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Signal Accuracy of Terahertz Chemical Microscope for Lung Cancer Cell Detection

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Short Resume

- Yuichi Yoshida was received B. E. degree from Okayama University in 2020.
- Currently, he is a Graduate School of Interdisciplinary and Engineering in Health Systems, Okayama University, Okayama, Japan.
- He is involved in developing terahertz sensing devices and systems for medical diagnosis.

Introduction

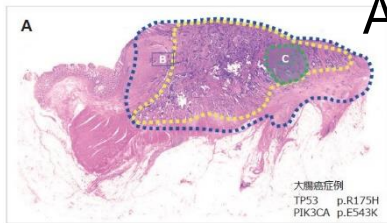
Cancer genomic medicine

Analyzing the cancer genome and providing patients with personalized treatment

Genetic information that differs among individuals

Main protocol of cancer genomic medicine

Tissue test



http://pathology.or.jp/genome_med/pdf/textbook.pdf

Above 30 %



Genome analysis



<https://limo.media/articles/-/8715>



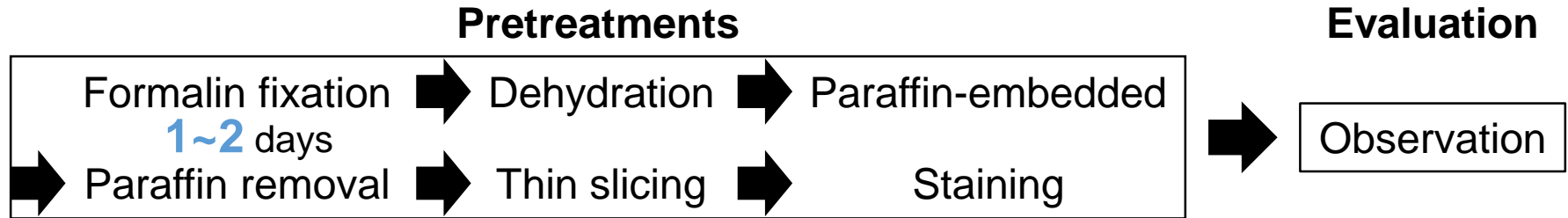
Treatment



Evaluation of the ratio of the number of cancer cells in a tissue is essential.

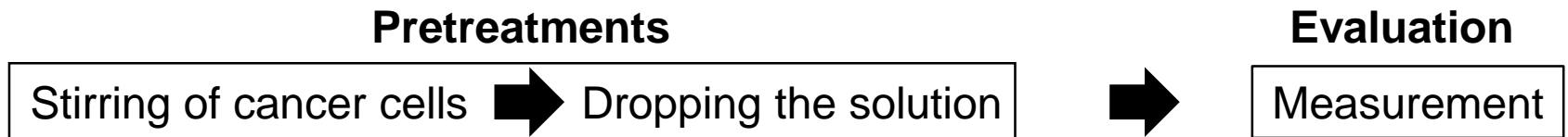
Conventional vs Proposed Method

Conventional method (Formalin-Fixed Paraffin-Embedded : FFPE)



- This process takes **at least 2~3 days**.
- **Evaluation skill is needed** to evaluate the number of cancer cells.

