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► **To cite this version:**

Jean-Marc Diénot. The rise of electromagnetic pollution and interactions in mobile and transport applications using new electronic chips and energy devices. Euroscience Open Forum ESOF2018, Jul 2018, Toulouse, France. pp.1-1, 2018. hal-02168381

HAL Id: hal-02168381

<https://hal.science/hal-02168381v1>

Submitted on 28 Jun 2019

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To cite this version :

Diénot, Jean-Marc The rise of electromagnetic pollution and interactions in mobile and transport applications using new electronic chips and energy devices. (2018) In: Euroscience Open Forum ESOF2018, 9 July 2018 - 14 July 2018 (Toulouse, France). (Unpublished)

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THE RISE OF ELECTROMAGNETIC POLLUTION AND INTERACTIONS IN MOBILE AND TRANSPORT APPLICATIONS USING NEW ELECTRONIC CHIPS AND ENERGY DEVICES

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The development of wireless electronics, digital systems and mechatronics sciences leads to performant applications in our environment: smart systems, mobile systems, all electrical vehicles, wireless connectivity, aerial and humanoid robots, etc. These structures merged because of main progress in material and semi-conductors for electronics, both in digital and power components, and techniques for integration so to keep performances and reliable activity for user's convenience. Two main scientific drawbacks : the rise of electromagnetic interferences and pollutions, and the endless rise of temperature that need to be more and more cooled. They impact on scientific and industrial working policies, because of changing the real conditions of the official state-of-the-art regulatory rules, both for EMC (Electromagnetic Compatibility) and Reliability Standards.

