【様式４】

“Technical Research and Development for Improving Quality of Road Policy”
Summary of the Study

No.	Theme	Representative of Researchers
No.22-4	Research Development for the defect inspection of road constructions implemented with sophisticated ultra-high frequency electromagnetic waves	Tohoku Univ. Prof.Oyama

In order to realize the improved safety of road constructions, highly sophisticated new non-destructive inspection method by using ultra-high frequency electromagnetic waves will be developed, and its applicable conditions and limitations will be also clarified. For these purposes, various kinds of concrete test constructions were formed and our original terahertz imaging will be carried out.

1. Background and Object

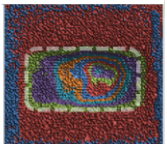
Terahertz (THz) wave frequency locates between light and electromagnetic wave, and its frequency is ranging 10^{12}Hz, which is about 100 and 1000 times higher than that used for present mobile phones. Recently, we can successfully realized compact and practical THz light sources and its application fields are extended widely. It has been shown that THz light has many advantages over IR and visible light like high transmittance for cement concrete materials, safety for human tissues, high reflectance for metals and large absorption coefficient for water. On the basis of THz wave advantages, we proposed the THz wave application for safe and efficient inspection means of road construction defects. THz research has been getting started in very recent years, thus the material database in road construction field has not been well established in THz frequency region. In our research, THz material data base will be established in the road construction field and then artificially made defects contained samples will be measured by THz imaging system.

2. Activity in Research Period

The main objective of this research is to develop the novel non-destructive defect inspection means for road constructios. For this purpose, not-used THz waves are applied to realize the efficient defect inspection means on the basis of those high transmittance and safe for human tissues. Under the basic measured data for road constructions, artificially made defect contained sample concrete materials will be imaged by THz scanner. THz imaging scanner is constructed with movable light source/detector unit with high power THz light source. After construction of THz scanner, artificially made defects embedded in concrete blocks will be measured, and then the possibility and limitation of THz imaging against the road constructions will be investigated.

3. Result

Concrete thickness 30mm



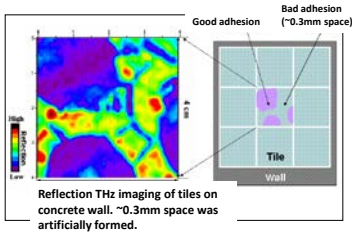
THz imaging of corroded iron bar construction embedded in concrete blocks. Concrete thickness over iron bars is 30mm. Dotted line area is corresponding to the corroded area.

Before embedding in the concrete

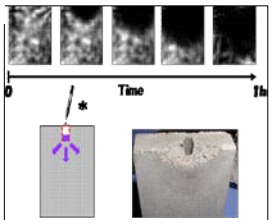
Iron bar constructions. Area indicated by dotted line is the seriously corroded region

When the concrete thickness over embedded metal construction is below 40mm, corroded region of embedded iron bars were successfully recognized by THz imaging scanner. However, when the concrete thickness is over 50mm, embedded corroded region cannot be seen by the present THz imaging system.

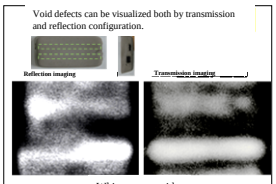
THz imaging successfully visualized the various defects in concrete blocks. For example, void in concrete, water diffusion into concrete and adhesion failure area recognition of ceramics tiles on concrete wall were shown.



Reflection THz imaging of tiles on concrete wall. ~0.3mm space was artificially formed.



A set of THz images for water diffusion into concrete block. Black area is corresponding to the water diffused area.



0.12THz imaging of artificially made voids in concrete block.

4. Papers for Presentation

Journal papers

THz application for non-destruction inspection (in Japanese), Nihon kougyou publication, Test instruments, 18(5), (2013), 1-5] Seiya Takahashi、Yutaka Oyama

Observation of damage in insulated copper cables by THz imaging, NDT & E International, Volume 61, January 2014, Pages 75-79, Seiya Takahashi, Tomoyuki Hamano, Kaori Nakajima, Tadao Tanabe, Yutaka Oyama

Academic meeting presentation (International)

SUB-TERAHERTZ INSPECTION OF DEFECTS IN BUILDING BLOCKS, Yutaka Oyama* and Kyosuke Saito, First International Conference on Advances in Structural Health Management and Composite Structures (ASHMCS2012) 28-31, Aug. 2012, Chonbuk National University (CBNU) in Jeonju, Jeonbuk, South Korea.

Hikari Dezaki, Tadao Tanabe、Yutaka Oyama, Joint Symposium on Materials Science and Engineering 2011, Nanyang Technological University Singapore, 2011.6.18, Material science and technology as a basis for device realization for THz, Oral

Hidetaka Kariya,Sato、Tadao Tanabe、Kyosuke Saito、Nishihara,Taniyama、Yutaka Oyama, Honolulu Prime 2012_The Electrochemical Society, Hawaii Convention Center and the Hilton Hawaiian Village, 2012.10.7~10.12, Non-Destructive Evaluation for Evaluation for Corroded Metal Surface Using Terahertz Wave, Poster

Hidetaka Karia, Kyosuke Saito、Yamagata、Tadao Tanabe、Yutaka Oyama, Honolulu Prime 2012_The Electrochemical Society, Hawaii Convention Center and the Hilton Hawaiian Village, 2012.10.7~10.12, Application to Non-Destructive Inspection of Copper Corrosion via Coherent Terahertz Light Sources , Poster

5. Practice of the Study and Future Subject

The present research results cannot be limited within the concrete road construction inspection only, but can be also applicable for the defect inspection of metal corrosion and degradation embedded in the non-polar materials like woods and polymers. For example, outer sustaining steel cable, which is embedded in PE polymer, can be clearly inspected without peeling of PE. Under the superior features of THz waves like high transmittance for polymer and high reflectivity from metal, highly efficient and novel inspection means can be expected as one of the killer application of THz waves.

6. Contribution to Improving Quality of Road Policy

At present, THz method cannot be practically applied because of its limitation of size and transmittance. Instruments have to be also improved for practical test. Thus, further basic research has to be developed for future practical test. However, present research has clearly demonstrated the possibility for novel and quite new inspection means for road defect inspection. In that means, it is considered that the contribution of the present research is quite high.

7. Reference Website

http://www.material.tohoku.ac.jp/~denko/lab.html