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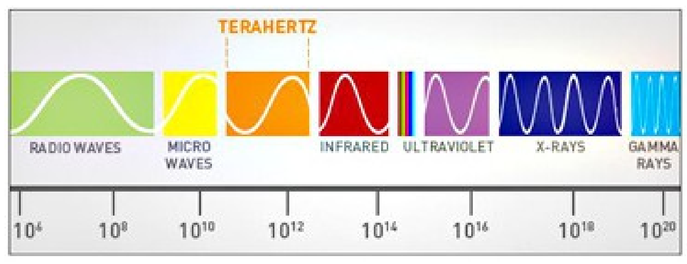
XXX Cycle - II year presentation

Compressive Sampling (CS) - Terahertz Technology (THz)

Compressive Sampling (CS) is a new acquition strategy capable of digitizing the input signal directly in a compressed form, acquiring only a reduced number of samples, but sufficient to successively reconstruct the input signal by means of suitable algotihms (CVX, L1-Magic, Greedy). **CS permits to overcome the limitations of Nyquist-Shannon theorem** as **(i)** it's impossible to reconstruct a signal if it will be acquired one-sidedly, **(ii)** time of acquisition will be very long if signals have infinite length.

Terahertz Technology (THz) is an electromagnetic radiation in frequency range (0.1–10 THz) , that can deeply penetrate many non conducting materials, is non ionizing and **allows contactless and non-destructive analysis** of the materials under investigation by study of their "fingerprint" via spectroscopic measurements.



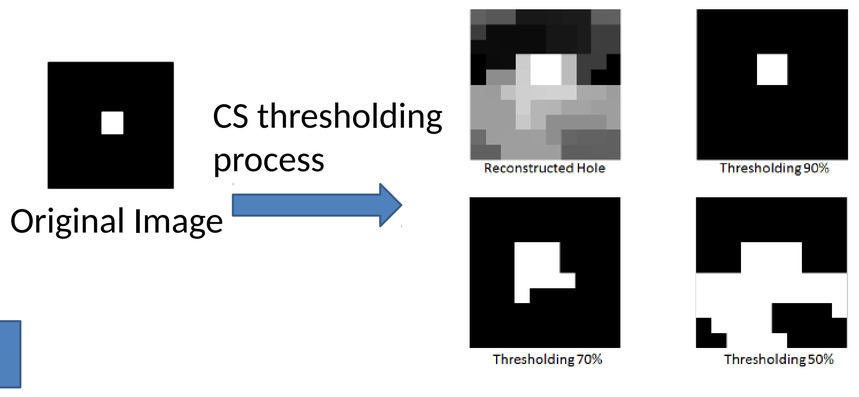
In the second year, CS approach has been applied to THz Imaging, in order to reduce the time duration of defect detection through non-invasive tests. [1] A performance assessment, then, has been conducted for evaluating the granted performance in dependence on different parameters affecting the measurement process when it is experimentally carried out. At this aim a proper quality index has been selected. In general, it is possible to distinguish between **Pixel Difference Measurements** and **Human Visual Based Measurements**.

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[X(i,j) - Y(i,j)]^2$$

Mean Square Error: is a Pixel Difference Measurements estimating the quality of an image by performing the pixel-to-pixel difference between the reconstructed image and the reference one.

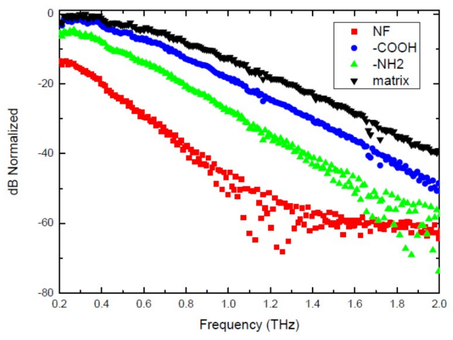
$$SSIM\,(X,Y) = \frac{(2\mu_X\mu_Y + C_1)(2\sigma_{XY} + C_2)}{(\mu^2{}_X + \mu^2{}_Y + C_1)(\sigma^2{}_X + \sigma^2{}_Y + C_2)}$$

Structural SIMilarity index (SSIM): is a Human Visual Based Measurements using human perception as a reference, taking into account parameters that can change the perception of an image as brightness, contrast, texture, orientation.

