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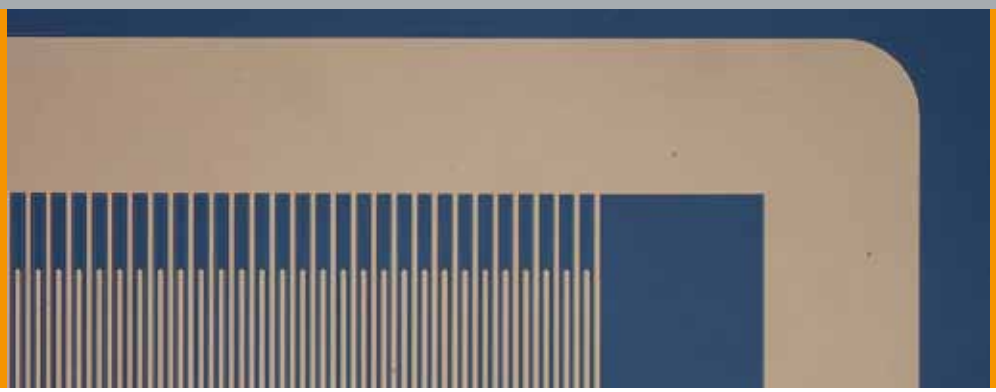

# Programme Inter Carnot Fraunhofer
# ARTEMIS
## Antenna aRrays for TErahertz Material Identification and Security applications


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### The challenge: Terahertz for standoff identification

For civil security applications, Terahertz (THz) technique has unique features: hazardous substances like explosives and drugs can be detected from a safe distance (standoff identification). In ARTEMIS terahertz time domain spectroscopy (THz-TDS) is the most promising approach because this technique covers a spectral range reaching from 1 to 3 THz in which almost all hazardous substances have significant absorptions and where the effects of the scattering of clothing and absorption of water vapour are acceptable. THz technologies have experienced rapid progress during recent years towards a mature technique for off-line applications. For standoff identification, however, high power THz emitters and highly sensitive THz detectors are required which are currently not available.

### Our vision: Powerful emitters, sensitive detectors

To overcome this currently existing lack, ARTEMIS proposes the realization of emitter and detector arrays based on 3 different types of antennas. The characteristic of each single element is well known, but their combination opens new perspectives. More than a simple geometric arrangement of individual elements, these arrays are an integration of highly efficient Near InfraRed (NIR) focusing optics (e.g., micro lens array) and THz collecting optics with corresponding integrated electronics for the detector array. Both performance and costs of the components must fulfil the market requirements. The novel optical design of the arrays increases the performance and the competitiveness of THz technique, enabling it to remotely identify explosives in real time.


**Our innovation:**
**Arrays combining 16 LTG-GaAs PCS**

ARTEMIS focuses on design, fabrication and testing of arrays of low temperature grown (LTG)-GaAs photoconductive switches (PCS) to get powerful THz emitters and sensitive THz detectors. In the first step, the single antenna is the simplest and best known design for pulsed THz generation or/and detection: stripline (SA) and dipole antenna (DA) and Horn antenna (HA).
Going to arrays, for an SA, the number of THz sources in the array is determined by the number of foci between the electrodes. The number of elements of the DA array is limited to 16. For continous waves (CW) applications, HA are well known, but for pulsed applications they need to be redesigned before a single HA can be mulitplied to an array of elements. This step forward permits concentration on the optical aspects that are non-standard: how to illuminate 16 or more PCS simultaneously with efficiency? The fabrication of PCS is realized on an LTG-GaAs layer, on a Si GaAs substrate and in a further step with a LTG-GaAs layer on High Resistive (HR) Si substrate. The demonstration of THz arrays on Si is a significant breakthrough, because low-cost large diameter HR Si wafers are standard in microelectronics. More antenna arrays of larger area are then possible, resulting in reduction of cost. There are also some technological advantages of Si: it has a higher thermal conductivity, less loss and dispersion for the higher part of the THz band and it is also less brittle than GaAs.

**Our know-how:**
**From epitaxy to system design**

The innovation chain goes from the realization of the LTG-GaAs photoconductive switches on HR Si substrates up to simplified but performant electronics to achieve an acceptable signal-to-noise ratio (SNR), through efficient pumping optics (e.g., micro lenses) and outcoupling mechanisms (e.g., antireflection coating or Si lens). Improved THz emitters and detectors are achieved when the semiconductor chips with the antenna structure is combined with the corresponding electronics and optics. Without these components the arrays cannot be used effectively. These complete arrays can be exploited either as independent arrays in laboratories or as part of an innovative measurement system. ARTEMIS covers a wide spectrum of transverse knowledge:

- Powerful emitter arrays and highly sensitive detector arrays
- LTG-GaAs antenna on Si GaAs substrate
- LTG-GaAs antenna on HR Si substrate
- Low cost and performance optimized electronics for controlling antenna arrays
- Highly efficient NIR pump optics and THz out- and incoupling optics.

Due to these results, the data acquisition time and system price can be reduced significantly. Both have a positive effect on the industrial acceptance of this novel technique for security applications and non destructive testing.

**Our advantage:**
**Synergic partners at your service**

Fraunhofer IPM is a specialist in integration of optics, electronics and mechanics to an industrial grade. Whereas, IEMN has an excellent reputation in epitaxy, growing of semiconductor material for THz and manufacturing of photoconductive switches.

In ARTEMIS, Fraunhofer IPM and the Institute IEMN aim to design such powerful THz emitter and sensitive THz detector which will increase the performance of standoff to the improvement of civil security. These components will be also interesting for other markets like quality and process control.

This unique complementary allow the creation of tailor-made innovation.

*The project is supported by the German Federal Ministry of Education and Research and by the French National Research Agency in the frame of the Programme Inter Carnot Fraunhofer.*