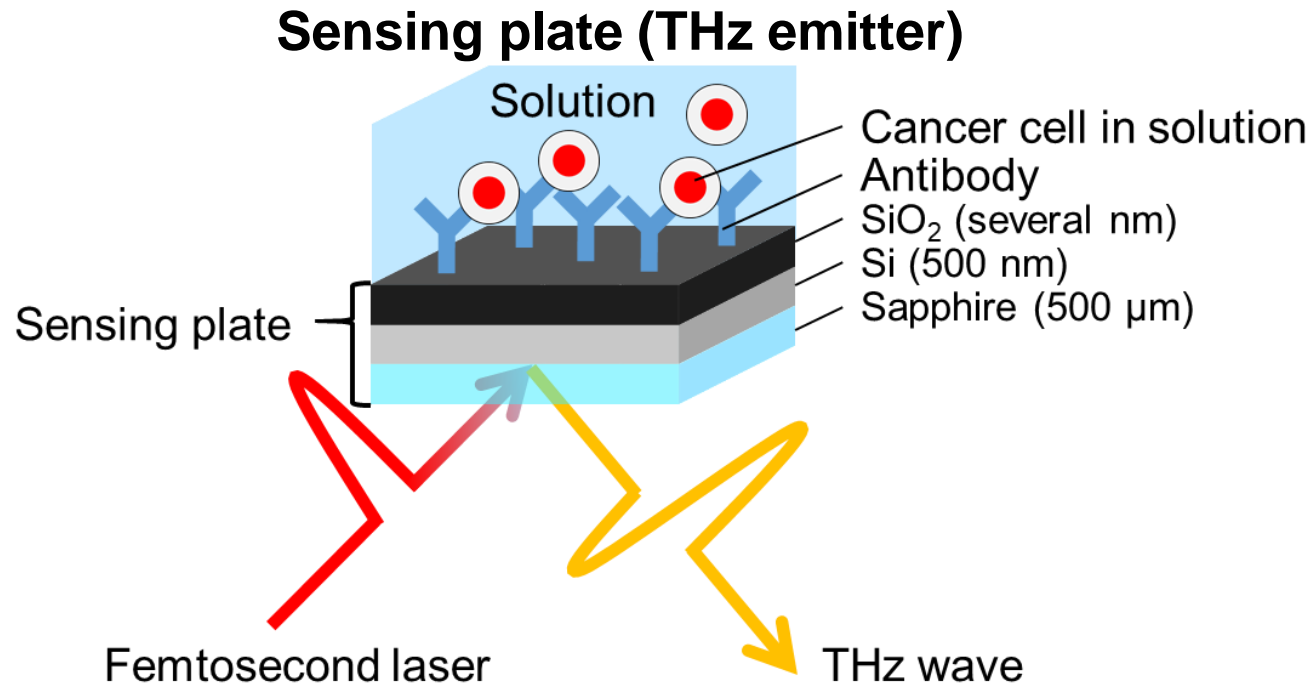
Proposed method (Terahertz Chemical Microscope : TCM)



- This process takes **about 10 min**.
- **No evaluation skill is needed** to evaluate the number of cancer cells.

TCM can be expected **much easier and faster evaluation** than FFPE.

