

Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
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Lab web site	www.iemn.fr
Polytech name	Polytech Lille
University name	University of Lille
Country	France

PhD information	
Title	Wireless communications at THz frequencies for backhauling in beyond 5G cellular networks
Main topics regards to CSC list (3 topics at maximum)	Wireless communications, advanced semiconductor devices

Required skills in science and engineering	Electrical engineering, High frequencies
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Subject description (two pages maximum)

From the connected society data usage, the market is pulling the wireless data-rates. Since 10 years, researchers have made significant efforts to reach the required technological breakthrough towards wireless communications at high data-rates. This continuously growing demand on data rates has driven the carrier frequencies to be extended up to the THz range, for front and backhaul in cellular communications. Recently, a new standard has been established by the IEEE, emerging from the THz wireless communications research, that has been very intensive these last years. Many technologies offer interesting features for THz communications; among them, the photomixing techniques, directly compatible with fiber-optic back bones, have driven the highest data rates demonstrations so far.

The proposed thesis is in the core activities of the IEMN research group, towards the development of ultra-fast wireless transmissions in the "terahertz" frequency range (1 THz = 1000 GHz). For many years, the IEMN lab has been working on terahertz radiation sources based on photomixers (optical converters from optical waves to THz). These components have been used since 2010 to develop ultra-fast transmission links beyond 200 GHz. The interest of the increase in frequency makes it possible to considerably increase the speeds of data transported, in order to propose in the long term a wireless connectivity to the nomadic users. Recent achievements of the group can be found in the references hereafter.

Beyond the component aspects, the main telecommunication challenges in these frequency ranges are both related to the interconnection of these components, to the study of the THz transmission channel, the dimensioning of the complete system in relation to the intended application (indoor, inter-buildings, outdoor for point-to-point communications). Also, the experimental evaluation of the environmental effects (rain, dust, fog) on the propagation is of great importance for the development of these systems.

More specifically, the thesis will be carried out around several activities whose aims are experimental and include field-trial demonstrations. Based on advanced core components developed in the IEMN, the main goal of the thesis will be to demonstrate state-of-the art THz links with innovative approaches, that could include the following items; directly close to the subject:

- Components design and characterizations up to the THz range
- Realization of THz transmission / reception system at 300 GHz for the measurement of channel impulse responses ($h(t)$), study of the associated channel, as well as MIMO (Multiple In, Multiple Out) in the 300 GHz band.
- Development of THz beam coupling optics, these lenses or mirrors being associated with the antennas.

- Study of propagation to THz ranges for SISO outdoor propagation (Single In, Single Out), influence of the environment (measurements in climate chambers: controlled atmosphere, humidity, dust).
- Study of the THz channel in indoor propagation: aspects of multi-path multi-path paths and associated interferences.
- Realization of THz telecommunications demonstrators.

Silicon photonics targets the terahertz region, Nature Photonics News and Views, G. Ducournau, <https://doi.org/10.1038/s41566-018-0242-0>, Sept. 2018

Single-channel 100 Gbit/s transmission using III–V UTC-PDs for future IEEE 802.15. 3d wireless links in the 300 GHz band, V. Chinni, ..., G. Ducournau, Electronics Letters 54 (10), 638-640, 2018

10-Gb/s Indoor THz Communications Using Industrial Si Photonics Technology, E Lacombe, ..., G. Ducournau; IEEE Microwave and Wireless Components Letters 28 (4), 362-364, 2018

J Ma, NJ Karl, S Bretin, G Ducournau, DM Mittleman, "Frequency-division multiplexer and demultiplexer for terahertz wireless links", Nature communications 8 (1), 729, 2017.

T Nagatsuma, G Ducournau, CC Renaud, « Advances in terahertz communications accelerated by photonics", Nature Photonics 10, 371–379 (2016) doi:10.1038/nphoton.2016.65, 2016.

Other references can be found on the Google Scholar page of Professor G. Ducournau:

https://scholar.google.com/citations?hl=fr&user=D8t_KToAAAAJ&view_op=list_works&cstart=0&pagesize=20