

# Ion sensing for nano liter level solution by a terahertz chemical microscopy

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## 1. Introduction

There are various ions in our body, such as sodium ion and potassium ion. Breaking of ion balances will lead to serious diseases. Therefore, the sensing systems for ions are required in the medical diagnoses. Conventionally, the distribution of ions is measured by the ion chromatography. However, this system can not separate ions that have similar magnitude of polarities. Our group developed a detection system named THz Chemical Microscope (TCM), which can use the amplitude of THz wave to visualize the chemical potential changes in the water solution. A device named the sensing plate is that the amplitude of radiated THz wave changes if there are chemical reactions on the sensing plate. Ion sensitive membranes are immobilized on the surface of SiO<sub>2</sub> side of THz sensing plate and dropped the ion solution with different concentration, which lead to different amplitude of radiated THz wave. Therefore, ions in solution can be detected by TCM. In this work, we first detected the amplitude of THz wave changes with dropping nano liter level water. From this result, ions can be detected by using several hundred  $\mu\text{m}$  size ion sensitive membrane.

## 2. General Instructions

We used the femtosecond laser pluses to irradiate sensing plate. Photo-excited carries inside the Si layer are generated by the laser pluses from the sapphire layer of THz sensing plate. It generates instantaneous current when the Photo-excited carries are accelerated by the depletion layer electric field. As the result of the carries acceleration, the THz wave proportional to the time derivative of the instantaneous current is radiated. When surface potential changes by the measuring object contacts surface of SiO<sub>2</sub>, the local electric field at depletion layer in the Si layer changes. In this study, sodium ion sensitive membrane was immobilized on the THz sensing plate surface. Different concentration of sodium ion solution was dropped into sodium sensitive membrane. The concentration of sodium ion was varied in the range of  $10^{-4} \sim 10^{-1}$  M. Different concentration of sodium ion lead to changes of surface potential as changes in the intensity of THz wave. In order to detect Multi-ion in the same time, many kinds of ion sensing membrane should be immobilized on the sensing plate. Therefore, small size of ion sensing membranes are necessary. In order to understand how small size of sensitive membrane that the TCM can detect, a Nano size of water droplet which from

32 nL to 16 nL is dropped to the sensing plate. As the laser spot irradiate the water droplet, the amplitude of terahertz wave was changed.

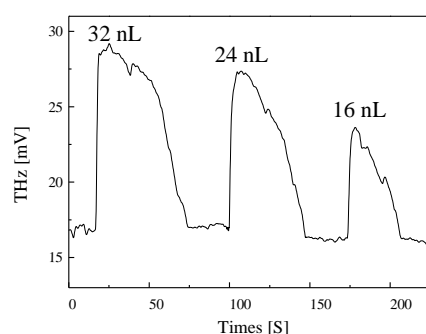


Fig. 1 the amplitude of THz wave with water droplet

There are three peak values in Fig. 1, which represent the amplitude of THz wave when the water droplet 32 nL, 24 nL, and 16 nL is dropped into the sensing plate. It could be obtained from the Fig. 1 that big volume water droplet leads to high amplitude of THz wave. The width of THz wave represents the evaporation time of water droplet. The diameter of water droplet at 16 nL was detected as 300  $\mu\text{m}$ . Therefore, if the ion sensitive membrane, whose size is at least 30  $\mu\text{m}$  is immobilized on the sensing plate, ion also can be detected.

## 3. Conclusions

Water droplet which size is 16 nL, 300  $\mu\text{m}$  can be detected by TCM. Use the same size of ion sensitive membrane, ion also can be detected by TCM theoretically.

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## References

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