Compound Semiconductor Industry Innovation Meets REACH

August 2011

AZUR SPACE SOLAR POWER GMBH
Fraunhofer IAF
Freiberger
OSRAM Opto Semiconductors
Photoindustrie-Verband e.V. THE IMAGING ASSOCIATION
Soitec
SPECTARIS Verband der Hightech-Industrie
TEXAS INSTRUMENTS
united monolithic semiconductors
WVM WirtschaftsVereinigung Metalle

Outline

1. **Safety and Sustainability**
2. **Market Innovations in Hightech Industry (Examples)**
    a) Photonics
    b) Photovoltaics
    c) RF-communication
3. **Major Concerns Regarding the REACH/CLP Process**
4. **Downstream Consequences of CLP Classification**
5. **Threads to Europe's Competitiveness & Ability to Innovate:**
   Case Study Gallium Arsenide (GaAs)
6. **Conclusions**
7. **Backup**

1. Safety and Sustainability

- Europe's compound semiconductor industry actively supports the REACH /CLP goals for safer use of chemicals in the European Union.
- Europe's compound semiconductor industry has implemented in its manufacturing operations the highest standards for Occupational Health, Environmental Protection, Recycling & Sustainability and Product Safety.
- Europe's compound semiconductor industry is continuously investigating and investing into R&D to even enhance these standards.

Invitation:

Please come and visit our facilities to receive first hand information and make yourself a picture about our safe manufacturing facilities.

1. Safety and Sustainability

Case Study: Synthesis of GaAs

GaAs Synthesis Conditions:

- Takes place in a clean room environment
- GaAs material is processed in closed systems (PROC 1)
- Appropriate risk management measures are in place to protect workers and the environement
- No skin and inhalation exposure of workers is expected
- Automatic systems, strict controls and monitoring in place

1. Safety and Sustainability

Case Study: Exposure of Workers in GaAs Production

Exposure

100% Inhalation of 10µg/m^3 GaAs during an 8 hour shift (worst case)

= max. 100 µg GaAs per worker

↓

Incorporation

Respirable fraction max. 15%

= max 15 µg GaAs

↓

Bio - availability

As-bio availability thereof (realistic): 1%

= 0.15 µg As

As daily intake from food sources:

2 l Drinking Water[1,3] ➔ 10 µg As

300 g Sea Food[2,3,5] ➔ 7.5 µg As

100 g Rice[3,4,5] ➔ 7.5 µg As

➔ more than 10 times higher

<u>Footnotes</u>

1. German Drinking Water Directive
2. WHO 2001
3. Assuming 50% bio-availability (realistic)
4. Californian brand
5. Inorganic arsenic species

1. Safety and Sustainability

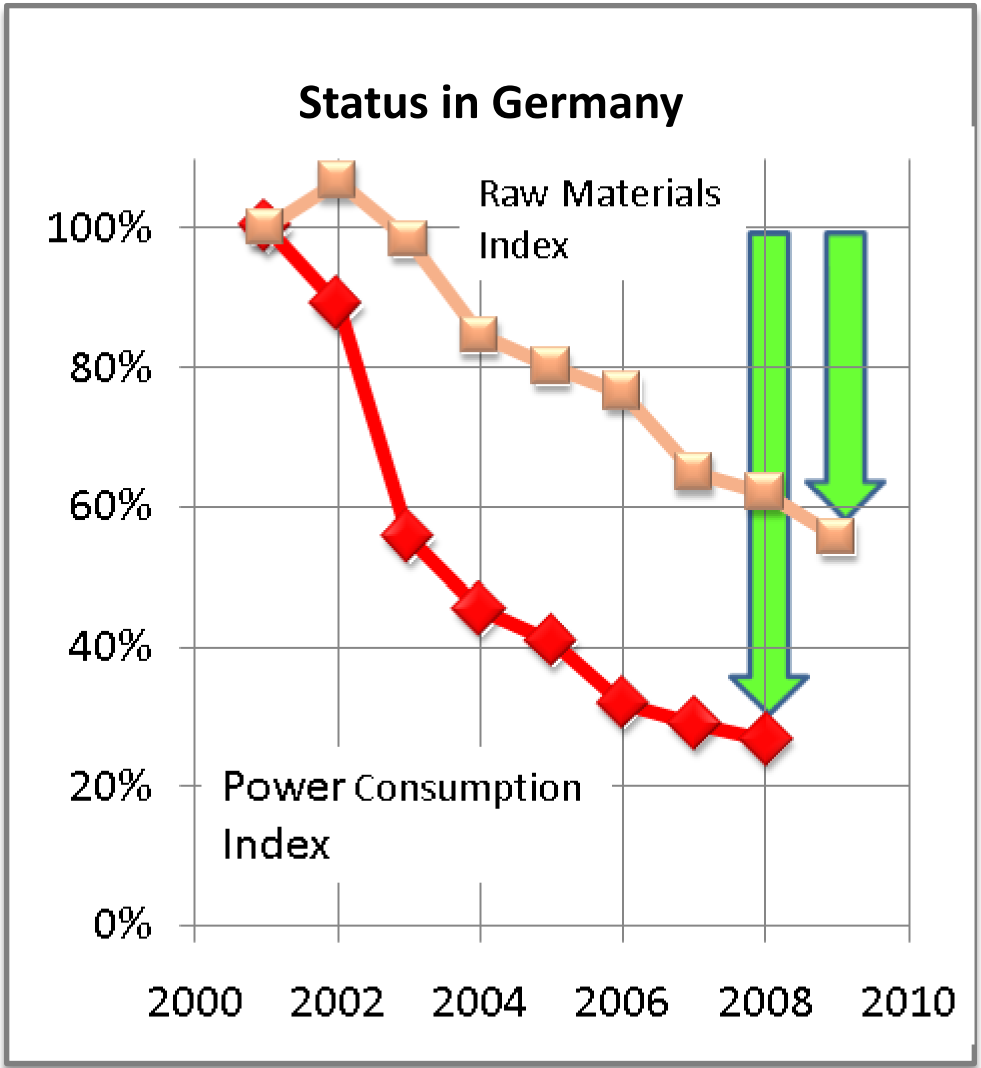
Case Study: Sustainability in GaAs Production

Sustainability in GaAs Production:

- Specific* raw materials consumption reduced by 60 %
- Specific* power consumption (CO_2 footprint) reduced by 75 %
- Technological lead over Asia