Sensing Plate



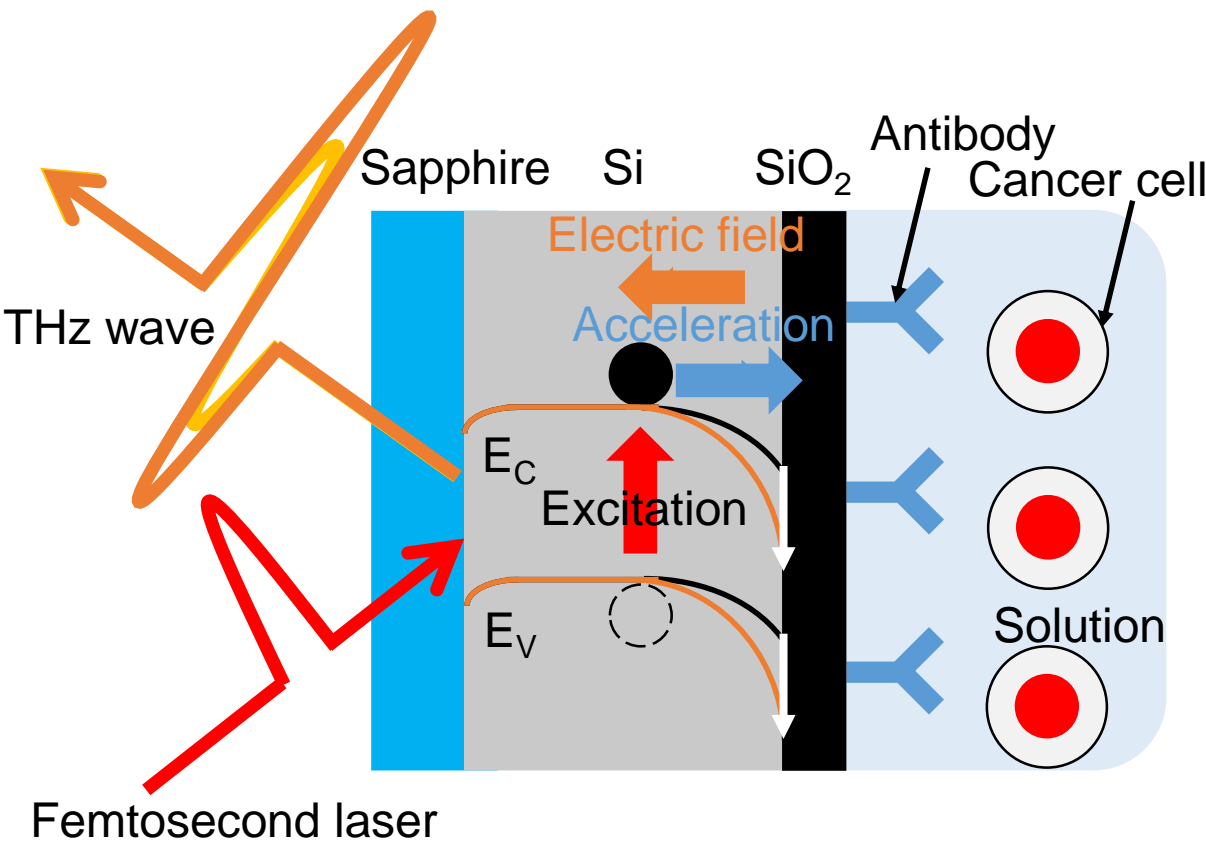
Cancer cells
react with antibodies

Electric potential change
on the sensing plate

**Terahertz amplitude
change**

**TCM can measure cancer cells in solution
on the sensing plate as the change of terahertz amplitude.**

Measurement Principle of Cancer Cell



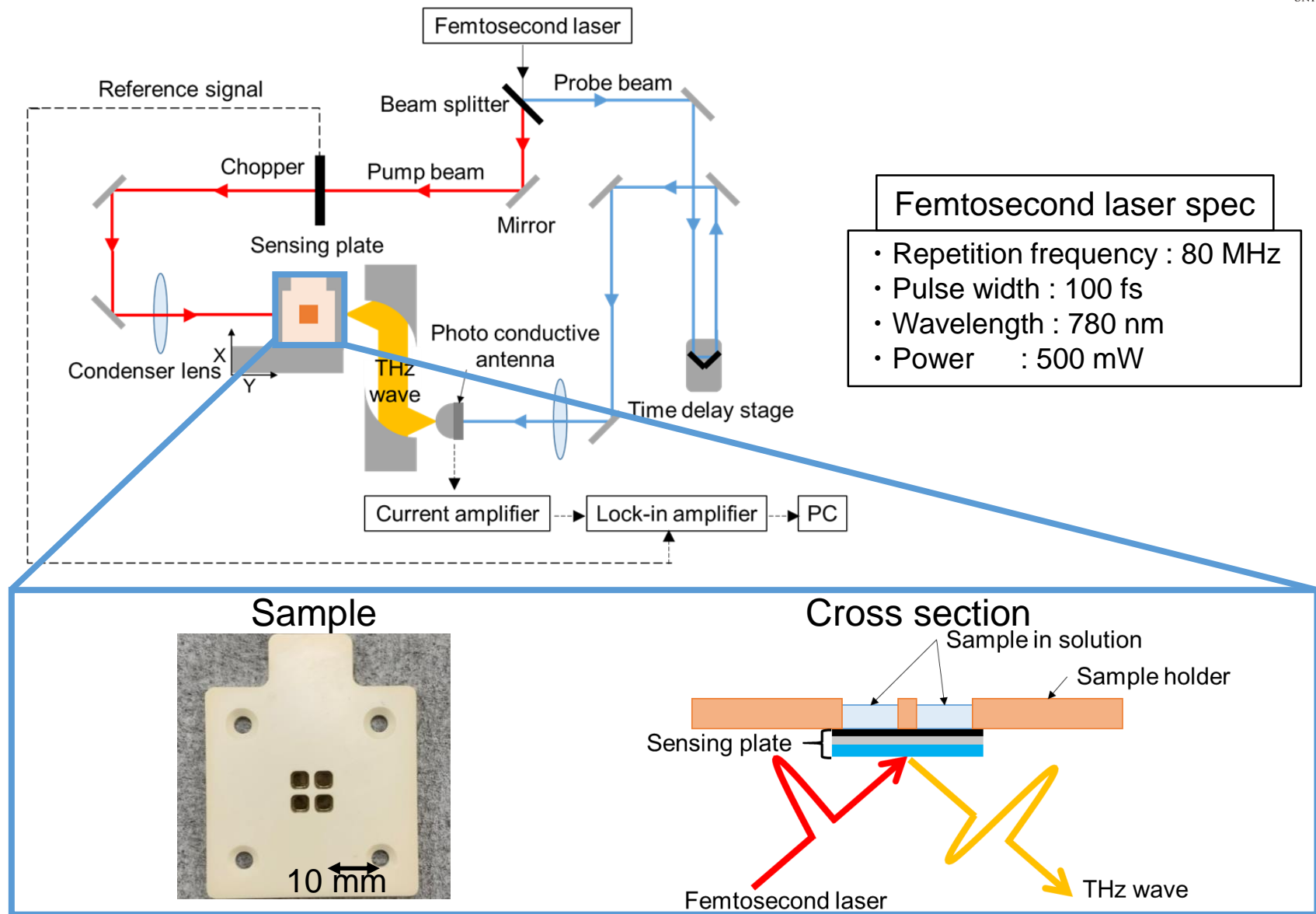
- Antibody is reacted with cancer cell
- Electric potential is changed by the charge of cancer cell
- Electric field is changed by electric potential change
