COVER PAGE

Project Title: Exploring the effect of thermal energy by the plasmonic photothermal catalyst in hydrogen generation	
Federal Award Identification Number: DE-SC0025804	
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Principal Investigator Information: ILTAI I KIM	**Recipient Organization:** Texas A&M University, Corpus Christi 6300 Ocean Dr, 5844 5844 Corpus Christi, TX 78412-5844 Country: USA **UEI:** Y3RET2XN41S5

ACCOMPLISHMENTS

This project is to provide scientific insight about the enhanced mechanism of plasmonic photocatalytic reaction rate between the chemical and thermal effects. To achieve this object, the controlled plasmonic photocatalyst nanodot array will be fabricated using electron beam lithography (EBL) technique. The photochemical cell will be mounted on top of surface plasmon resonance (SPR) imaging setup, integrated with nanosecond imaging and gas analysis (desktop gas analyzer and GC or GC-MS), by following the photoelectric cell (PEC) configuration. The femtosecond transient absorption spectroscopy will be obtained. Out of the the obtained femtosecond spectroscopy data, two temperature model will be obtained to estimate the true surface temperature of plasmonic nanorods. The nanosecond temperature filed will be obtained by the nanosecond SPR imaging. The experimentally obtained temperature will be compared with two temperature model and thermoplasmonics simulation to verify the true surface temperature. Various nanoarray will be prepared to investigate the local nanoscale heat transfer and heat accumulation effect. The excitation nanosecond laser beam size will also be varied to explore its effect. Furthermore, the hybrid detection of temperature and gas morphology will be tried by correlating the temperature field and its generated gas morphology.

At the current project period, the following tasks were done. The plasmonic simulation for the best performance using FDTD was performed to have the optimum design. Two temperature model is being verified for thermal simulation. Thermoplasmonic simulation is being studied based on COMSOL Multiphysics. The ultrafast (nanosecond) surface plasmon resonance (SPR) imaging system is being assembled (developed). Some equipment was placed an order: one nanosecond imaging camera (Andor iStar sCMOS) and potentiostat (Biologic). The pulse (nanosecond) laser (Quanta Ray INDI) system was verified for its operation. Desktop gas analyzers are reviewed and tested compared with the GC.

For training and professional development, one postdoctoral researcher was hired as of Oct. 1, 2025.

For dissemination of the project result, one journal article was published in the Journal of Applied Physics (JAP) with the subject of interference fringe technique for contact angle and nanoscale thickness measurement, which can be applied to measure the gas morphology during the plasmonic photocatalytic reaction. In addition, one conference paper was published in 10th Thermal and Fluids Engineering Conference (TFEC) with the topic of varying thickness detection during evaporation.

For next period of the project, firstly, the nanorod array for plasmonic photocatalytic reaction will be fabricated at the nanofabrication center (CINT) at SNL. Secondly, the nanosecond imaging camera will be assembled to the surface plasmon resonance imaging set-up with the nanosecond laser for nanoseconds SPR imaging. Thirdly, the gas analysis will be performed with GC-MS, GC, and desktop gas analyzer. The photoelectric cell (PEC) configuration will be established with the purchasing potentiostat and the custom-designed photocatalytic cell. Fourthly, the thermal simulation will be conducted based on the thermoplasmonics simulation (COMSOL Multyphysics) and two (or four) temperature model (based on femtosecond transient absorption spectroscopy). In addition to the hired postdoc researcher, one graduate (doctoral) student will be hired.

PRODUCTS

The products shown below include only Publications with a 'Published' status and Intellectual Properties with a 'Granted' status. Products with other statuses are not included in this report. The Revision Type indicates whether a product is New (newly added), Updated (existing product modified), or No Change (existing product reported without modifications) during the current budget period. Note that 'Updated' statuses may appear more frequently as products progress through the publishing process. All products listed have been reported for the current project period of this award.

PUBLICATIONS

Journal Article (New):
Kim, Iltai Isaac; Lie, Yang, "Interference fringe (IF) technique for droplet contact angle and thickness measurements: Ultralow contact angle and nanoscale thickness measurement", *Journal of Applied Physics*, Volume 138, 024701, Published, 2025, DOI: 10.1063/5.0273187.

Conference Paper/Presentation (New):
Kim, Iltai Isaac; Lie, Yang; Greathouse, Jeffery; Yoon, Hongkyu, "Transmission interference fringe (TIF) for evaporating droplet’s contact angle variation", *10th Thermal and Fluids Engineering Conference (TFEC) March 9-12, 2025*, Published, 2025.

INTELLECTUAL PROPERTIES

There are no intellectual properties to report.

PARTICIPANTS AND OTHER COLLABORATING ORGANIZATIONS

The table below only contains participants who have identified an affiliation with the Awardee Institution. Participants from any associated subawards may not be included in this count.

PARTICIPANTS DETAIL

Project Role	Number of People	Total Person Months Worked
Co-Investigator	2	14
Faculty	1	0
Postdoctoral (scholar, fellow or other postdoctoral position)	1	1
Principal Investigator/Project Director	1	2
Total Responses	**5**	**17**

PARTNERS DETAIL

There are no partners to report.

IMPACT

This project can provide scientific insight on understanding the fundamental mechanism of enhancing plasmonic photocatalytic reaction between the chemical and the thermal effects, using femtosecond transient spectroscopy, nanosecond surface plasmon resonance thermometry, gas analysis, and thermal simulation.
The developed hybrid detection technique of thermometry and gas morphology can be directly applied to the thermal phenomena, such as boiling and evaporation, to understand the enhanced heat transfer mechanism. Furthermore, the ultrafast SPR technique can be applied to diverse interfacial phenomena, including wetting and electrochemical systems.
Through this project, one postdoctoral researcher and one graduate student will be trained. In additions, a few undergraduate students will be trained. This training will be done in collaboration with Sandia National Lab.
This project can contribute to establish unique imaging capability in ultrafast phenomena, which can position TAMU-CC as one of the few laboratories across the nation which can perform the research, and will help TAMU-CC to become a leader in ultrafast optical diagnostics.
The developed ultrafast imaging technique based on surface plasmon resonance can be transferred to the relevant industry.
The project outcome can contribute to commercialization of the developed detection technique by initiating the start-up company.