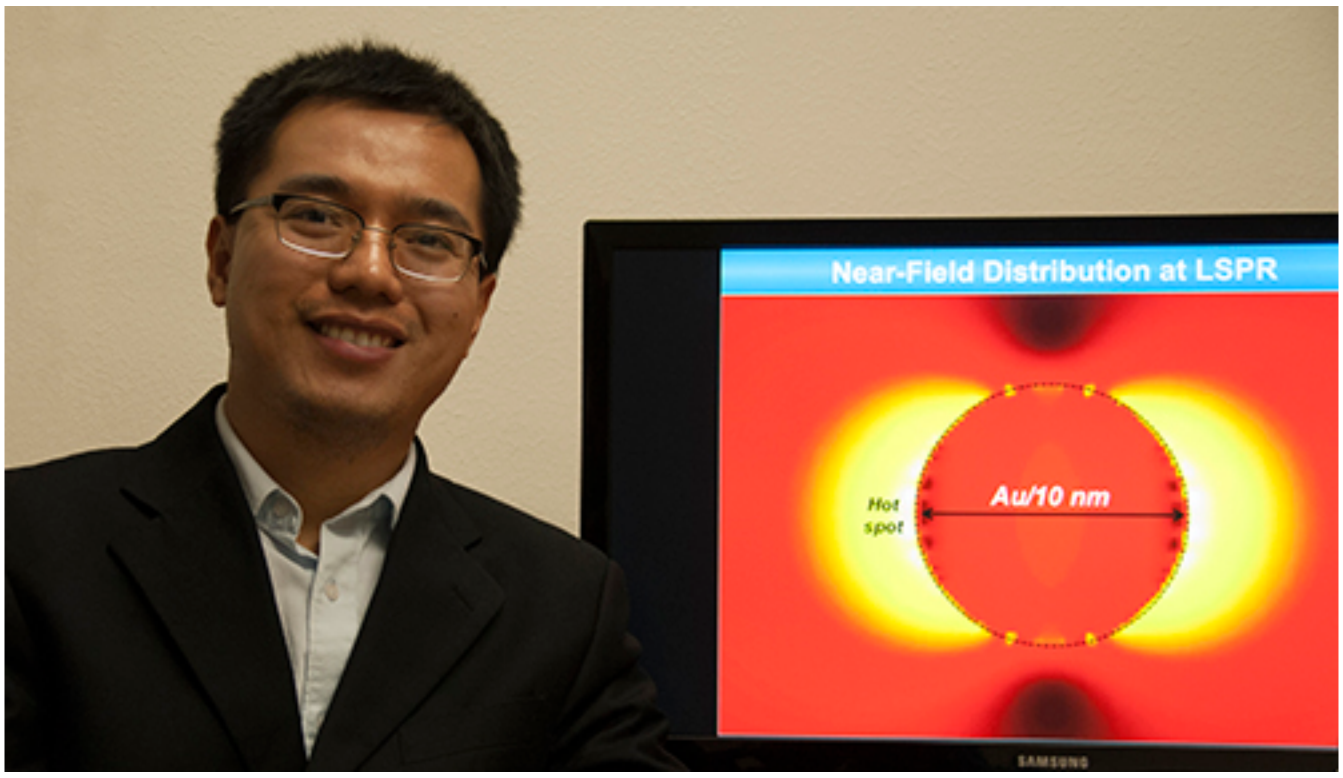
Penn State Alumni Award Winner Yuebing Zheng Explains Optics Research

AUSTIN, TEXAS—January 27, 2014, by Carol Grosvenor



Assistant Professor Yuebing Zheng, first recipient of the Penn State Graduate School Alumni Society Early Career Award. In this article, Dr. Zheng explains his research into light at the nanoscale. The image on screen is a 10 nanometre gold particle he and his research team simulated. They are in the early stages of using such particles for use in medical diagnosis, solar energy and information technology.

Assistant Professor Yuebing Zheng in the Mechanical Engineering Department at The University of Texas at Austin has been selected as the first recipient of a newly established award for graduate student alumni at Penn State University. **The Graduate School Alumni Society (GSAS) Early Career Award** recognizes alumni who have demonstrated exceptional success in their chosen field within the first ten years after obtaining their graduate degrees. The award is open to all fields of study. Zheng received his Ph.D. at Penn State in 2010, and continued his research as a post-doc at the University of California, Los Angeles (UCLA), before beginning his career here in the fall of 2013. Zheng was nominated by his former graduate advisor, **Dr. Tony Jun Huang**, in the department of Engineering Science and Mechanics, Penn State, and his post doc advisor, **Dr. Paul S. Weiss** at the California NanoSystems Institute, UCLA.

Award criterion:

Exceptional achievement and success early in one's career and the potential to make a significant impact throughout one's career.

This can be demonstrated in a number of ways. Examples include but are not limited to demonstrated leadership, substantive contributions in one's field, or national/international recognition for one's contributions.