➔ Expelling GaAs from Europe implies major drawback

(*) per cm² of produced wafer surface

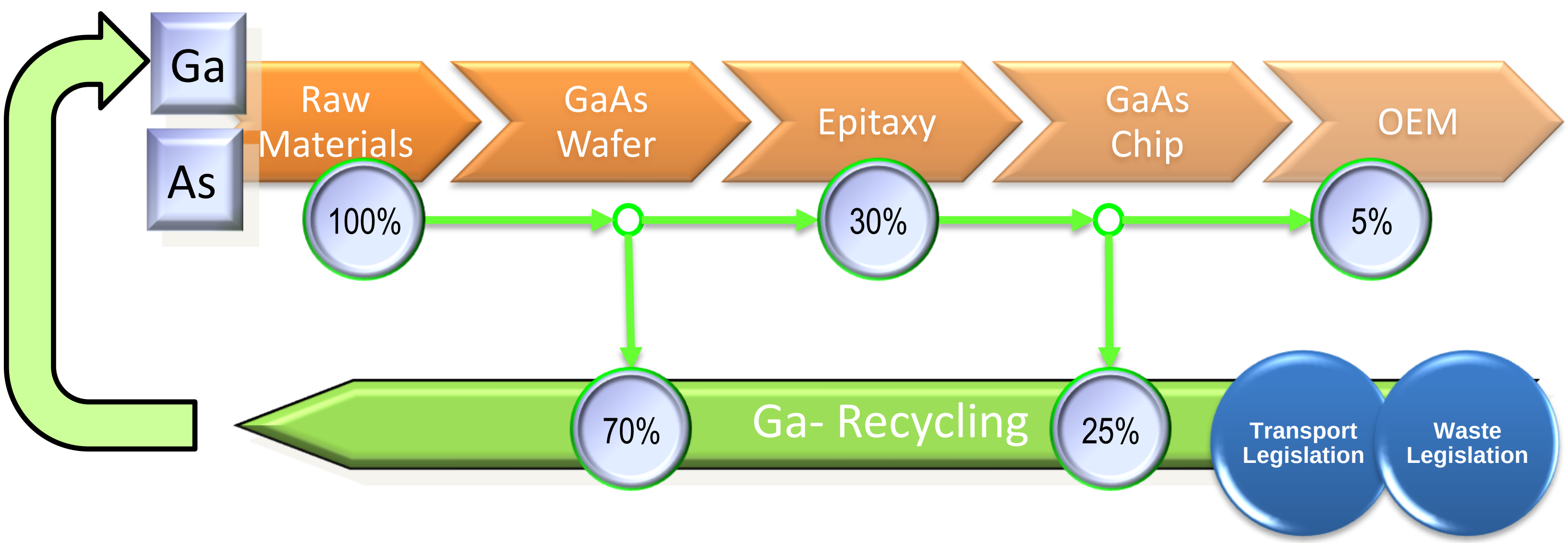


1. Safety and Sustainability

Case study: Closed GaAs Recycling Flow in EU

- Efficient recycling has been implemented and includes all manufacturing processes and sites in Europe
- Existing recycling crosses boarders within Europe and across the Atlantic including US companies

➔ **closed GaAs cycle established in production and recycling lines**



1. Safety and Sustainability

Case Study: GaAs Device Application, Safety of Products

Broad Band Communication device that includes 15 GaAs chips manufactured by TriQuint

Total weight: 385 g
Total GaAs content: 8.35 mg
Arsenic content: 4.33 mg

GaAs conc < 22 ppm; As conc ~ 12 ppm calculated on total weight of the device

GaAs fully encapsulated
NO consumer exposure

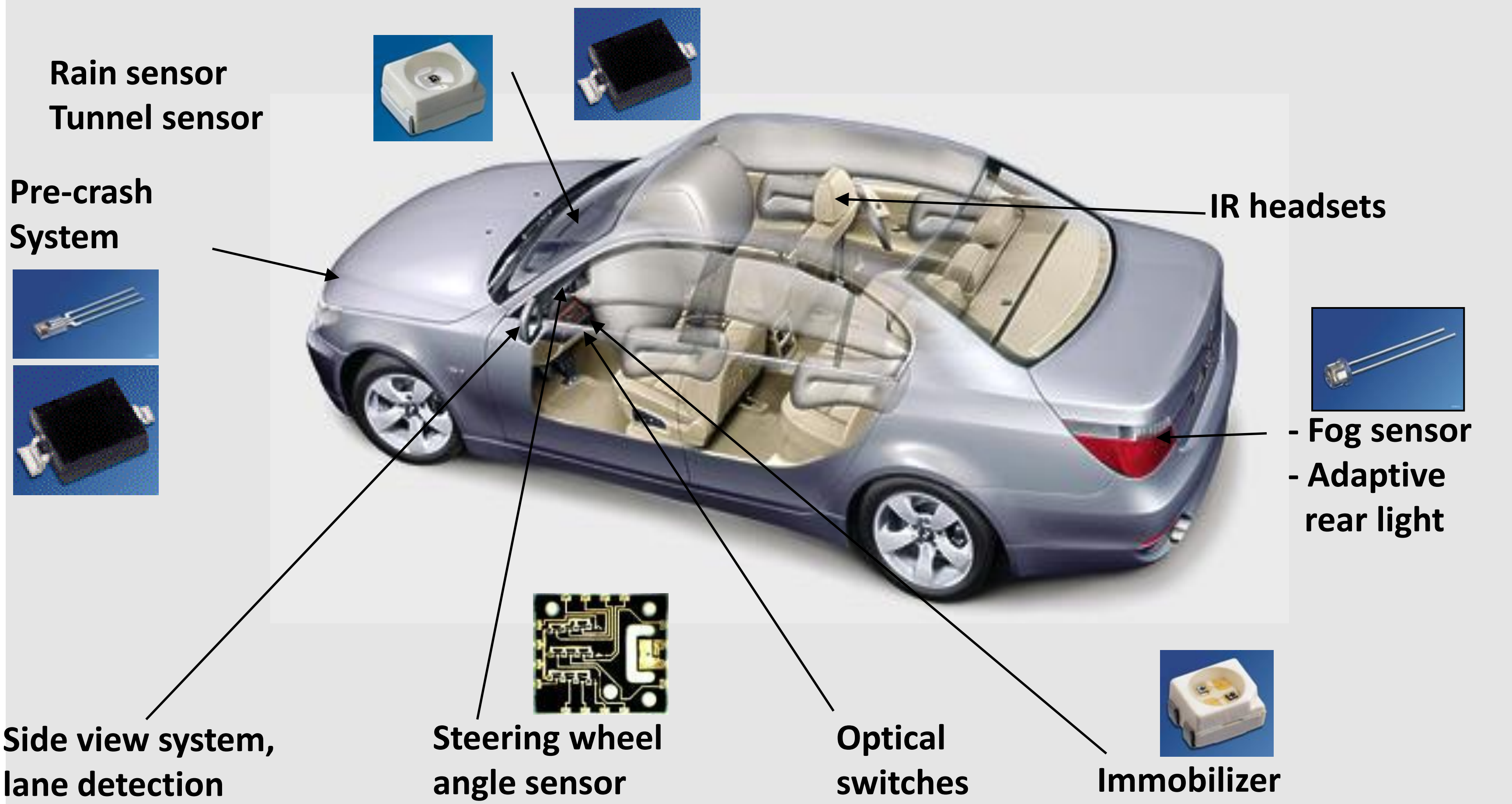
2. Hightech Industry and Market Innovation (Examples)