- THz amplitude is changed

$$E_{\text{THz}}(t) \propto \frac{\partial J(t)}{\partial t} \propto e \frac{\partial n(t)}{\partial t} v + en \frac{\partial v(t)}{\partial t}$$

Electric field change

THz amplitude change = The number of cancer cells

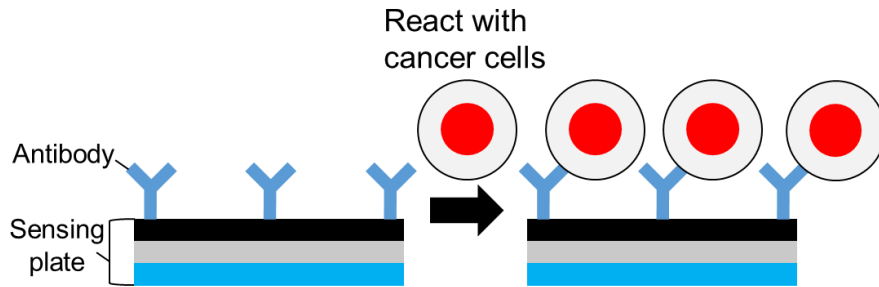
TCM Overview



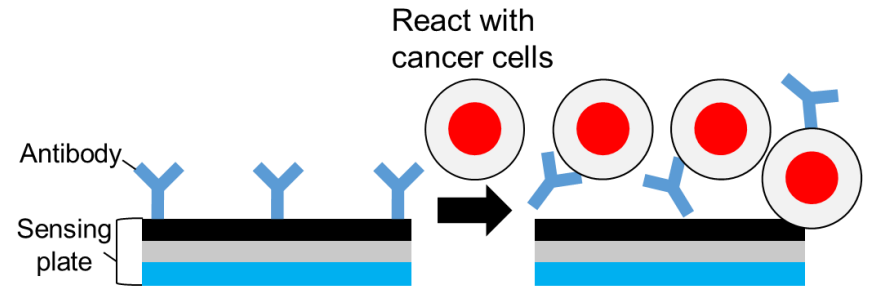
Antibody Immobilization

- Immobilizing antibodies on the sensing plate is essential.
- The accuracy of antibody immobilization has a significant impact on the detection of cancer cells.