Research overview

Zheng's research program, exploring nanoscience and nanotechnology at the interfaces of multiple disciplines, will likely lead to advances in multiple directions and industries.

Related Links

- Dr. Yuebing Zheng's Faculty Bio
- Dr. Zheng's Research Site
- The Graduate School Alumni Society (GSAS) Early Career Award
- Resonant Frequency
- Surface Plasmon Resonance (SPR)

Surface Plasmon Resonance

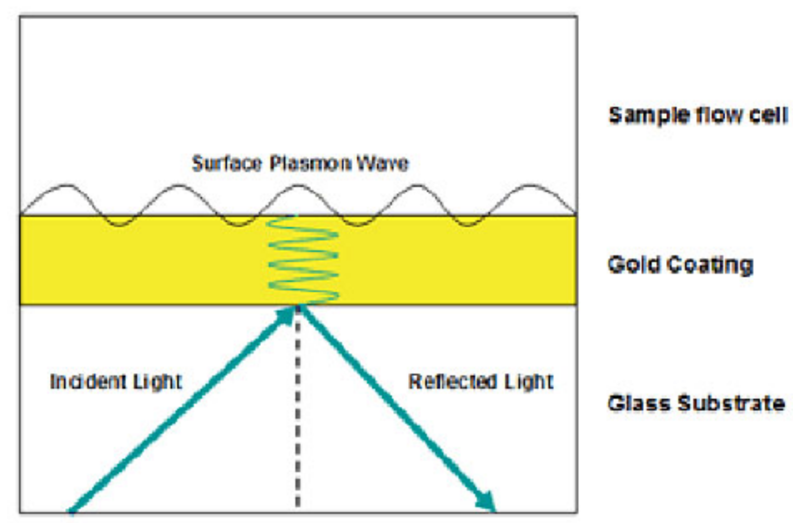


Diagram explaining surface plasmon resonance, which creates a wave when a light beam is shown on gold and refracted off of it. Image courtesy of SensiQ Technologies. See their page for more information on surface plasmon resonance (SPR) principles. The company is not affiliated with The University of Texas at Austin or involved in this research.

Definition from Wikipedia: **Surface plasmon resonance (SPR)** is the collective oscillation of electrons in a solid or liquid stimulated by incident light. The resonance condition is established when the frequency of light photons matches the natural frequency of surface electrons oscillating against the restoring force of positive nuclei. SPR in nanometer-sized structures is called **localized surface plasmon resonance.**

SPR is the basis of many standard tools for measuring adsorption of material onto planar metal (typically gold and silver) surfaces or onto the surface of metal nanoparticles. It is the fundamental principle behind many color-based biosensor applications and different lab-on-a-chip sensors. Read more.

Eventually, he envisions that it could lead to powerful biomedical diagnostic tools available to users worldwide on as a cell phone app to check things like their blood sugar level or for a type of cancer. He also thinks it could aid in faster biofuel production, be used in nanoscale optical devices and solar energy applications. For example, Zheng envisions a sensor inside cell phones that would be able to view cells in blood samples well enough to be able to make a diagnosis of illness or send data to a doctor for review.