Innovation and products for lighting, automotive, telecommunication datalinks, data storage, laser welding, medicine…

➔ Photonics

Photonics

GaAs Based Devices in Automotive Applications

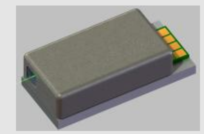


Photonics

GaAs Based Devices in Mobile Applications

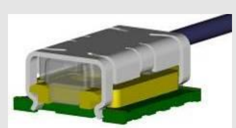
IR Flash

Laser Projection



Proximity sensor

Optical data transmission between display and mainboard



Optical on/off switch for flip and slider phones

Photonics

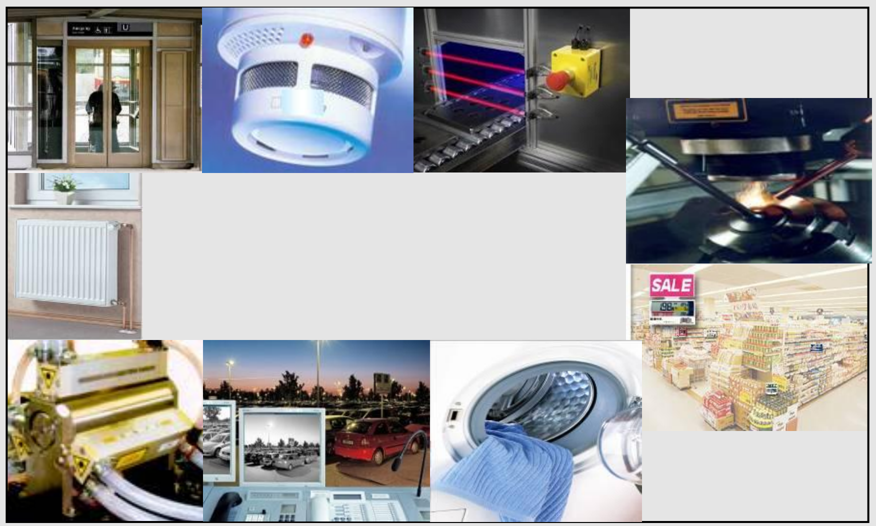
GaAs Based Devices in Industrial Applications

