CALL 2010

Project profile

HEECS

High efficiency electronic cooking systems

Microwave ovens are now based on bulky magnetrons that have reached their limits of performance and energy efficiency while occupying a relatively large space. Furthermore, there are currently no energy labels used in the market for these appliances. While current standards provide a helpful comparative test protocol, they do not allow for a full spectrum of efficiency measurements, representative of realistic use scenarios. The ENIAC JU project HEECS is addressing the operational specifications of electronic cooking systems to improve their efficiency and define a complete set of European standards.

Sub Programme

- Nanoelectronics for energy efficiency
- Design methods and tools for nanoelectronics
- Silicon process and integration for nanoelectronics
- Equipment, material, processing for nanoelectronics

In Europe, microwave ovens consume currently some 12.8 TWh of energy a year. They generate heat using the radio frequency (RF) radiation of a magnetron, a rather old-fashioned method which consumes a lot of energy with relatively poor efficiency – around 40% to 50% or less, depending on food type and product design. The ENIAC JU project HEECS is focusing on innovative technologies to reduce energy consumption of domestic microwave ovens by 25%. Such an improvement would therefore save more than 3.2 TWh a year.

Green and modular

HEECS will take a green and modular approach. Modularity involves splitting the microwave system into different modules – patch aerial, RF hybrid power board and transistors, RF signal conditioning board, thermal and packaging modules – and focusing on increasing the energy efficiency of each element. The approach will be green because it will ensure that each module is improved and consequently the system as a whole is more efficient than the current magnetron technology.

One major issue affecting current microwave efficiency is the strongly fluctuating load on the magnetron microwave source. This is a function of the type, volume and location of the food within the microwave cavity. To handle the enormous load fluctuations, the microwave source is heavily over dimensioned. In addition, the path to the microwave cavity is very susceptible to energy losses. To overcome these drawbacks, the HEECS project team will investigate the adoption of multiple solid-state amplifier silicon based components and generators units with several aerials, each with its individual signal control.

A revolutionary approach

Breakthrough technologies in the HEECS project will include:

1. New and improved semiconductor process technologies, devices and integrated circuits featuring

submicron lithographic dimensions and layer stack control;
2. An improved thermal management system capable of efficiently cooling the RF circuit package and making use of the dissipated heat energy in an efficient way;
3. Intelligent electromagnetic field controllers optimising the microwave energy transfer to the food and the energy distribution within the food that will use monolithic microwave integrated circuits and dedicated microcontrollers in high-end integration technologies; and
4. Optimised configuration and systems architecture delivering optimum efficiency of the hardware, firmware and software components – such as aerial, RF transistor, RF emission drive control and packaging modules.

By achieving and integrating these four main technical objectives, HEECS will improve the energy efficiency of future microwave ovens and dramatically change the entire concept for the better. It will migrate from a traditional magnetron source to an innovative silicon-based solid-state RF system using optimised silicon-based solid-state components, dedicated aerials and the RF dissipation – waste energy – for convective and other food-heating techniques, such as steam heating or direct infrared radiation.

Advanced devices

The ENIAC JU project will investigate a new way to focus electromagnetic field intensity and to enhance power distribution to the food by means of monolithic microwave integrated circuits. Improvements in overall efficiency will be obtained by improved impedance matching for each heating operation. Integrated circuits will be studied to manage the control of multiple RF power amplifiers.

New wide-band materials systems, such as gallium nitride (GaN) technology, will be explored and new devices will be produced to benefit from the enormous performance potential of GaN in terms of power density and efficiency as well as its excellent thermal properties due to the use of silicon carbide substrates. With this work, the peak power added efficiency is expected to rise from a current 50% to above 60%, reducing the wasted power by 20%.

New standards/markets

The primary aim of the ENIAC JU project HEECS is to combine synergetically the skills and experience of leading European specialists to address the operational specifications of electronic cooking systems with much improved energy efficiency and to establish a complete set of European standards. This will in turn open up marketing opportunities on a worldwide scale and reinforce the leading role of European domestic appliance manufacturers.

Many other applications could also benefit from HEECS technologies. These could include: pharmaceuticals preparation; plasma lighting; drying cereal grains and powders; improved base station technology for mobile phones; and low cost, high power solid-state scanning radar.

Energy efficiency

Partners:

- Bergh Hybrid Circuits
- Chalmers University of Technology
- ComHeat Microwave
- Delft University of Technology
- NXP Semiconductors Netherlands
- Plextek
- University of Padua
- Warsaw University of Technology
- Whirlpool Europe
- Whirlpool Sweden

Project co-ordinator:

- Fredrik Hallgren, Whirlpool Sweden

Key project dates:

- Start: March 2011
- Finish: February 2014

Countries involved:

- Italy
- The Netherlands
- Poland
- Sweden
- United Kingdom

Total budget:

- €4.99 million

Details correct at time of print but subject to possible change. Updates will be included in the project summary at the end of the project.

The ENIAC Joint Undertaking, set up in February 2008, co-ordinates European nanoelectronics research activities through competitive calls for proposals. It takes public-private partnerships to the next level, bringing together the ENIAC member states, the European Commission and AENEAS, the association of R&D actors in this field, to foster growth and reinforce sustainable European competitiveness.

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