Integrated Passive Devices 2020
• Active and Passive Antenna Systems for Telecom Infrastructure 2019

STRUCTURE, PROCESS & COST REPORT
• RF Modules for Connectivity Comparison (WiFi & Bluethooth & UW) 2020
• mmWave Radars Comparison 2020
• Smartphone RF FEM Comparison 2020 (4 volumes)
• SAW Filters Comparison 2020
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- RF Acoustic Wave Filters 2019
- Antenna for 5G and 5G-related Applications 2019
- RF GaN 2019

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- Equipment and Materials for Thinning Semiconductor Substrates 2020
- Epitaxy Growth Equipment for More than Moore 2020
- Deposition (PVD + CVD + ALD + Thermal Oxidation): Equipment & Materials for MtM Devices 2020
- Glass Substrate for Semiconductor and Displays at the Wafer and Panel Levels 2020
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- Small Dimension Wafers Market 2020
- Nano-Imprint Technology Trends for Semiconductor Applications 2019

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- BioMEMS 2020
- High-End Inertial Sensors 2020
- Point-of-Need Testing: Application of Microfluidic Technologies 2020
- Sensing and Computing for ADAS Vehicle 2020
- Sensing and Computing for Robotic Transportation 2020
- Status of the MEMS Industry 2020
- Status of the Microfluidics Industry: Techniques, Manufacturing and Materials 2020
- Ultrasound Technologies for Consumer, Medical and Industrial Markets 2020
- Wearables for Consumer and Medical Markets 2020
- Emerging Printing Technologies 2019
- Inkjet Printheads: Dispensing Technologies & Market Landscape 2019
- Next Generation Sequencing & DNA Synthesis: Technology, Consumables 2019
- Organs-On-Chips Market and Technology Landscape 2019
- Piezoelectric Devices: From Bulk to Thin-Film 2019
- Uncooled Infrared Imagers and Detectors 2019

STRUCTURE, PROCESS & COST REPORT
- Automotive Inertial Sensors Comparison 2020
- Consumer Magnetic Sensor Comparison 2020
- MEMS Microphones Processes Comparison 2020
- Mobile Inertial Sensors comparison 2020
- Piezoelectric Material From Bulk to Thin Film – Comparison 2019
- Particle Sensor Comparison 2019

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- Circulating Tumor Cells Isolation 2020
- LiDAR 2020
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- MEMS Sensors & Actuators: 2019 IP Trends and Prospective
- Microneedles for Biomedical Applications 2020
- Piezo MEMS 2020
- Nanopore Sequencing 2019

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OUR 2020 MONITORS COLLECTION (1/2)

MARKET MONITORS

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. Starting from Q4 2019

Application Processor – NEW
The monitor examines and forecasts the application processor segment. It tracks processor revenue, units, and wafer volumes at both fabless chip designers and at the foundries themselves, sliced across various relevant parameters including process node, end product segment, core and IP type, etc. The monitor also examines the reported financials of players within the ecosystem. Starting from Q4 2019.

Compound Semiconductors – 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. Starting from Q4 2019

CMOS Image Sensors – 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 ON Semiconductor will thus be analysed. Starting from Q3 2019

DRAM
This monitor analyzes the evolution of the DRAM market in terms of revenue, shipments, capex, and near-term price evolution, as well as demand per market segment (data centers, mobile, automotive, graphics, and PC), DRAM technology evolution, and detailed profiles of main suppliers. It also provides DRAM monthly pricing to track the price evolution of key components and packaged solutions.

NAND
This monitor provides all data related to NAND revenue per quarter, NAND shipments, pricing per NAND type, near and long-term revenue, market share per quarter, capex per company, and a market demand/ supply forecast, along with a complete analysis and details on the demand side, with a deep dive into client and enterprise SSD, data centers, mobile, automotive, PC, and more.
PATENT MONITORS

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 MMICs, packaging, modules and systems.

RF Acoustic Wave Filters

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

Microfluidics

From components to chips and systems, including all applications.

Solid-State Li-ion Batteries

This monitoring service tracks patents related to 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.

REVERSE TECHNOLOGY MONITOR

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 monitor will provide the design wins for the top smartphones OEM, the packaging evolution in term of type, footprint, pitch, as well as die area evolution per function, technology node, wafer size. It will offer a clear view of the technological strategy of the semiconductor companies leading the market and a direct comparison between OEM.
**OUR 160+ TRACKS**

Access anytime via our web portal new teardowns and updates, as our analysis progresses

System Plus Consulting's teardown tracks uncover innovative design features and new semiconductor components to guide enterprises toward more streamlined solutions in future designs. We provide clients unmatched intelligence into 5 main tracks:

**PHONES** - 440+ PRODUCTS ALREADY AVAILABLE

- **APPLE**
  - iPhone 11 Pro 512GB
  - iPhone 11 Pro 256GB
  - iPhone XR

- **OPPO**
  - OPPO Reno 5G
  - OPPO K1
  - OPPO R17 PRO

- **SAMSUNG**
  - Samsung Galaxy A50 64GB Dual SIM
  - Samsung Galaxy Fold
  - Samsung Galaxy Xcover 4s

- **XIAOMI**
  - Xiaomi Mi Mix 3 5G 64GB
  - Xiaomi Black Shark 2 128GB 8GB RAM
  - Xiaomi Redmi Note 7 Pro

**SMART HOME** - 90+ PRODUCTS ALREADY AVAILABLE

- **AMAZON**
  - Amazon Show 5
  - Amazon Echo plus (2nd gen.)

- **GOOGLE**
  - Google Home Hub
  - Google Clips

**WEARABLE** - 130+ PRODUCTS ALREADY AVAILABLE

- **APPLE**
  - Apple Airpods Pro w/Wireless charger
  - Apple Watch 5

- **BOSE**
  - Bose Frames

- **FITBIT**
  - Fitbit Charge 3
  - Fitbit Versa
  - Fitbit Flyer

**CONNECTED DEVICES** - 110+ PRODUCTS ALREADY AVAILABLE

- **MICROSOFT**
  - Microsoft Surface Go

- **SAMSUNG**
  - Samsung Tab S5e

- **VERIZON**
  - Verizon HUM x (Gen 1)

**AUTOMOTIVE**

First teardowns available from Q1 2020 (60+ in 2020)

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To meet the growing demand for market, technological and business information, i-Micronews Media integrates several tools able to reach each individual contact within its network.

We will ensure your company benefits from this

**ONLINE**

- i-Micronews e-newsletter
- i-Micronews.com
- FreeFullPDF.com

**ONSITE**

- Events

**INPERSON**

- Webcasts

**Unique, cost-effective ways to reach global audiences.**

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.

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.

- #15,100+ monthly unique visitors on i-Micronews.com
- #10,900+ weekly readers of i-Micronews e-newsletter
- #110 attendees on average
- #14+ key events planned for 2020 on different topics
- #280 registrants per webcast on average to gain new leads for your business

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