Smoke detector

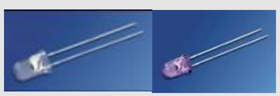
Production control

Light curtain

Material processing



Energy meter



E-pricing system

Solid state laser pumping

Illumination
CCTV

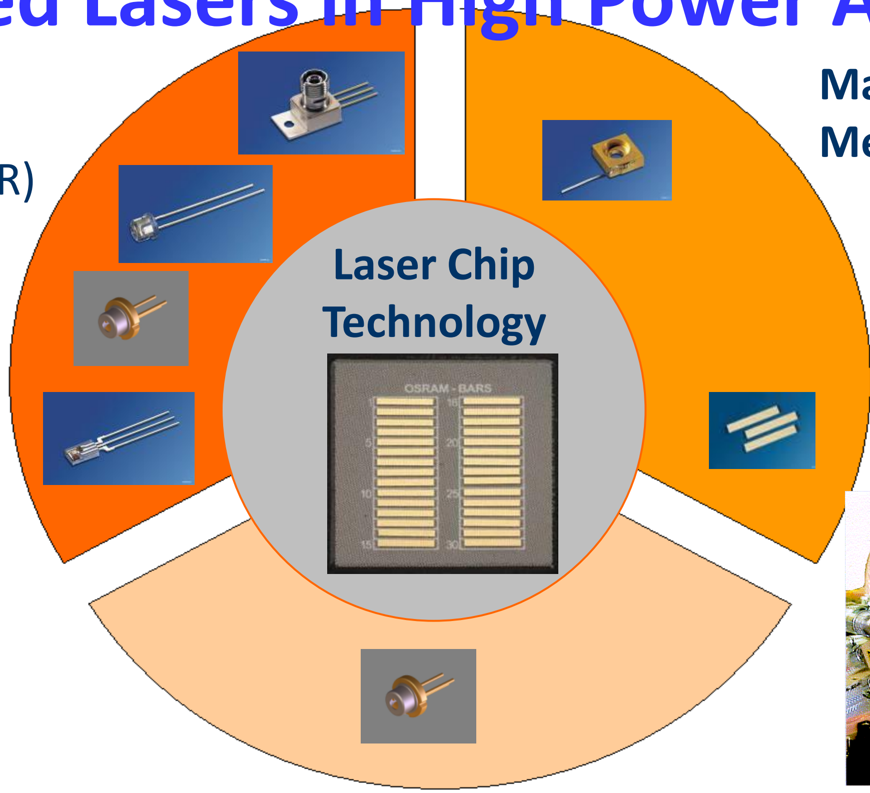
Turbidity sensor

Photonics

GaAs Based Lasers in High Power Applications

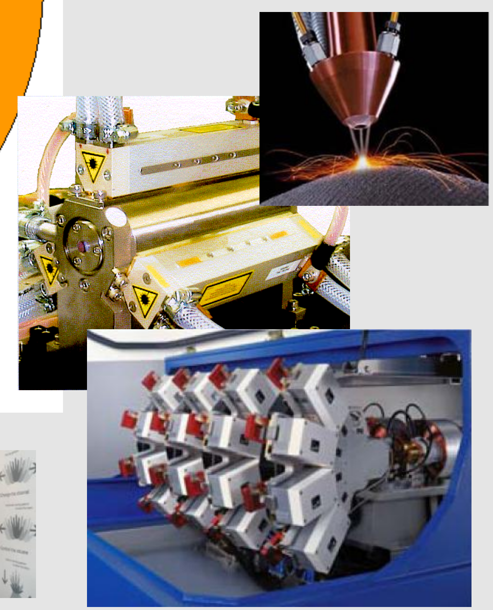
SENSING

- Time of flight (LIDAR)
- 3D-Camera



Material Treatment & Medical

- Pumping of sold-state and fiber lasers
- Diode lasers



IR Illumination

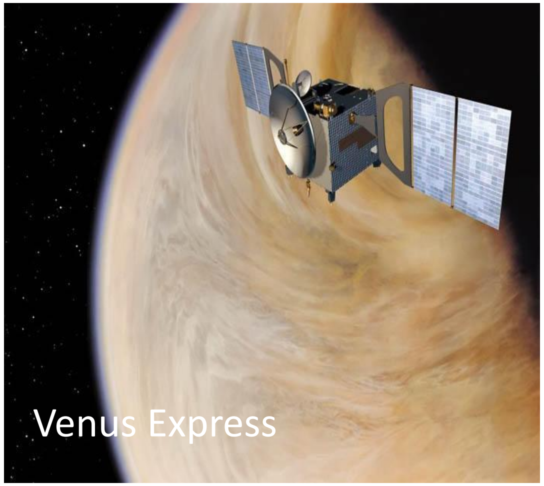
- Gesture recognition
- CCTV

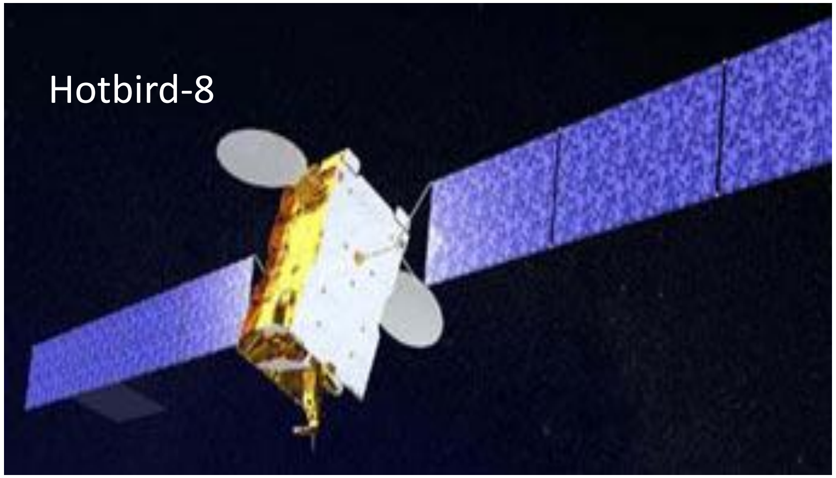
2. High-tech Industry and Market Innovation (Examples)

Innovation and products for European space satellites and regenerative solar energy future as well

➔ Photovoltaics

European satellite programs enabled by compound semiconductor high efficiency solar cells



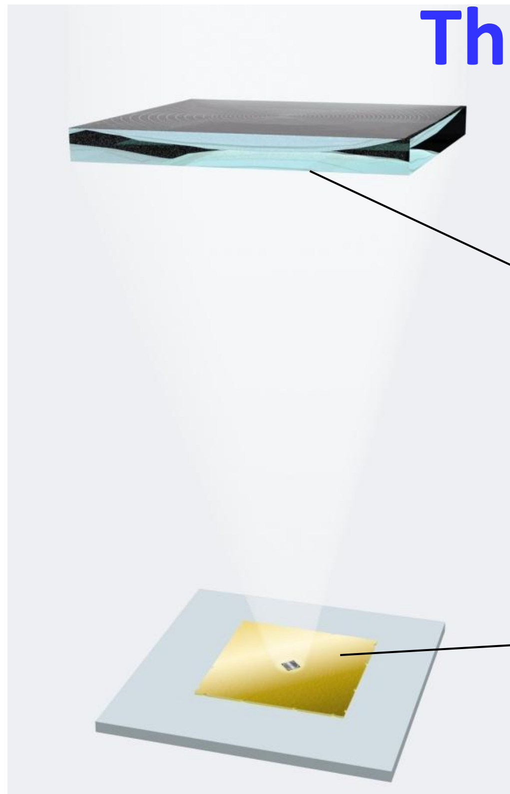


Photovoltaics

The Principle of CPV[3]

- Drastically reduced semiconductor area
- Best solar cells available in the market (~40% efficiency)
- Modul efficiency above 30%.

➔ **Substantial efficiency potential is the key driver for cost reduction:**



80-85% **optical efficiency**

module efficiency above 30 %

40% **cell efficiency**

System Cost ↓ / **Power** ↑ = Cost (Steel, Glass, Cell) ↓ / **Efficiency** ↑ * DNI[1] = **Cost** ↓ / kWh ↑ = LCOE[2] ↓

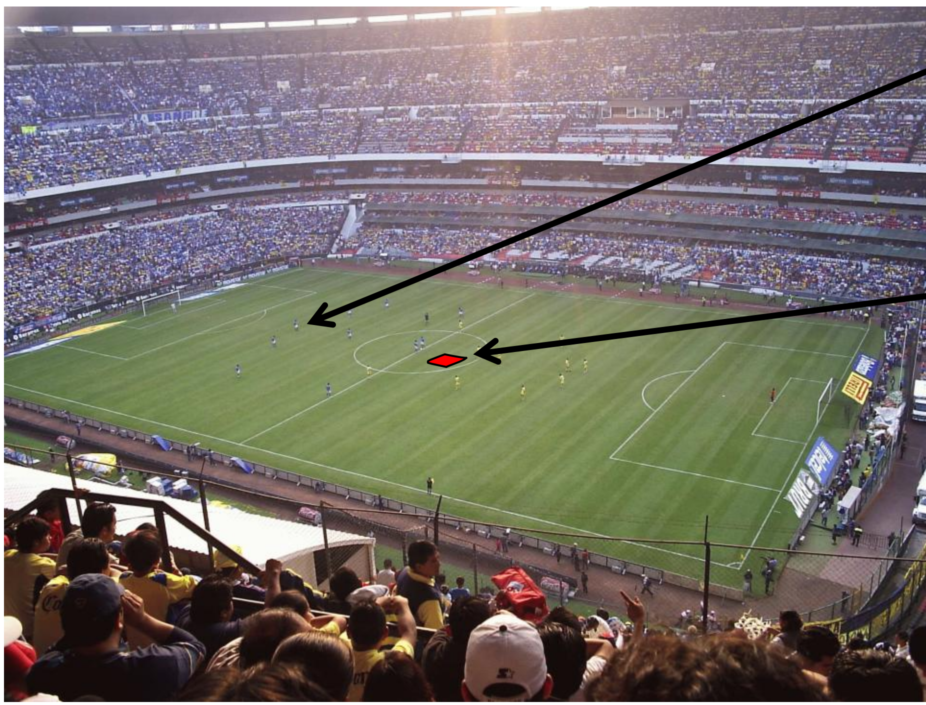
[1] *DNI = Direct normal irradiance,* [2] *COE = levelised cost of energy,* [3] *CPV = concentrator photovoltaics*

Photovoltaics

Si vs. GaAs usage
(for a 1 MWp PV plant)

