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IR vision: from chip to image/Vision IR : du composant à l'image

Foreword

Infrared vision is gaining tremendous importance in many fields of human activities. It displays indeed a certain amount of specificities which make infrared imaging a strategic technology, such as:

- *night vision*: the scene is not illuminated, the blackbody photons being spontaneously emitted by the elements of the scene. There is no need of high power illumination, the observation is passive and thus not easily detectable;
- *observation range*: thanks to Raleigh law, infrared light is less diffused by the atmospheric environment than visible light. Moreover, certain region of the optical spectrum are less absorbed by water vapor than the others, allowing vision through clouds, mist,...;
- *thermal imaging*: following extensions of Planck's law, quantitative measurements of temperature are feasible, leading to a good knowledge of the physical scene.

These specificities are put to work in many different applications:

- *Defense applications*: night vision provides information on day time, as well as night time, tactical activities. It is widely used for Intelligence purposes (aerial reconnaissance) or tactical strikes (IR seeker for cruse missiles),...;
- *Teledetection*: infrared information is used in many satellite programs for agriculture monitoring, meteorology, urbanism studies, pollution control, mining,...;
- *Thermal imaging*: infrared radiometry allows us to extract quantitative information, giving access to a physical understanding of the scene such as local temperature (high power line survey, thermal insulation), emissivity (nature of surfaces),...;
- *Industrial process control* such as glass production, cement control, quality assessment (industrial welding,...).

For all these reasons, infrared imaging is publicly known as a key element of supremacy in modern conflicts, as shown by the latest Kosovo or Iraq crisis. It will play also a major societal role for the control of immigration fluxes across sensitive borders, as well as in many aspects of law re-enforcement. Concerning industrial applications, infrared imaging is spreading in new areas such as microelectronics process, aeronautics,... . New applications have also been recently emerging such as shipwreck rescue, firemen equipment, medical imaging (mammography for instance), high resolution long wavelength astronomy imaging and detection of SARS carriers at airport, for example.

Infrared detectors are key elements in an infrared imaging system: in fact, the device performance is dimensioning the whole infrared imaging system. For this reason, the French Délégation Générale pour l'Armement (DGA) has funding research activities in this field since many years.

Three different and complementary technological families of infrared detectors are available in France nowadays:

- *two quantum technologies*: Mercury Cadmium Telluride (MCT or HgCdTe) and Quantum Well Infrared Photodetectors (QWIPs);
- a *thermal technology* based on microbolometers.

In brief, quantum technologies display high performance, are somewhat delicate to operate (they require cryogenic cooling) and are well adapted to Defense applications. On the other hand, microbolometers display lower performance but are well adapted to commercial applications thanks to room temperature functioning and potential lower price. Depending on the technology, 320×256 or 640×512 staring arrays are now available in France. These technologies are at the industrial level, which places France within the world leaders in the infrared industry together with the USA. These developments are based on upstream research, performed at different research organizations such as CEA/Leti/LIR, Thales TRT; Onera, Celar, CNRS,... New developments on their way in the laboratory include quantum boxes or superlattice photoconductors, Blocked impurity Bands,... for quantum detectors and pyroelectric, MEMS,... for thermal detectors.

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This special issue of the *Compte Rendus Physique* aims at describing the State of the Art in infrared detection research. It consists in the minutes of a workshop entitled

Journée Scientifique de l'ONERA
Vision infrarouge : du composant au système

held in Chatillon on 7 April 2003, under the auspices of ONERA (French Aerospace Research Establishment) and the *Académie des Sciences*. This meeting has gathered the main actors in the French infrared detector field. A second workshop will take place in 2004 dedicated to infrared imaging systems.

The talks given at this Conference reflect the different aspects of today's research:

- Different figures of merit (FOM) are commonly used to compare the performances between infrared detector technologies: such figures of merits (detectivity D^*, noise equivalent power NEP,...) are briefly recalled in the first paper by *E. Rosencher* (*Onera*). These FOMs allow one also to define the frontiers of infrared performance and to define new roads for performance enhancement in each technology. One has to note, however, that infrared imaging is a very subtle field where complex considerations tend to blur the clear-cut view given by classical FOMs (D^*, NETD,...) such as $1:f$ noise, available bandwith, acoustic noise due to cooler vibration, autonomy, spatial fluctuations, read-out electronics noise, cost, availability,... Clearly a new formalism will have to be developped in the near future, allowing more relevent figures of merit to be defined.
- The talk given by *J.L. Tissot* (from *Ulis*) describes the latest developments in uncooled thermal detector arrays, using the amorphous silicon micro-bolometres, confirming the potential of this technology in the 8–12 µm range.
- *E. Costard* and *Ph. Bois* (from *Thales*) describes the latest developments in quantum well infrared photoconductor (*QWIP*) technology, which opens the way to extremely large infrared detector arrays, multispectral detection. They describe the particular progress obtained in the enhancement of the BLIP temperature in these devices.
- B. Vinter (from *Thales*) and V. Berger (*Université Paris VII*) report on the progress in *uncooled* quantum detectors using antimonide alloys (InGaSb based) in the 3 to 5 µm region, where quantum electron and photon engineering might allow an enhancement of BLIP tempertures and decent detectivities to be obtained at room temperature.
- The potential of quantum dot infrared detectors are described by *Ph. Boucaud* and *S. Sauvage* from *IEF*. The advantages of this technology could be the enhancement of BLIP temperature due to an increase of the excited photoelectron lifetime, as well as a better optical coupling with incident infrared light due to the quantization of the transverse motion of the electrons in the quantum dots.
- Mercury Cadmium Telluride (HgCdTe) material potential is then described by *G Destefanis*, from *LETI/Lir* showing that large uniform wafers can be realized now, allowing large and reproducible devices to be processed in the 3 to 5 µm range. Recent advances in the 8 to 12 µm range are also presented, as well as the potential in multispectral imaging.
- Finally, the HgCdTe technology latest status is described by *Ph. Tribolet* (*SOFRADIR*).

One of the main evolutions of the infrared detector area in the last few years has been the development of huge arrays, which allow a high definition infrared image to be obtained. This has given rise to new kinds of characterization tools taking into account the small size of the devices, their proximity, their large numbers and their complexity. This will be developped in the following papers:

- Technological characterization of infrared devices by *P. Burgaud et al.* from Celar;
- Characterization and modeling of infrared devices by *P. Castelein et al.* from *LETI/Slir*;
- New methods of characterization based on non diffracting optics by *N. Guerineau et al.* from *ONERA*.

We hope that this special issue will be a good background of the present status and future development in infrared detectors.

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