Alliance 4: Electrical Energy

Research axes and facilities

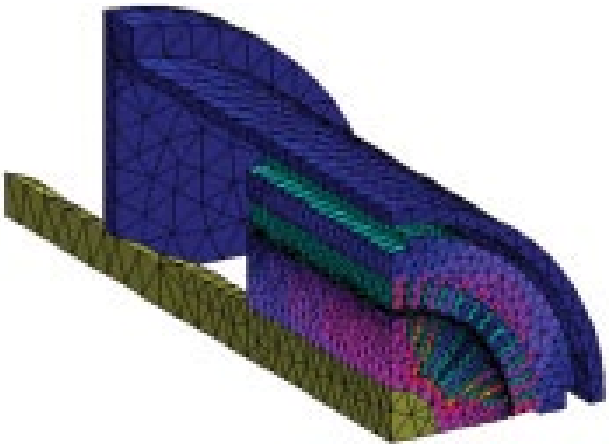
Functional materials are central to the production, conversion and storage of electrical energy. Within today's harsh energy landscape, electricity already plays a major part as a "noble" energy vector. Electricity offers flexibility, efficiency, and easy/simple/discreet end-usage, while avoiding carbon emissions / greenhouse gases at the industrial or domestic appliance level. Today, improved control and management of electricity help increase its efficiency and reliability.

However, the major technological breakthroughs which have established electricity as central to our daily lives and our civilisation are linked to progress in materials for its production and conversion, as well as to its storage which is today its weakest link.

We aim to overcome new technological barriers, by designing components, devices and systems that exploit physical principles and novel materials. Our synergy will involve technological advances developed in LETI & LITEN and by industrial partners.

Actions within LANEF

Magnetism for sustainable energy. Magnetic materials («hard» magnets, «soft» iron alloys) are core to electromechanical conversion systems, and determine their efficiency. NEEL develops new concepts and novel materials, in partnership with industry (ArcelorMittal, Metalor, Toyota…). G2Elab is renowned for its experience in materials integration within components and systems; its software package FLUX (European leader & N°2 worldwide, marketed by CEDRAT), derives from over 30 years of know-how in electromagnetic numerical modelling.



Flux model and measure of the radiated field of an alternator

Exotic materials for novel Energy Systems and Power-MEMS. Magnetocaloric and thermoelectric materials are exploited in pioneering cooling systems and thermal energy converters (ArcelorMittal, Cooltech Applications, McPhy Energy SA, …). Concerning thermoelectric materials, we develop Bi_2Te_3 (p and n type) thin films and nanowires for room temperature applications. The growth of thermoelectrical nanowires inside a nanoporous alumina matrix will be optimized and the physical properties will be studied in the future (Schneider Electric-ADEME).

The «multiferroic» coupling of piezoelectric, magnetostrictive and shape memory materials at the mezzo- and micro-scale is explored in novel actuators, smart energy harvesters and power-MEMS.

Diamond growth for power devices

From hydrogen to electricity. Hydrogen (H_2) is an attractive clean energy vector for distributed stationary power, portable power and transportation applications through electricity production in fuel cells. Research activities conducted at NEEL and INAC, in close collaboration with LITEN and industrial companies (McPhy, Axane, Hélion, Nissan,…) cover the whole "H_2 economy" from materials for H_2 solid storage (recent prototypes already meet the American DOE target for 2015 on capacity, start-up McPhyEnergy, 5 CNRS patents), to materials for membrane-electrode assemblies, fuel cell water management (first *in operando* study on the synchrotron CRG-D2AM line at ESRF in 2010) to prototype fuel cell development.

Green power electronics. Diamond is the «ultimate» semiconductor, exhibiting high breakdown voltage, ultra-fast commutation times with low losses, and superb thermal conductivity. NEEL recently demonstrated 10 kV diamond rectifiers, and the technological challenges of component integration will benefit from G2Elab's 20 years of original research on monolithic and hybrid integration of power electronics for Alstom, Schneider, Renault, PSA…

Key figures:

- **Permanent scientists from INAC, LNCMI, NEEL, G2ELab**
- **60 PhD students and postdocs**
- **Strong collaborations withTsukuba, Tver State University, Sao Paulo University**
- **R&D and industry: LETI, LITEN, ArcelorMittal, Schneider-Electric, CEDRAT, Metalor, Cooltech Applications, McPhy, Toyota, Axane, Helion, Nissan**
- **An average of 8 patents per year**

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