Good antibody immobilization



Bad antibody immobilization



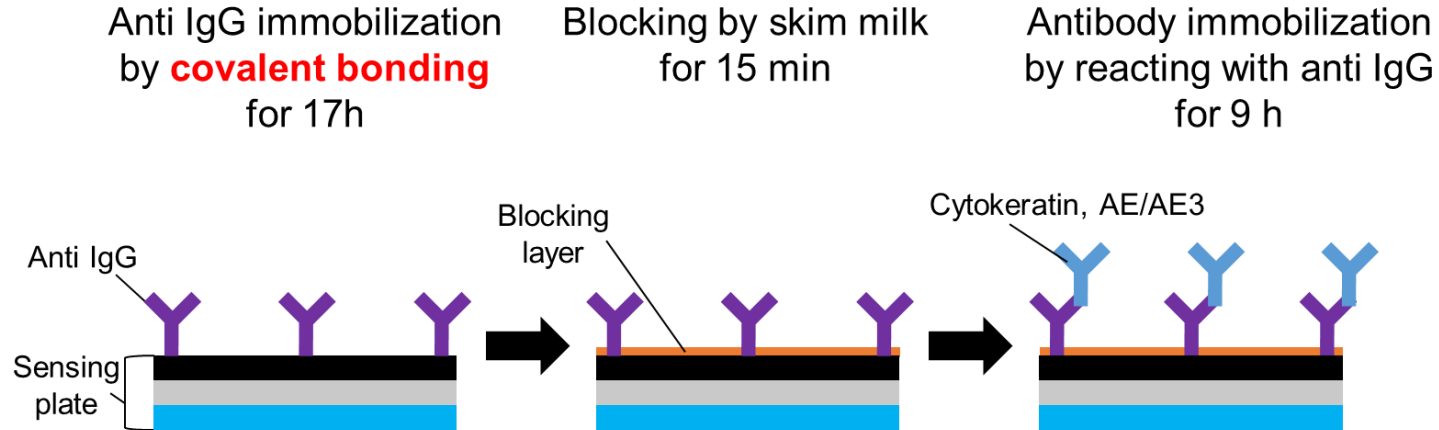
Cancer cells can be detected **accurately**. Cancer cells can be detected **inaccurately**.

In this study

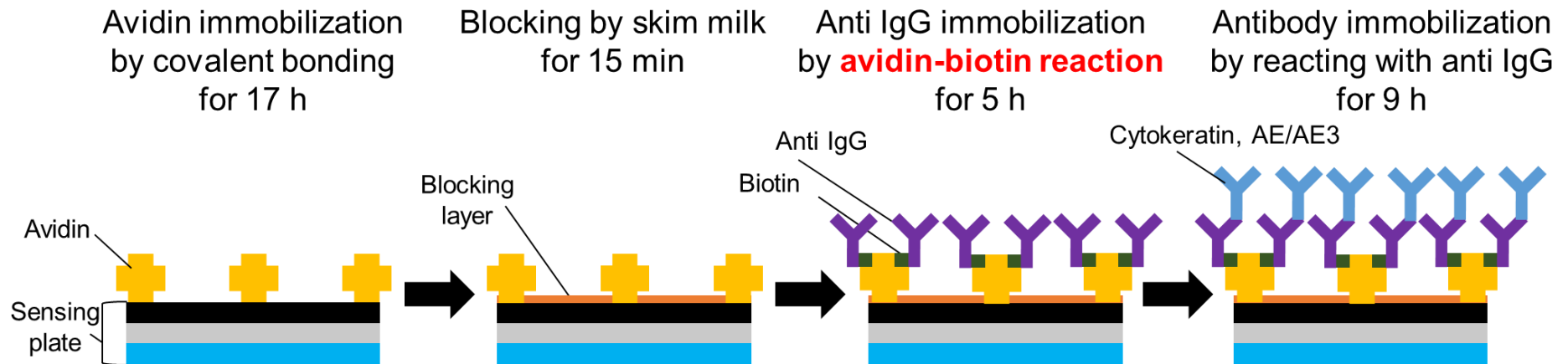
Investigating antibody immobilization method for accurate detection of cancer cell