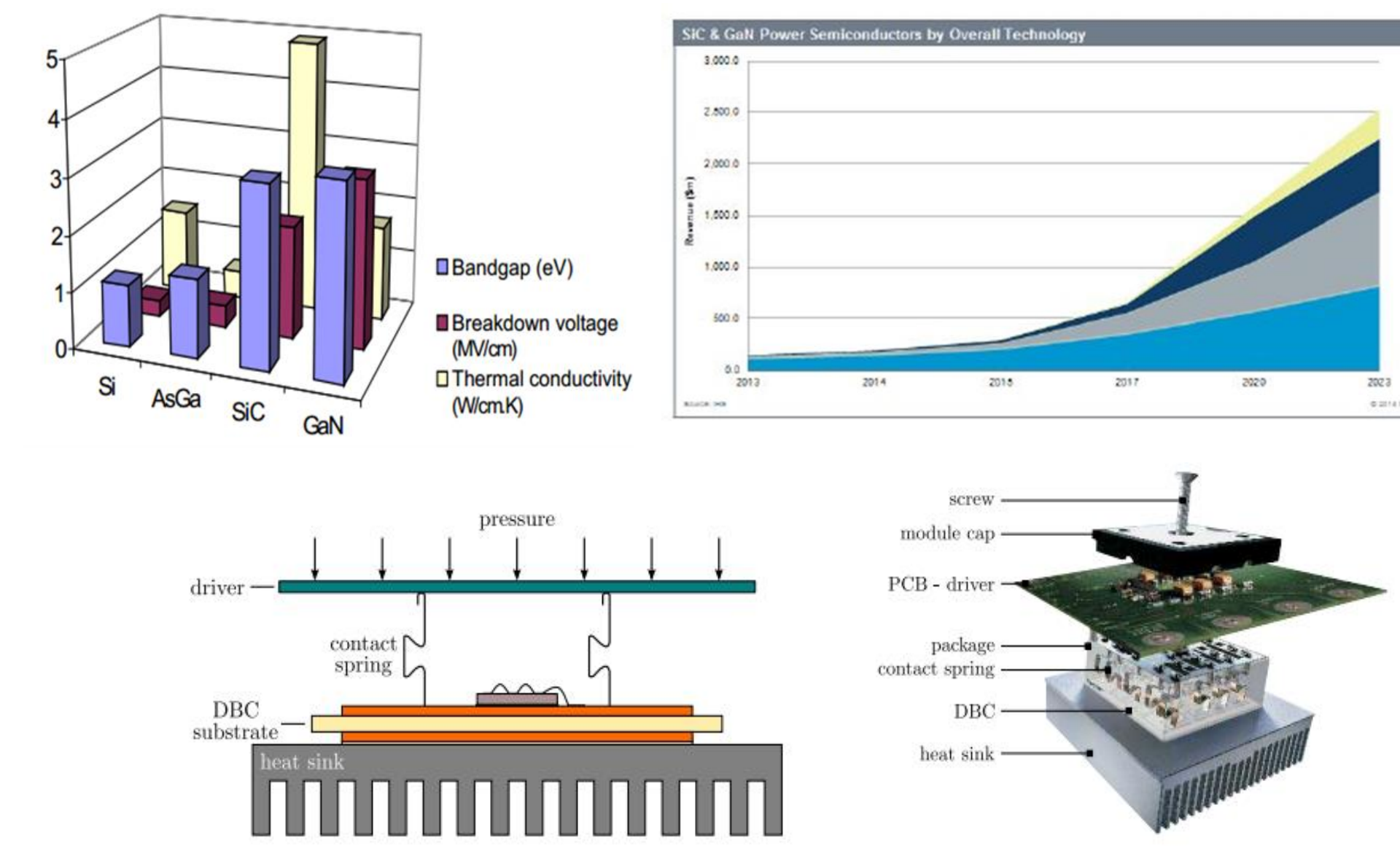
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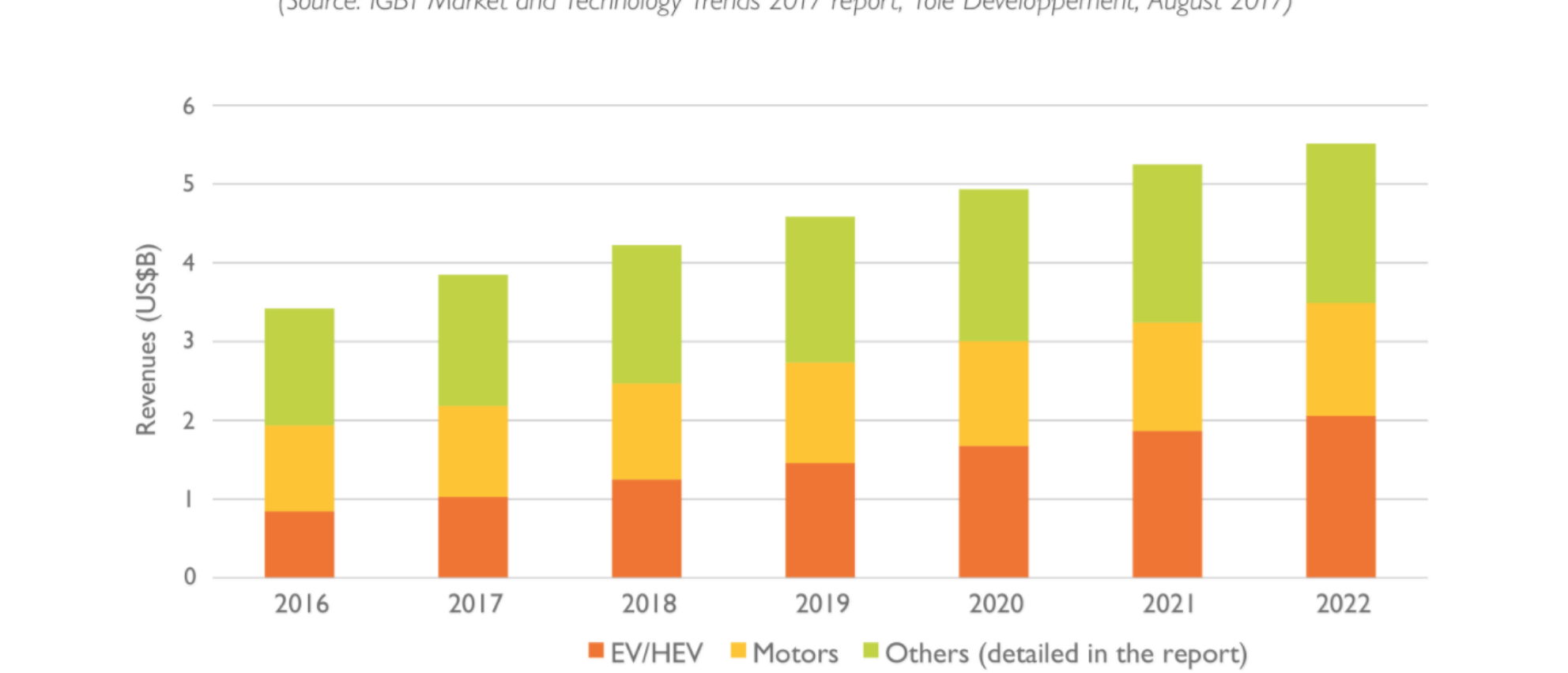
http://labceem.iut-tarbes.fr/

NEW SEMICONDUCTOR/COMPONENTS + NEW INTEGRATION TECHNIQUES = NEW SMART MOBILE AND POWER APPLICATIONS

YEAR	SWITCH COMPONENT	POWER RANGE	FREQUENCY RANGE	dV/dt dI/dt
1970	Thyristor Power Diode	3kV 3kA	100Hz	1kV/μs 100kA/μs
1980	gate turn-off thyristor GTO	3kV, 3kA 100A, 1kV	300Hz 3kHz	10kV/μs 100kA/μs
1985	Metal Oxide Silicon Field Effect Transistor MOSFET	100V 100A	100-400kHz	10kV/μs 10kA/μs
1990	Insulated Gate Bipolar Transistor IGBT	1000V 100kA	1-10kHz	10kV/μs 10kA/μs
2002	TrenchMOS/UMOS	25V 50A	1MHz	10kV/μs 10kA/μs
2005	IGBT for Traction	4kV 100kA	1-10kHz	10kV/μs 10kA/μs
2006	SIC Schottky Diode	40V 10A	100-500 kHz	10kV/μs 10kA/μs
2010	SIC Junction Field Effect Transistor JFET	1200V 10A	10-100kHz	10kV/μs 10kA/μs
2012	GaN Diode	1000V 115A	1MHz	10kV/μs 10kA/μs
2014	SIC MOSFET	1200V 10kA	100-500 kHz	50kV/μs 10kA/μs
2016	GaN Power Transistor (WFFET)	800V 10A	10-50 MHz	40kV/μs 1kA/μs
2025MOSFET-IGBT...	...2400V 100kA	1 - 100MHz	200kV/μs 100kA/μs