Si Modules

6 000 m²



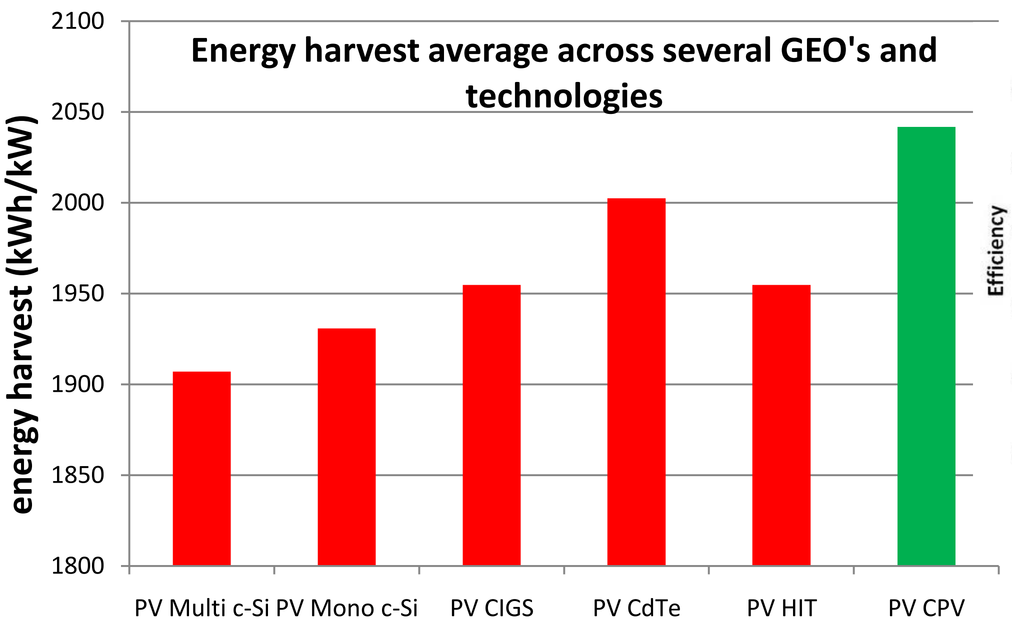
TJ GaAs CPV
5 m²

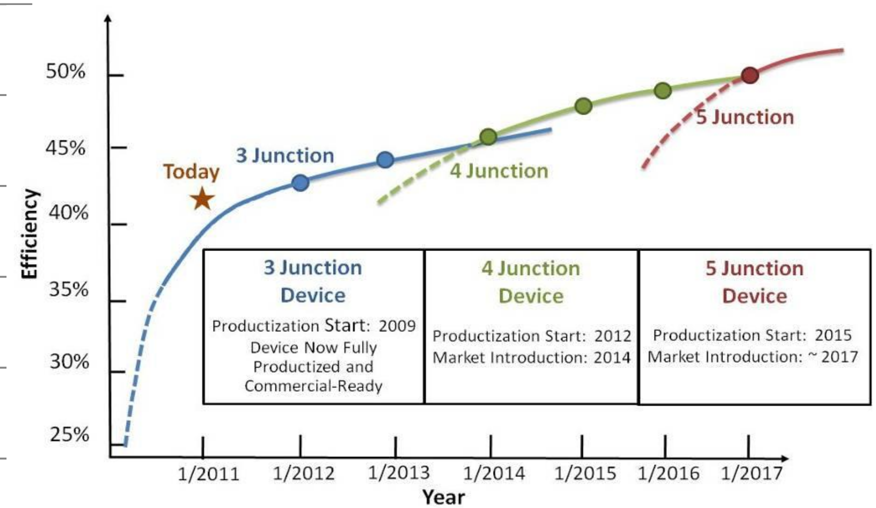
Photovoltaics

Energy harvested per technology and geo:

- measure how competitive the PV technology is
- actual comparison based on data sheets for module and cell efficiency, actual local DNI[1]
- measurements show advantage of CPV[2] (green)
- with further innovation from triple to quintuple solar cells, see below, the gap will be even larger.

➔ **CPV technology is going to be competitive to bulk energy**



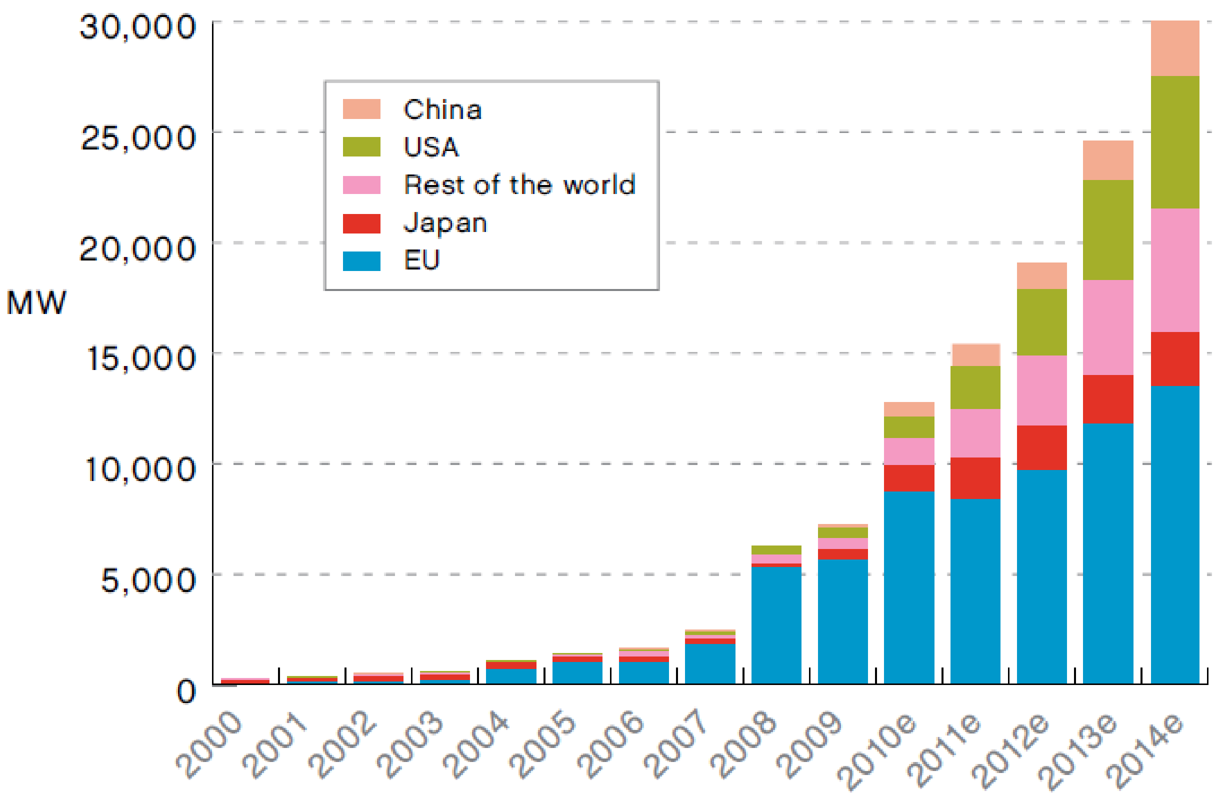


CPV annual report 2010

[1] DNI = Direct normal irradiance, CPV = concentrator PV

Photovoltaics

Terrestrial Market – Annual PV Forecast and CPV



EPIA Forecast May 2010

CPV (concentrator photovoltaic):

2014: potential in Europe ~ 600 MW,

2015+: due to cost reduction and technical ripening further fast growing.

