EUROPEAN COMMISSION

Community research

MORGAN

Materials for Robust Gallium Nitride

24 European partners – Total Cost 13.9ME – Funding 9.2ME

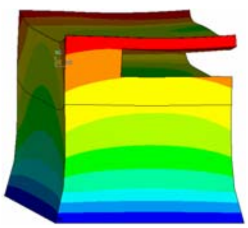
Objectives

- Development of sensor and RF transistor materials, processing and packaging for harsh environments, *e.g.* high temperature and high electric field
- Combining the properties of gallium nitride and diamond promises world-beating materials for new applications and environments
- MORGaN will develop:
  - Innovative diamond-based composite substrates
  - Nanocrystalline diamond coatings for passivation and heat removal
  - Low stress and low defect density GaN films
  - Growth optimisation of InAlN/GaN heterostructures
  - Nitrides with high thermal and chemical stability
  - Packaging, interconnect and metallisation techniques.

Impact

- Strategic materials for European industry
- Improved devices for high power applications and harsh thermal or chemical environments:
  - Sensors in very high temperature environments (>500°C)
  - Aggressive wet chemical sensors for pH >15
  - Solid-state components compatible with 1kW power emission around 2GHz
- Key applications areas include:
  - Space and aerospace
  - Oil industry
  - Power generation
  - Automotive.

III-V materials



MORGaN will directly explore a new $In_xAl_{1-x}N/GaN$ heterostructure developed in the FP6 UltraGaN project. This allows lower intrinsic mechanical stress, minimising material degradation mechanisms. A novel "nano-columns" technique developed at the University of Bath will be used to grow low defect density GaN film.

Using these technologies, MORGaN will develop polycrystalline diamond/Si sandwich hybrid substrates and compliant heterostructures for growing low defect density GaN film, including AlGaN alloys. It will also explore growth optimisation of InAlN/GaN heterostructures for electronic and sensing applications under extreme conditions.

Diamond-based materials

Diamond has the highest thermal conductivity of any solid, with values in high quality CVD diamond of ~2000 $Wm^{-1}K^{-1}$. This makes it potentially the ultimate substrate for many high temperature and extreme power applications.

GaN alloys have demonstrated impressive power handling capability: performing from DC voltage to microwave operation with breakdown fields reaching over 5 $MVcm^{-1}$.

MORGaN aims to develop hybrids combining the excellent thermal behaviour of polycrystalline diamond with the electrical efficiency of GaN compounds. MORGaN will target the full potential of GaN without being limited by the thermal conductivity of GaN, or even SiC.

Harsh environment devices

Industry requires electronics to operate in increasingly harsh environments *e.g.*: extreme heat, pressure, large electric fields or chemically aggressive substances.

Moreover, high power electronics generates internal harsh environments as a consequence of power dissipation from large current flow at high bias.

MORGaN will develop new semiconductor materials which are stable, especially at high temperature, and substrate and package combinations that enable rapid heat extraction and/or the capability to withstand high temperature. Chemical inertness is also key in highly corrosive environments.

Packaging and metallisation

Packaging & metallisation are essential considerations in extreme environments. Metal contacts must be stable, the package and device must be both thermally compatible and chemically stable. MORGaN will study a III-N material system with polycrystalline diamond-based substrates and nanocrystalline diamond heat spreading layers.

Advanced 3D ceramic packaging and new metallisation techniques based on the emerging technology of $M_{N+1}A_XN$ alloys will also be explored. Furthermore layer techniques may be used to manufacture very complex geometrical structures and MORGaN will develop new ceramics and metal system for high temperature applications.

Consortium

III-V lab ALCATEL-THALES · elementsix ADVANCING DIAMOND · IMPACT COATINGS · MFA · UNIVERSITY OF BATH · AIXTRON · GWENT GROUP · swerea IVF · University of Ulm EBS · EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE · EIÚ · micro GaN · VIVID COMPONENTS · University of Glasgow · Université Joseph Fourier · TU WIEN · fcubic free form fast · iemn · GOOCH & HOUSEGO · THALES

SEVENTH FRAMEWORK PROGRAMME

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