

Interview with John B. Asbury, Chief Scientific Officer

Why did you become a scientist/chemist/researcher?

J.A.: My grandfather was my inspiration to become a scientist. I am, in fact, his namesake. Eugene John Barber was a third-year graduate student in the Department of Chemistry at the University of Washington studying the gaseous diffusion of uranium hexafluoride with George H. Cady in 1941.

Cady was a famous inorganic chemist who was well known to the War Department at the time (predecessor of the Pentagon). When the Manhattan Project was begun after the US entered WWII, Cady was asked if he had a student knowledgeable about gaseous diffusion because the process was needed to separate the isotopes of uranium for the nuclear bomb. Cady recommended my grandfather.

My grandfather helped the design and scale-up process of gaseous diffusion at the K-25 site in the secret city, Oak Ridge, TN during the war. After the war, he completed his PhD with Cady and worked in the nuclear industry for 50 years before he died in 1996. My grandfather's work was top secret when my mother and uncles were growing up.

By the time I was in high school and college, he could talk about it. I treasured talking with him and was inspired to follow in his footsteps. My grandfather worked at the leading edge of energy research in his day. In a small, less dramatic way, I want to work at the leading edge of energy research in my day.

Have you thought about how these products could change the world?**How so?**

J.A.: Our instruments offer a combination of chemical selectivity through transient absorption signatures and unprecedented sensitivity to resolve chemical intermediates in catalytic reactions at low concentrations that is needed to overcome fundamental challenges in energy and biochemical research--limitations that have hindered development of renewable and sustainable energy technologies.

Let me take a few words to unpack this statement. Or more than a few words—our history is vital to answering this question.

The ability to harness energy and direct it through engineered systems is foundational to modern society, and there is a need to identify new means of harnessing energy in a sustainable way for society to continue as we know it.

Natural systems do this with photosynthesis--a photocatalytic process by which solar energy is converted into chemical energy for later use. The development of artificial photosynthetic systems based on engineering materials that sustainably convert renewable energy into chemical fuels remains a grand challenge.

It has not been solved because the catalytic reactions that lead to the conversion of CO₂ to fuels and the oxidation of water to form O₂ are complicated, multi-step processes. Decades of research have

demonstrated that traditional trial and error approaches are insufficient to find catalysts to enable efficient, sustainable artificial photosynthesis.

Experimental techniques have long been needed to investigate and ultimately control the catalytic reactions in scalable, engineered systems that mimic naturally occurring photosynthesis. Numerous experimental methods have been developed over the years to address these challenges, leading to new insights about fundamental steps in the photocatalytic reactions.

None the less, the complexity of the reactions and the need to study them under operating conditions has limited progress. For example, experimental methods such as vibrational sum frequency generation (SFG) have been used to identify chemical intermediates at catalyst surfaces that would provide important insights about how to control photocatalytic reactions. Unfortunately, the SFG technique has lacked the sensitivity needed to study the reactions under realistic conditions that mimic those in operating photocatalytic devices. This has been a major obstacle to progress in the field.

The noise suppression technology developed at Magnitude Instruments is poised to overcome this challenge. By decreasing the noise in the transient absorption measurement, we have demonstrated limits of detection that are orders of magnitude lower than the prior state of the art. This is what enables our instruments use for photocatalytic studies of chemical reactions at catalyst and nanoparticle systems under realistic conditions.

The generation and transport of electrical current in new types of photovoltaic materials can also now be studied and correlated with their structural properties under conditions that are closer to operating solar cells than ever before. This enables mechanistic insights about the photochemical reactions to directly inform the development of practical devices for solar energy conversion. We help close the loop between fundamental science and practical applications in energy science.

What inspired you to create these products?

J.A.: See previous answer (laughs).

Back in 2011, I wrote a proposal to the Department of Energy (DOE) to develop a new type of ultrafast spectroscopy to study the electrical properties of new types of photovoltaic materials and to discover how those properties depended on the molecular and structural properties of the materials.

This would help develop design rules for how to make the materials more efficient. The technique, called ultrafast Photocurrent Detected Infrared Spectroscopy (PDIRS), was designed to combine electrical and spectroscopic information about the materials to develop these design rules.

At the time I wrote the proposal, I did not realize that the experiments could not be done with existing technology used in the ultrafast spectroscopy field. The reason for this is that the damage threshold of photovoltaic materials is orders of magnitude lower when they are attached to electrodes and incorporated into functioning electrical circuits needed to detect photocurrent. This damage threshold was below the detection limits of existing spectroscopic equipment at the time.

Consequently, I pushed my students to develop more sensitive detection systems because my program manager at the time would not allow me to switch topics.

Out of desperation, my students Christopher Grieco and Eric Kennehan (Magnitude Co-founders) experimented with numerous electrical designs and detection schemes to try to deal with the ever-decreasing signal levels as we kept reducing the intensity of the laser pulses used in the experiment.

After several successive improvements, they found a way to measure and subtract noise in the experiment with far greater fidelity than had previously been achieved. At the conclusion of the grant from the DOE, we decided the PDIRS technique was subject to too many artifacts to be worth pursuing further.

Fortunately, through this process, my students developed a way to significantly reduce the noise in our transient experiments. We applied these techniques to our transient absorption spectrometers and observed orders of magnitude improvements in our signal/noise ratios. The improvements were so dramatic, we realized that others would need the same capability because it opened new avenues of investigation that were previously inaccessible.

That was the start of Magnitude Instruments.