Summary Report on the R&D on Terahertz Technology in Europe

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NICT Europe Center

R&D on Terahertz Technology in Europe

R&D on Terahertz Technology in EU

In Europe, R&D projects for Terahertz are supported by the European Union (EU) in the issue 3 "Components, system, engineering" regarding micro-electronics and photonics, and issue 8 and 9 as "Future and Emerging Technologies" (FET).
We can see the terminology "Terahertz (THz)" from the Working Program 2009-2010 for ICT, which means the increase of the interests in THz.

Under the 7th Framework Program (FP7), there are many research projects on THz:

- TERACOMP: Quantum Cascade Laser (QCL) for THz frequency coms.
- ULTRAPHASE: Ultra high speed quantum physics.
- Lighter: THz spectroscopy (Max-Planck Institute for Polymer Research)
- THzPowerElectronics: Semi-conductor transistor (Ferdinand-Braun-Institut).
- GRADE: Graphene field effect transistors and graphene base transistors.
- iPHOS: Wireless technology in the sub-terahertz wave range.
- DOTFIVE, DOTSEVEN: SiGe HBTs technology for 500GHz and 700GHz.
- INSIDDE: Terahertz camera for non-destructive inspection on arts.
- TERASCREEN, XP-DITE, IMSK: Body-scanning technology by using terahertz or millimeter waves.

R&D on Terahertz Technology in Europe

Aid by the funding agencies

UK: Engineering and Physical Sciences Research Council (EPSRC)

France: French National Research Agency (ANR)

Germany: Deutche Forschungsgemeinschaft (DFG)
Federal Ministry of Education and Research (BMBF)

- Millilink project supported by BMBF
  - Research by Fraunhofer IAF (Applied Solid State Physics), Karlsruhe Institute of technology (KIT), Siemens, Kathrein, etc.
  - Object: Seamless communications between radio wave and broadband optical communications.
  - Develops ultra-small electro circuits enabling large capacity of data transfer in 200GHz-280GHz.
  - Successful data transfer with 40Gbit/s in 240GHz between high buildings with a distance of 1km in May 2013.
  - Successful data transfer with 100Gbit/s in 237.5GHz in the research facilities with a distance of 20m in Oct 2013.

(Source : KIT)

R&D on Terahertz Technology in Europe

R&D by the research institutes (UK)

UK: R&D by 16 universities, 5 national institutes and 13 companies (in 2012)

- National Physical Laboratory (NPL)
  - Detecting THz, imaging, biological and medical application.
- Imperial College London established the "Centre for Terahertz Science and Engineering" (CTSE) in Feb 2012 for integrating separated R&D activities on THz into one research center.
  - R&D of new materials & electromagnetic characterization for THz applications.
  - R&D of passive components & active devices, based on advanced functional materials and micro/nano-fabrication processing technologies.
  - Exploration of new applications in telecommunication and electromagnetic sensing for bioengineering, security and defense applications.
  - Interdisciplinary education & training in electromagnetic material characterization, millimeter-wave and THz engineering, device/circuit simulation and metrology.
- TeraView (private company)
  - Developing & selling generators & detectors of THz, R&D on THz application.
  - For security, medicine, automobile, solar panel, medical, non invasive inspection of paintings and books by hand-manuscript.

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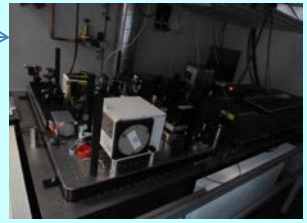
R&D by the research institutes (Germany)

Germany:

- German Federal Institute of Physics and Technology (PTB)
  - R&D on detecting THz.
  - Standardization on the power, attenuation and impedance up to 110GHz.
  - Established “Terahertz Communications Lab” with the Technical University of Braunschweig. R&D on the future needs of wireless bandwidth.
- Ferdinand-Braun-Institut (FBH)
  - In the field of microwave technology and optoelectronics.
  - R&D on imaging and wireless communications for 300-500GHz.

- Max-Planck Institute for Polymer Research
  - R&D on spectroscopy.
  - R&D on THz sensing and combination of optical & THz.



- Fraunhofer IAF and KIT
  - Millilink project (already explained in the previous page).

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R&D by the research institutes (France & Belgium)

France:

- Ecole Polytechnique: Laboratory for Optics & Biosciences
  - R&D on biological imaging using THz.
- Université Paris Diderot-Paris7: Laboratoire Matériaux et Phénomènes Quantiques
  - R&D on cascade laser, generation & detection of THz, integration of THz technology & telecommunications technology.
- Université Montpellier II
  - Established GDR 2987 “Semiconductor sources and detectors of THz frequencies”.
- Université Bordeaux 1: Laboratoire Ondes et Matière d'Aquitaine
  - R&D on source of radiation of THz, THz imaging, spectroscopy, especially Time-Domain Terahertz Spectroscopy (THz-TDS) for 150GHz – 4THz.
- CEA-LETI
  - R&D on THz imaging as well as infrared, visible light, ultra-red, millimeter wave and X-ray.

Belgium:

- IMEC (Interuniversity Microelectronics Centre)
- ETRO (Dept. of Electronics and Informatics) in the Vrije Universiteit Brussel
  - Jointly established “Brussels Integrated Sensor Laboratory” (BISENS) for integrated sensor for millimeter waves and THz (30GHz-3THz).

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Information from the face-to-face Interview

Q: What is the definition of THz?

- Most researchers answered 100GHz-10THz. However, only one researcher answered 300GHz-3THz.

Q: What is the advantage and disadvantage of THz in comparison with Millimeter wave or Infrared?

- Advantage: bandwidth, resolution.
- Disadvantage: available power, free-space attenuation, signal-to-noise ratio, technological problems.
- Advantage: Transparency and resolution is contradictory. Infrared is high resolution but low transparency. Millimeter wave is high transparency but low resolution. THz is in between and well balanced.

Q: What is the strong point for European research on THz?

- The promoting power is universities, small companies and spin-off companies in Europe.
- Most funding is from ministries for R&D. There are many applications for citizens, not for military defenses.
- R&D on THz is not related with military purposes. Europe is strong for fundamental physics using THz radiation, including astronomy & ultra high speed optoelectronics. Europe is strong for sensing & metrology.
- Time Domain Spectroscopy, Quantum Cascade Laser, Body scanner (100-500GHz), Space (such as ESA).

Q: What applications of THz are expected for communications technology?

- THz is useful for pico-cell and I will use it for data center. Currently, back side of the server rack is occupied with a lot of optical fiber networks. However, I will replace them by wireless using THz. THz is useful for short distance. I will realize Tera-bit class between server racks and it will be used by Google, E-bay or Amazon. However, they do not finance for research but they will buy if I realize a good application. THz is also useful for portable data kiosk for downloading films & DVDs.