2. High-tech Industry and Market Innovation (Examples)

Microwave and Millimeter-Wave Communication and Sensor Systems

➔ RF-communication/sensor system

RF-Communication

GaAs components are key enablers in mobile and infrastructure communication systems

- **Modern Smart phones and WLAN terminals are using GaAs for transmitters and switches**
- **Mobile phone base stations require GaAs components to achieve highest service quality**

- **Telecommunication networks are using radio links for high data rate connections**
  - low noise amplifiers are based on GaAs technology
  - highly linear power amplifiers require GaAs

  → high data bit rate transmission need III-V compound semiconductors (i.e. GaAs)

- **GaAs components are used in Cable TV repeaters systems**

... and many other RF-communication equipment

RF-Sensor Systems

GaAs components ensure security and independence

- **Microwave and millimeter-wave systems with GaAs components in security and defense**
  - RADAR technology enables detection of objects in complex environments
  - Counter measures against threads through use of electronic warfare (e.g. jamming of radio controlled improvised explosive device (IEDs))
  - Detection of weapons and other threats through millimeter-wave detection systems (e.g. body scanners)

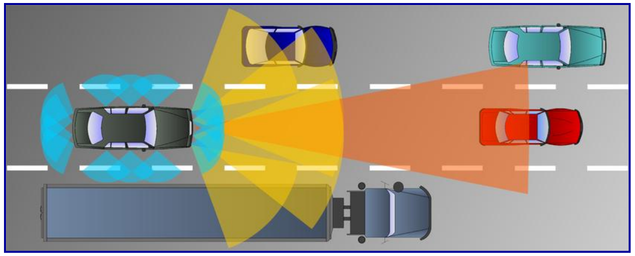
- **GaAs is indispensable for realization of such systems as it enables low noise signal detection and high power signal generation**

more than 50% of casualties of coalition troops in Afghanistan are linked to IEDs

Photo

MM-Wellen-Sensorik (FhG)

RF-Automotive



GaAs components for
safety improvement in mobility

- **Microwave sensors based on GaAs components are used in vehicles to assist the driver and to improve safety (ADAS - "Advanced Driver Assistance System")**
  - adaptive cruise control (ACC) based on 77GHz radar systems
  - blind spot detection and rear cross alert systems are using 24GHz/79GHz sensor system
  - → microwave sensor systems are proven to reduce fatalities and injuries in complex traffic environments

- **Distance control and emergency breaking system are becoming <u>mandatory</u> for truck in 2015 (EU legislation)**
  - obstacle detection by radar systems based on GaAs technology and components

3. Major Concerns Regarding the REACH/CLP Process

Toxicological Assessment & REACH/CLP Implementation:

1. The harsh CLP classification of GaAs proposed by RAC is not appropriately based on well established toxicological evidence:
   - The application of "Read Across" in this case is not in line with in the CLP/GHS Directive.
   - RAC has ignored most of the toxicological literature of the past decade.
   - Toxicological evidence has been weighted by RAC in a rather non-transparent way.
2. A case of similar concern is Indium Phosphide (InP)
3. Substantial new and relevant information on GaAs has been submitted during the 2nd public REACH consultation in March/April.
4. GAIT advocates an unbiased and open scientific re-evaluation of both end points (carcinogenicity and fertility) by ECHA/RAC in September.

3. Major Concern Regarding the REACH/CLP Process

Competitiveness & Innovation I:

1. GaAs and InP are key materials for most photonic, concentrator photovoltaic and communication devices.

2. In most applications these materials **cannot** be replaced due their unique electronic and optical performance.

3. Where substitution theoretically would be possible analysis reveals in most cases that time requirements and costs of replacements are unbearable.

3. Major Concern Regarding the REACH/CLP Process

Competitiveness & Innovation II:

4. An inappropriate CLP classification of GaAs and InP damages Europe's compound semiconductor markets without any realistic perspective for successful substitution (cf. RoHS).

5. An inappropriate CLP classification of GaAs and InP threatens the sustainability of the European compound semiconductor supply chain:
    - Depriving Europe of a key technology
    - Enhancing Europe's dependency on technology imports
    - Damaging Europe's ability to innovate in telecommunication and photonics
    - Damaging Europe's competitiveness in telecommunication and photonic industry

4. CLP Downstream Consequences

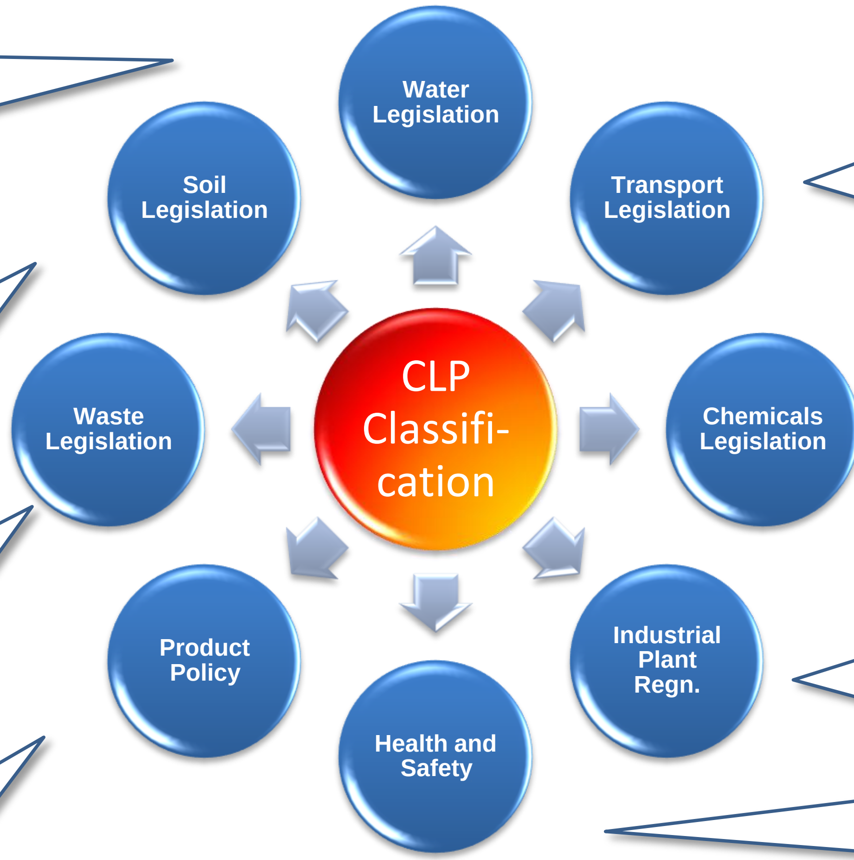
In General: Control of Community legislation in various areas !!