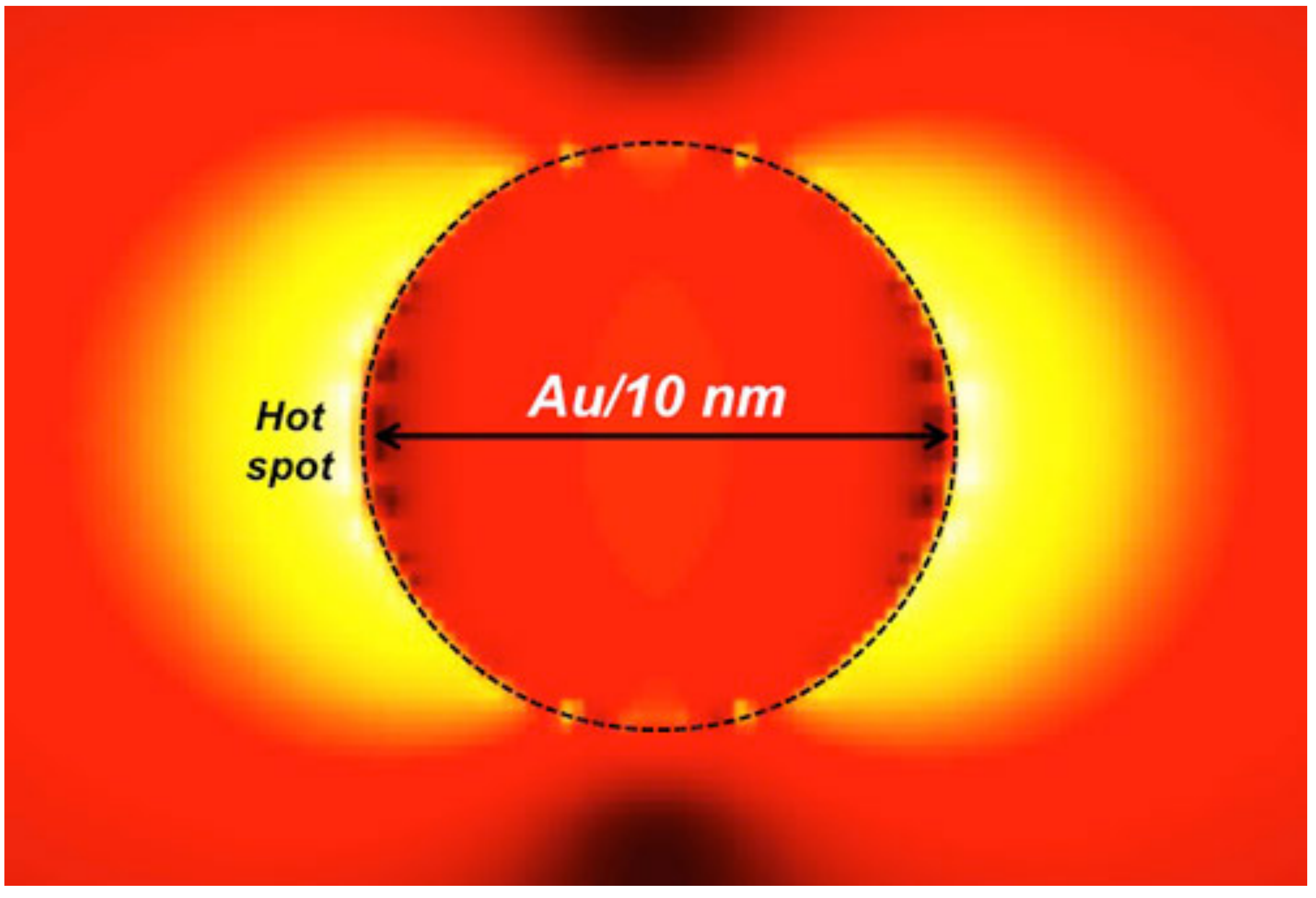
Join his research program!

If you're a prospective graduate student interested in optics, fluidics or nanomaterials and would like to get in on the ground floor of Dr. Zheng's research, please contact him. *He will be hiring two or three students into his program in the fall.*

Turn on the light, it's dark in here.

The key component the group is studying is **light at the nanoscale**, utilizing a phenomenon in physics called **surface plasmon resonance (SPR)** , the light-coupled collective oscillation of free electrons in metals. Zheng wants to make light more available, more intense, highly focused and spatially confined. This would produce crisper resolution at the nanoscale and have useful applications in diverse areas:

A. **Biomedical sensors** so small they could be inside the human body and transmit highly detailed images of cells useful in medical diagnosis and brain mapping.
B. Increase the speed of photosynthesis in **solar energy applications**, which could be useful in biofuel production as the highly concentrated light acts as a photocatalyst and could speed up chemical reaction and fuel production.
C. **Information technology applications** to control light signals at the nanoscale in optical computing and communications applications.



Gold spherical sensor image, 10 nanometres in diameter, made with simulated data by Dr. Zheng and his team. In the nanoparticle sensor, the team measures the scattered or absorbed light by single nanoparticles.

The image shown on his computer screen is a nanoscale particle the team made from simulated data, lit with a microscopic laser beam. *The particle itself is actually the sensor*. Currently, there are commercially available larger sensors larger sensors built on sheets of metal, but none that are actually nanoscale particles. This one is about 10 nanometres (see how small that is) in size and is made up of a group of gold (Au) atoms. They use gold, as it is a noble metal, (resistant to corrosion and oxidation in moist air), is highly conductive and has a long track record for biocompatibility in the human body (ex. fillings for cavities). Other noble metals can be used, and the team is researching other metals for different applications.

Particle design and concept

They have made particles that are spheres like this one, tubes, triangles and other shapes. You'll notice that the light falls off abruptly in the background, creating a sharp-edged halo around the particle it is lighting.

That is the concept of the initial research: *: the sharp focus at the nanoscale is below diffraction limit of conventional light*. Such a focus intensifies the local light source dramatically. By studying the particle's localized surface plasmon resonance (LSPR) for sensor applications, they are learning how to make the particles of high sensitivity, control the interactions of particles with molecules, biomolecules, and cells, and measure the light scattering and absorption by single particles that will allow the particle sensor to accurately relay information down to the single molecules.

The electrons from the gold move randomly when light is not present, but form oscillating waves when light with the resonant frequency is present. A slight variation in the surrounding environments of the particles can be detected by the sensor through a change in the oscillation frequency. That is essentially what the sensor is able to do with very intense, concentrated light, only at the nanoscale.

Currently, they are studying the process, testing material, and studying the nuances of surface plasmon resonance properties. When the team has a greater understanding and control of the process and phenomenon, they will move forward into both software and hardware development, as well as further exploration in several areas.

Dr. Zheng is extremely enthusiastic about diverse possibilities this research could bring to medicine, fuel production, nanoscale optics and solar energy. The future's so bright we gotta wear shades.