Process of Immobilizing Antibody

Covalent bonding method (Conventional)



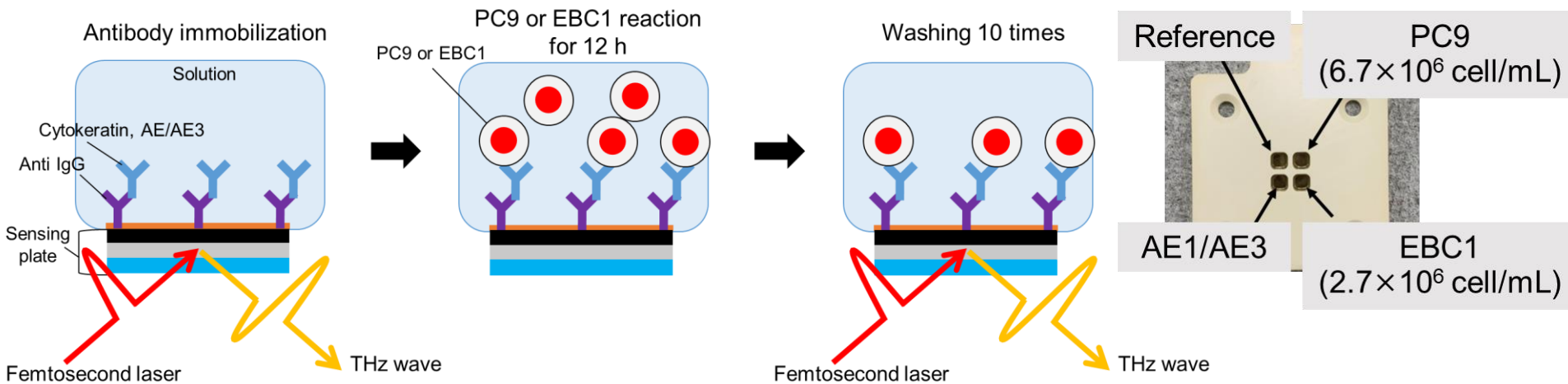
Avidin-biotin reaction method (Proposed)