Total IGBT market evolution by application for 2016-2022



ELECTROMAGNETIC CONCEPTS FOR INTERFERENCES AND COMPATIBILITY (EMI/EMC) IN MOBILE SYSTEMS = NEW CHALLENGES FOR ENGINEERS/DESIGNERS

SOURCE → **COUPLINGS MODES AND WAYS** → **VICTIM**

Investigations on EM noises and emissions
Investigations on EM couplings and shielding
Investigation on defaults and susceptibility cases

Frequency Range	Equivalent Wavelength (min)	NF frontier	Denomination and main EMC characteristics
0-9 kHz	33.3 km	5.3 km	Conducted Very low frequency (Electricity Mains)
9-150 kHz	2 km	318 m	Conducted Low frequency
150kHz-30 MHz	200 m	1.59 m	Conducted, High Speed Radiated Magnetic or Electric quasi static fields
30-300 MHz	1 m	15.9 cm	Conducted, very high speed Radiated near-field Radiated (RF)
300 MHz-3 GHz	10 cm	1.59 cm	Radiated RF and μwaves
3 GHz-30 GHz	1 cm	0.159 cm	Radiated High frequency waves

Conception → **R&D issues** → **EMI/EMC impacts**

Component Integration
Advanced integration Command control
High Voltage Number of component decrease
High Frequency Volume of converter decrease
High Temperature Materials, Packaging, Cooling

EMI/EMC impacts:
Auto-compatibility Parasitic, crosstalk
Couplings Nearfields
Radiation increase dielectric constraint,
Radiation increase Near-field
Shifts in Radiation behaviors Near-field couplings

Computer architecture Informations/Multimedia
Sensors - Antennas
Wireless communications RF chips and electronics
Electrical supply and converters Electrical motors Power electronics
Electrical buses Control buses Energy buses
Dedicated processors Control/security assistance

THE RISE OF ELECTROMAGNETIC NOISES AND FREQUENCY RANGE OF EMISSIONS WITH SWITCHING ACTIVITY = POWER SYSTEMS BECOME UNINTENTIONAL RADIATED SOURCES

1- Electromagnetic Field Cartography in Power PCB(Printed Circuit Board)

2- Common Mode Currents in a Flyback Converter

3- Radiated EM Fields in Power/mechatronic systems

THE CRITICAL IMPACT OF INTERNAL/EXTERNAL TEMPERATURE ON ELECTROMAGNETIC COUPLINGS AND IMMUNITY OF ELECTRONICS = NEW DEFAULTS AND SAFETY MARGINS

1- Effects of heating on Electromagnetic safety margins

2- Special Test Bench for EMC characterization with Temperature

SETUP #1: NEAR-FIELD CHARACTERIZATION - METHODS WITH THERMAL AGGRESSION

- Special Test Fixture with EM and Temperatures Probes
- RF Aggression Range: 1MHz - 6GHz
- Temperature Aggression Range: 20°C - 240°C

3- New figures of EM defaults in electronics chips

NEW PERFORMANCES IN ELECTRONIC FOR FULL ELECTRICAL MOBILE AND EMBEDDED SYSTEMS : HIGH POWER, HIGH VOLTAGE, HIGH FREQUENCY, HIGH TEMPERATURE

NEW CRITICAL CONSTRAINTS FOR ELECTROMAGNETIC EMISSION AND RELIABILITY :

MECHATRONICS/POWER ELECTRONICS **RADIATES EM FIELD TOWARDS 100MHZ ACTUALLY, UNTIL 1GHz IN THE FUTURE**

TEMPERATURE AND REAL MULTIPHYSICS ENVIRONMENT **REDUCES THE ELECTROMAGNETIC IMMUNITY WITH A RATIO OF 10 to 100**

COUPLINGS WITH SOURCES AND VICTIMS ARE ENFORCED: **SAFETY AND INTEGRITY OF THE MISSIONS OF MOBILE SYSTEMS BECOME CRITICAL**

NEW CHALLENGES FOR EMC/EMI RESEARCHERS AND R&D ENGINEERS IN DESIGNING ACTUAL AND FUTURE ELECTRICAL TRANSPORTATION SYSTEMS : ROBOTS, DRONES, BUSES, TRAINS, CARS, PLANES...