- Sewage
- Handling of Aquatic Toxic Substances

- Remedial Obligations
- Examination Values
- Action Values

- Waste Catalogues
- Product Waste Legsln.
- Export/ Import Control

- Restrictions / Bans
- Integrtd. Product Policy
- Consumer Protection
- BRITE / EURAM



- Dangerous Goods
- Road & Railway
- Aviation
- Marine Transport

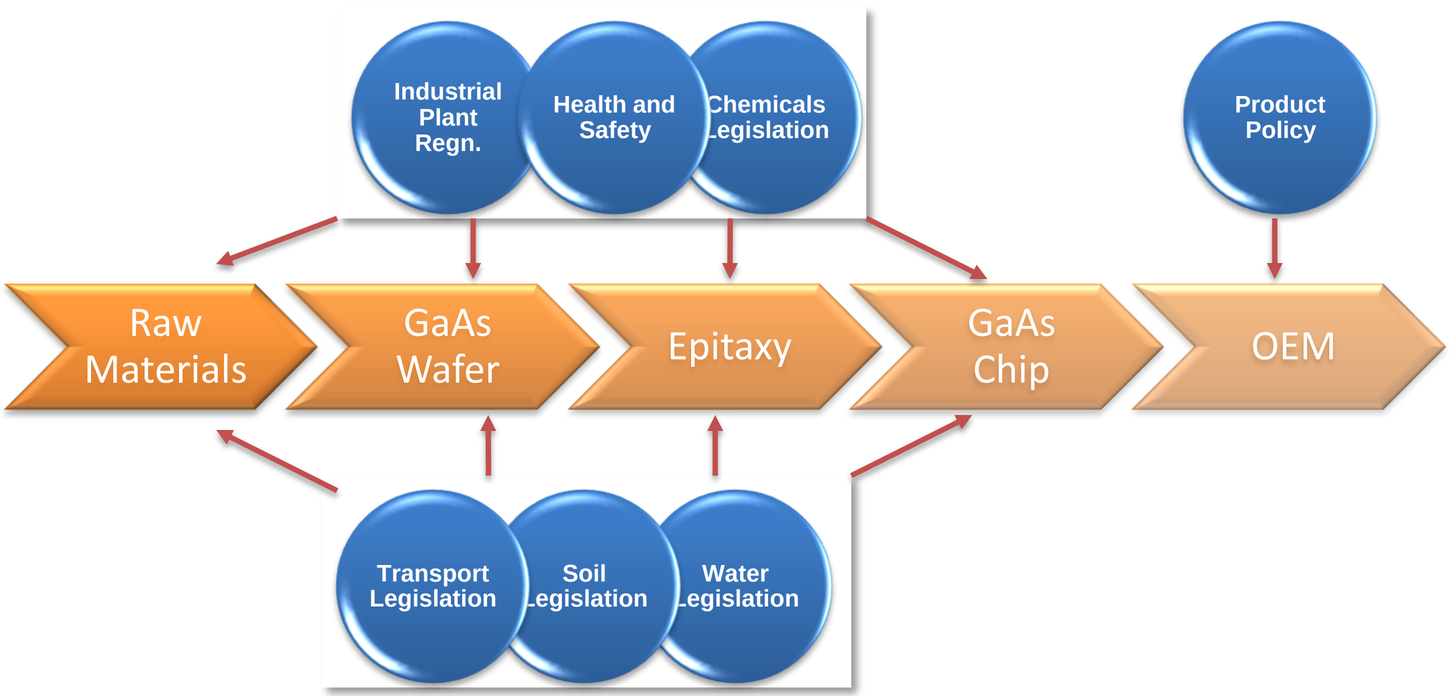
- Test Guidelines
- Risk Assessments
- Registration
- Authorization

- Approvals
- Seveso Directive
- Imm- / Emission Lmts.
- Environmtl. Impact Ass.