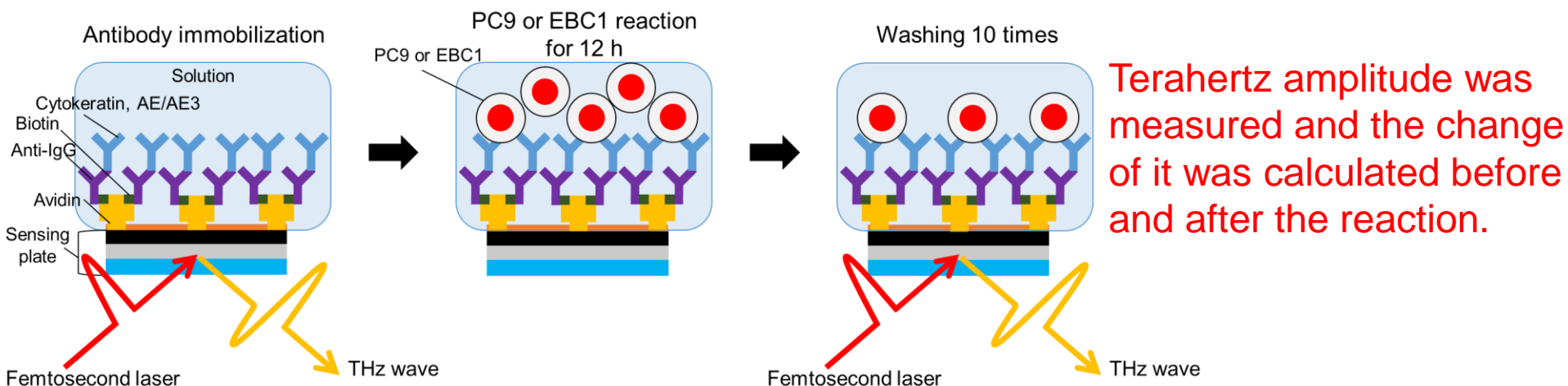
Measurement Method of Lung Cancer Cell

- Antibody : Cytokeratin, AE1/AE3 (This antibody is reacted with adenocarcinoma cell and squamous cell carcinoma cell)
- Target : PC9 (human lung adenocarcinoma cell) , EBC1 (human squamous cell carcinoma cell)

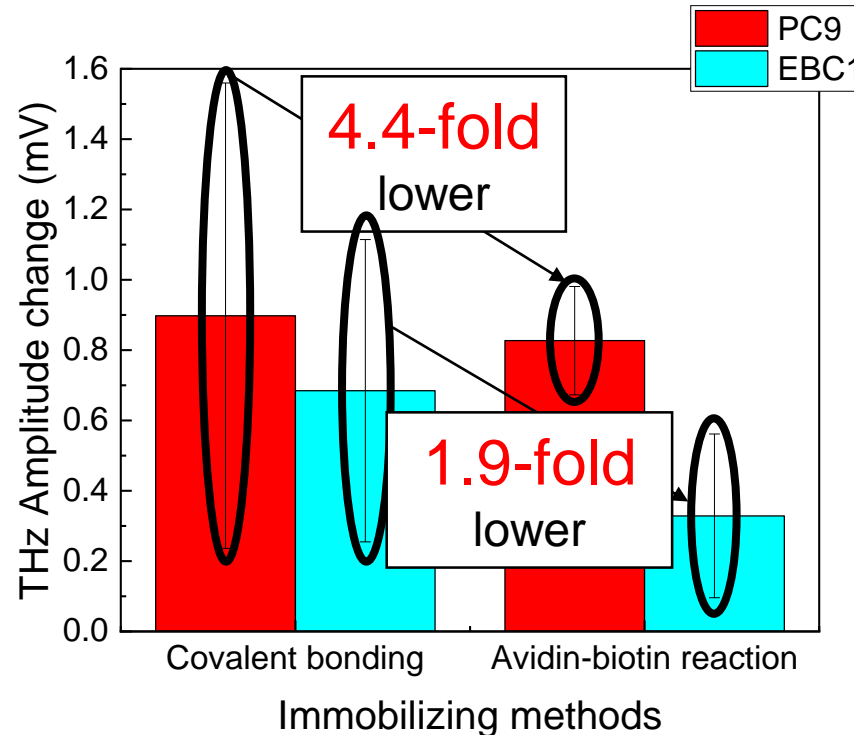
Covalent bonding method (Conventional)



Avidin-biotin reaction method (Proposed)



Covalent Bonding vs Avidin-Biotin Reaction



PC9 and EBC1 could be measured accurately by immobilizing antibody using avidin-biotin reaction.

Summary

- Antibody was immobilized on the sensing plate using covalent bonding and avidin-biotin reaction to measure cancer cells.
- Covalent bonding method and avidin-biotin reaction method were compared by measuring PC9 and EBC1 with TCM.
- In the avidin-biotin reaction, standard deviation of terahertz amplitude was **4.4-fold** lower for measuring PC9 and **1.9-fold** lower for measuring EBC1 than the covalent bonding.
- PC9 and EBC1 could be measured accurately by immobilizing antibody using avidin-biotin reaction.