Tesi di Laurea Magistrale

Terahertz confocal microscopy with a quantum cascade laser source

Summary

The recent advances in generation, manipulation and detection of Terahertz (THz) radiation have been accompanied by a growing interest in the application of THz technologies to a wide range of fields spanning from imaging, remote sensing and security controls, to spectroscopy and biomedical science.

An appealing reason for developing photonic techniques in this frequency range is the capability for THz rays to penetrate common packaging materials (paper, plastic, wood, ceramics).

The recent invention of quantum cascade lasers (QCL) emitting at THz frequencies is enabling a major step forward in THz imaging technologies thanks to the availability of a powerful, compact, solid-state, laser source. Once combined with bolometer array camera detectors, they have allowed the first systems for stand-off THz image acquisition operating in real time up to distances of more than twenty meters.

On the other side, there are also great expectations for THz microscopy, especially as a potential diagnostic tool in quality inspection of various industrial productions or in molecular biology at the cell level. Yet, this research direction is just in its infancy, with most works focusing on near-field techniques.

In the present thesis work, I focused instead on trying to transfer the principle of optical confocal microscopy to the THz, by implementing the first confocal imaging system based on a QCL, in this case emitting at ~ 3 THz. The confocal spatial filtering can sensibly reduce the depth of field of the microscope, as well as improve its resolution and contrast, making it very useful for inspection of close-by surfaces, where different planes have to be clearly distinguished, or where a depth information is crucial.

The use of a QCL source required various preparatory tests and measurements, to assess the emission beam quality and to choose the best option for the spatial filter. In order to reduce the emitting area and improving the profile regularity, hollow metallic waveguide couplers and pinholes were examined. The waveguides were also fully characterized in terms of propagation and coupling losses to QCLs in different configurations, proving that very low-loss modes can be efficiently excited, an interesting result for the future development of THz endoscopes.

The definitive confocal setup was finally assembled and characterized in terms of lateral and axial resolution and several images of test objects were collected in order to show the excellent performance of the instrument realized.

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