- Occuptnl. Expsr. Lmts.
- Exposure & Risk Ass.
- Safety Measures
- Storage

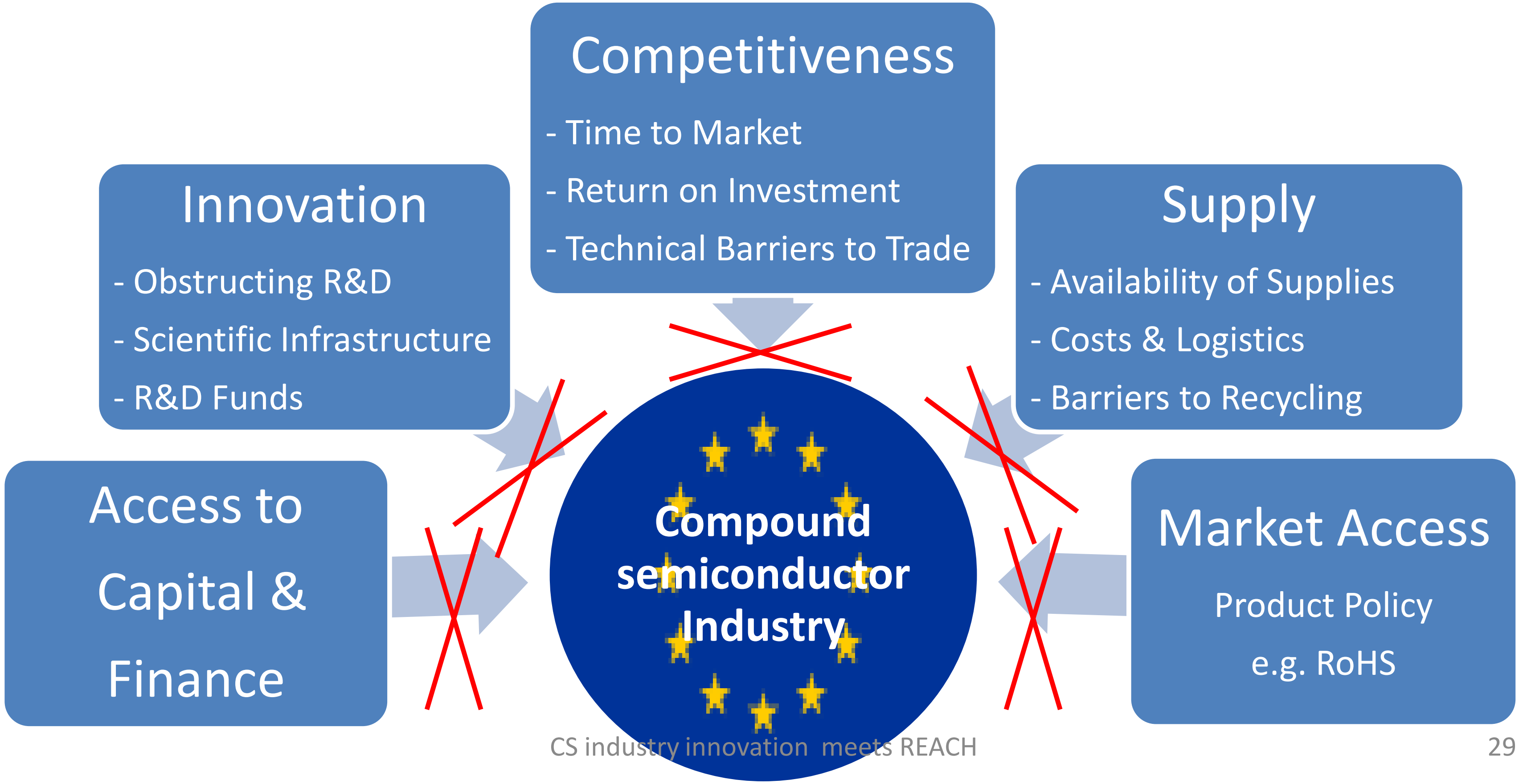
4. CLP Downstream Consequences

Relevance to the Production of GaAs Wafers and GaAs Based Devices:



5. Threads to Europe's Competitiveness & Ability to Innovate: Case Study GaAs

The CLP Classification of GaAs must be based on clear weight of scientific evidence. Incorrect classification will hamper European's High Tech innovation and competitiveness :



6. Summary and Conclusions

- The CLP classification of GaAs proposed by RAC in 2010 is **NOT** supported by toxicological evidence.

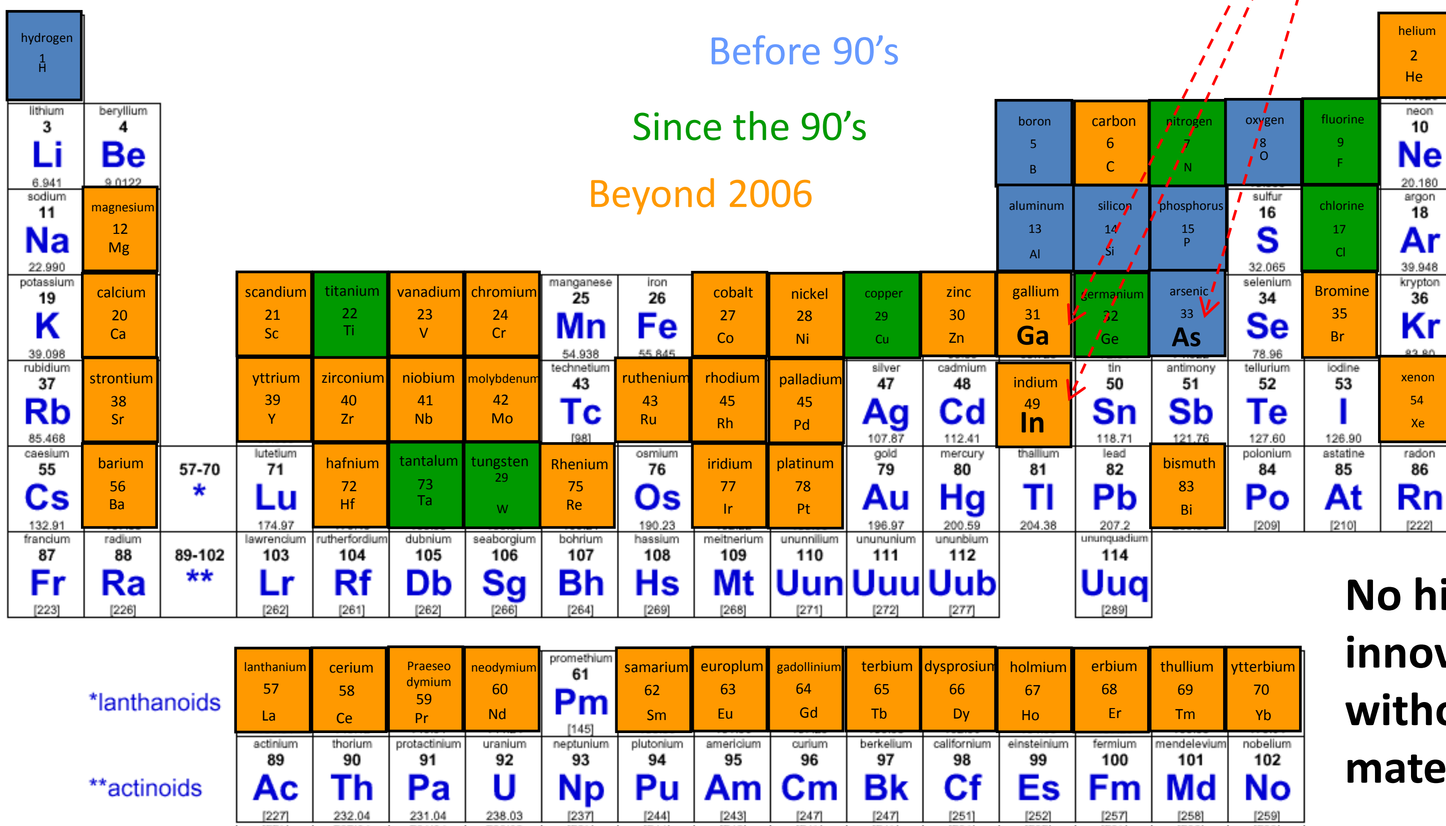
- An inappropriate CLP classification of GaAs will damage European Industry as there is no realistic scope for substitution of GaAs in the key applications:
  - Affecting Europe’s automotive, telecommunication, power, optical, renewable energy industries
  - Threatening Europe‘s ability to innovate, competitiveness and technical education
  - Threatening Europe‘s technological progress
  - Threatening Europe‘s global technical leadership and market share

- We advocate for an unbiased and open scientific re-evaluation of carcinogenicity and fertility of GaAs by ECHA/RAC this September.

7. Backup

Material science is an enabler for the innovation. Accomplishments in the last recent years are based on the use of rare earth and III-V materials.

III-V materials pushing innovation and technology significantly !



No high tech innovation without critical material use!