36 Developing hybrid mechanoluminescence materials for visualization of structural health

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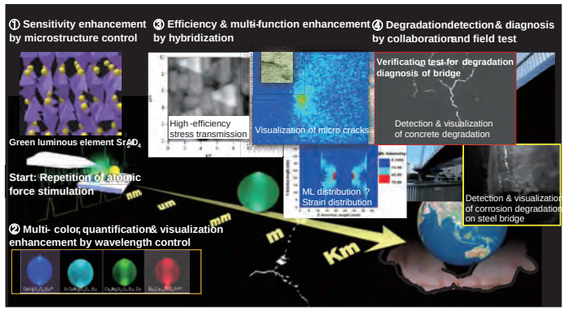
R&D Objectives and Subjects

Objectives

- We develop novel mechanoluminescence (ML) materials for nondestructive inspection of structural degradation and damage by visualization of the stress/strain distribution. The novel ML materials have a unique property that the ML intensity increased quantitatively with the stress/strain change, and such a property can be employed to quantitatively evaluate degradation distribution and status at the same time for efficient inspection and repair.
- We develop ultrasensitive ML materials for a direct view of the micro-cracks and degradation in the structures, such as welded areas, etc., in steel bridges, even without removal of the surface paints/films. The preventive detection of fatigue cracks and preventive repair can ensure effective maintenance.

Subjects

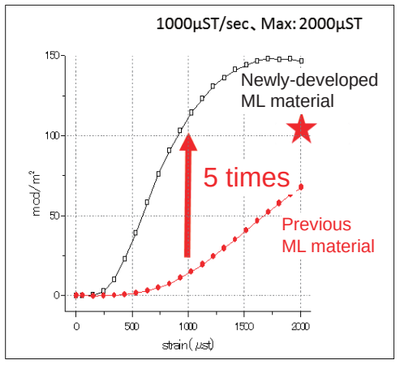
- Development of ultrasensitive ML materials for effective visualization of structural degradation, stress/strain concentration and cracks
- Development of hybrid materials for quantitative analysis of degradation/damage degrees
- Implementation of the field verification test of developed technology aiming to use during the periodic inspections of infrastructures (highways, etc.)



Current Accomplishments (1/2)

Ultrasensitive ML materials for visualization of the invisible fatigue micro-cracks

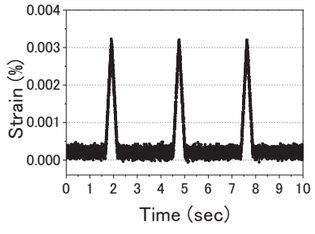
- We developed a new ultra-bright and sensitive ML material, which can emit higher than 100 mcd/m^2 to a small strain of 0.1%
- Using the newly-developed ultrasensitive ML materials, effective visualization of fatigue micro-cracks could be achieved with 0.003% strain variation.
- Under the same experimental condition, the newly-developed ML material enhanced the ML to 5 times compared to the previous materials.



- Detected cracks which used to be invisible

(A) Before test

(B) Test by 0.003% strain variation



(C) During test

(A) Metal specimens coated with current (top) and SIP newly-developed ultrasensitive ML sensors (bottom).
(B) Strain curves of the test with maximum strain of 0.003% are used to simulate vehicles passing by on a highway.
(C) ML image of micro-cracks during the vibration – cracks can be clearly seen by the new sensor, whereas they cannot be seen by the previous sensor.

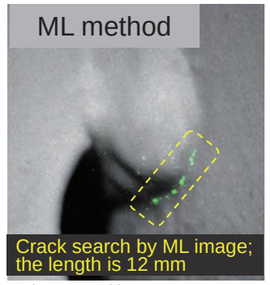
Current Accomplishments (2/2)

Newly-developed ML materials toward efficient, low-cost and labor-saving maintenance

- Field test of newly developed ML method was carried out on the steel welding joints with paint cracks occurring at highway bridges, without the removal of the anticorrosion paint to search if fatigue cracks had occurred or not.
- After the ML test, conventional magnetic testing (MT) was carried out to confirm the reliability of inspection results of the ML method. The result strongly confirmed the reliability and effectiveness of the ML method. Compared to ML, MT is time- and cost-consuming, the pretreatment of paint removal damages the inspected target also.
- SIP newly-developed ultrasensitive ML method was confirmed to be effective to search for cracks and visualize stress/strain concentration even without paint removal.
- The maintenance specialists highly appreciated the ML method to be of great merits in both labor and cost saving and to be a practically useful technology to detect fatigue cracks in steel without paint removal, to evaluate repair status, and to visualize stress concentration.

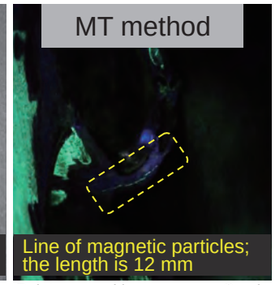
Effective detection and visualization of invisible cracks underneath the anti-corrosion paints

Field demonstration: Fukuoka Urban Expressway



Crack search by ML image; the length is 12 mm

Paint removal is not necessary. ML enables visualizing the crack in the structure underneath the paint.



Line of magnetic particles; the length is 12 mm

Paint removal is necessary. Crack visualization by particles dues to magnetic flux leakage.

A crack was successfully found by the ML method (before paint removal), and was also confirmed by MT method (after paint removal)

Goals

Quantitative targets

- ML performance
  Quantitative analysis of stress/strain concentration, visualization of strain distribution level of 0.01%
- Crack detection sensitivity
  Detection of micro-cracks with depth shallower than 1 mm

Social implementation

- We are developing a business environment on the fatigue crack visualization of steel bridges, effective confirmation of crack repair status, and stress concentration evaluation for repair necessity determination.

The world's first ML technology

Contribution to effective infrastructural maintenance and management

To improve ML materials ・Sensitivity ・Quantitative ・Optimization ・High durability	→	Field verification test for robustness and reliability	→	Standardization, guidelines and user manual preparation	→	Generalization and dissemination of technology

Established the *Mechanoluminescence Technology Consortium* for technology innovation, standardization, generalization.
https://unit.aist.go.jp/kyushu/MLTC/index.html
Contact: mltc-s-ml@aist.go.jp

Implementation and periodical inspection in infrastructures (e.g., steel bridges, highways)