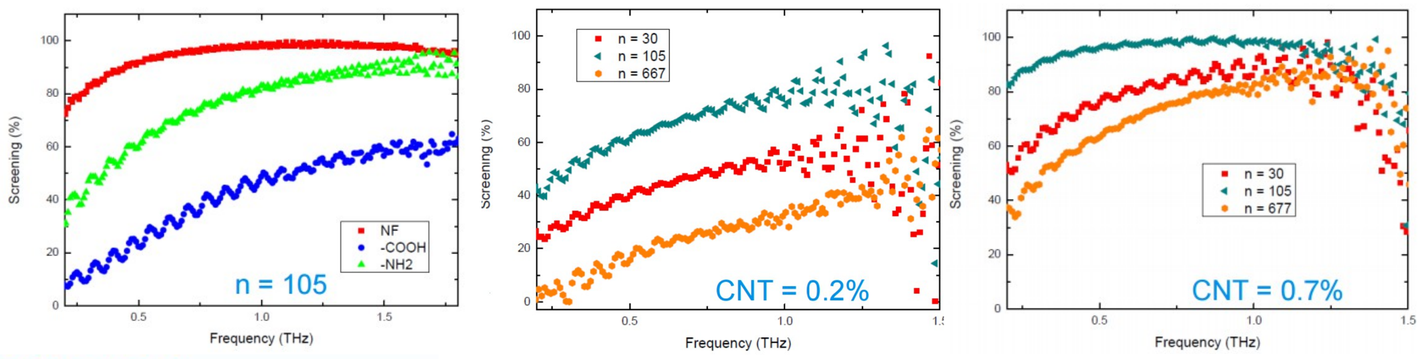


Terahertz Applications

Spectroscopy and imaging are the main applications of THz technology, because of the excellent properties. In fact, T-waves can excite vibrational and rotational modes in many molecules, giving rise to absorption peaks in the electromagnetic response. Recently, spectroscopy based on THz radiation has been intensively investigated, thanks to its "dual-use" capability of being exploited in many different fields. [2]



MWCNT supplied by Nanocyl S.A., pristine (NF) and functionalized with amino groups (-NH2), or carboxyl groups (-COOH).



Commercially available Multiwalled Carbon Nanotubes (MWCNT) composites with different functionalisation, volume concentration, and aspect ratio n (L/D)

Screening is defined as: $\left|\frac{T_{MWCNT} - T_{Matrix}}{T_{Matrix}}\right|$

Composite materials containing carbon nanotubes show good EMI shielding effectiveness and are good candidates for cost-effective, highly-flexible, biodegradable manufacturing. Surprisingly, nanocomposites filled with CNT having very high aspect ratio show very poor screening performance, in spite of the fact that large n values promotes the formation of conducting paths.

Pristine and poorly dispersed nanotubes in the matrix (showing on average both the highest number and the largest size of agglomerates) produces more scattering and therefore an increased interaction between the nanocomposite medium and the e.m. wave

[1] *Quality Analysis of reconstructed images with CS-THz process* submitted to ITEE I2MTC2017

[2] *Performance and metrological characteristics of THz systems for dual use applications*

Contacts

- **Università degli studi di Cassino e Lazio meridionale**
- **STMicroelectronics**

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Future activity

Applications of Compressive Sampling for eddy current testing techniques. In the last years, the effort of the research is been focused on the development of eddy current measurement procedures capable of providing as much information as possible about the presence, the location and the geometrical characteristics of defects.