Research Highlight #2010

Yasaman Soudagar, Ph.D. and Roshni Christo, Ph.D.

Exploring brain circuitry with the world's only patented multi-region imaging system

If you were asked what you had for lunch yesterday, you can probably quickly recall what you ate, even without prior anticipation of this question. This one example of brain function is the inspiration for many fundamental neuroscience research questions. It is also something Dr. Yasaman Soudagar had in mind when founding Neurescence and developing multi-region miniscopes, which are imaging systems that let researchers perform simultaneous multi-region functional imaging of neuronal activity. After Yasaman founded this neuroscience startup, she hired Dr. Roshni Christo as one of the very first employees due to her neuroscience background. Their different scientific paths have led to a unique collaboration in their current roles with Bruker's fluorescence microscopy team.

The History of Multi-Region Miniscopes

Yasaman is a physicist by training but has always had an interest in the brain both intellectually and personally following the diagnosis of a family member with schizophrenia. After studying physics throughout her entire academic career, she realized neuroscience research is at an inflection point and needs powerful new research techniques and tools to better understand the brain at the circuit level. Her idea was that these as of yet undeveloped tools would be able to apply mathematical models to the brain, similar to those she used in her physics studies.

> "LIGO is an interferometer that can detect gravitational waves and a displacement in space of 10 to the minus 18 meters. Nobody can imagine a 10 to the minus 18-meter displacement but, in physics, that's where we are at. How is it that for brain diseases, we don't even know what they really are? There has been a lot of progress, but a lot is still unknown, and we don't know how to assist patients. So, the dream is to help understand the brain and to understand the root cause of each brain disease. Of course, if we can figure out how the brain works, that's the Holy Grail, right?"
>
> - Dr. Yasaman Soudagar

The Holy Grail would be to completely understand the brain, but the more down-to-earth goal of many neuroscientists is to investigate fundamental research questions. By using multi-region imaging, Yasaman hopes to continually improve multi-region miniscopes to investigate brain circuitry and complex functional behaviors. Since Yasaman originally had this vision but less formal training in neuroscience, she took postdoctoral work in a neuroscience

ABOUT THE RESEARCHERS

Dr. Yasaman Soudagar is the co-founder of Neurescence and inventor of multi-region miniscopes. She obtained her Ph.D. in experimental quantum optics with a focus on quantum computing from Ecole Polytechnique of Montreal, Canada. Pursuing her interests in how the brain functions, she worked in several startups and took a postdoctoral position in a neuroscience lab. She took these experiences to start Neurescence, and following Bruker's acquisition of the company, she is now the senior director of multi-region miniscope R&D at Bruker.

Dr. Roshni Christo obtained her Ph.D. from Cochin University of Science and Technology in India after completing her thesis on dopamine neurotransmitter regulation in neonatal hypoglycemia. Subsequently, she took a postdoc position at Baylor College of Medicine, Houston, Texas making fluorescent constructs that were introduced into animal brains and imaged with two-photon microscopy. In 2020 she was hired as one of the initial employees of Neurescence and is currently the senior application scientist for multi-region miniscope microscopy at Bruker.

lab to learn more about the field and its emerging research needs. Shortly after, she met Dr. Roshni Christo who became the first official neuroscience expert at Neurescence.

Roshni did a five-year postdoc at the Baylor College of Medicine before moving to Canada to search for the right opportunity for her scientific strengths, marketing acumen, and outgoing personality.

> "I had a very clear-cut strategy on how to post on LinkedIn and how to reach out to my growing social network. As a neuroscientist in Toronto, I needed to reach out to my peers, and I needed them to bring value to my network. So, I was pleased how quickly this network expanded in Toronto, and when Yasaman posted the job opening in December, I felt I was exactly the right person at the right time. I quickly applied, I got interviewed, and that was the journey that brought me to Neurescence."
>
> - Dr. Roshni Christo

In addition to continuing to build her own scientific community, Roshni hopes to use her strengths and everything she's learned from social media to encourage young scientists and academic professionals to reach out and ask questions about the technologies they can use in their labs. The combination of Yasaman and Roshni's unique skills helped Neurescence quickly grow from January of 2020, and multi-region miniscopes are being used in several labs with a variety of focuses, such as studies on auditory, vision, and decision-making circuits. This success led to their acquisition by Bruker in November of 2022, where continual improvements are being made to the patented technology and the entire multi-region miniscope product line is benefiting from the much larger reach at Bruker.

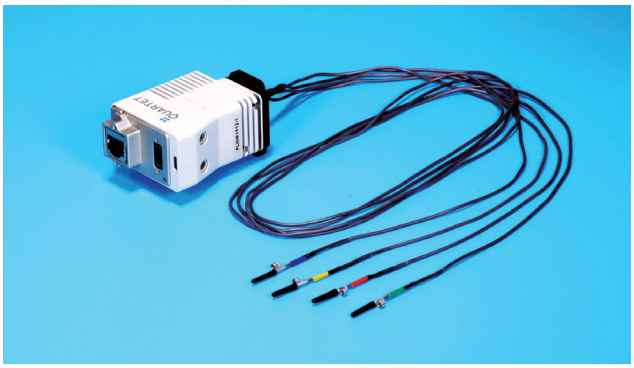
What is a Multi-Region Miniscope?

Yasaman and Roshni were two of several key players in the development of multi-region miniscopes, alongside Alex Papanicolaou and Jalani Kanem. Yasaman went into detail about the technical components that make the name very fitting for the technology.

> "A multi-region miniscope is an optical system that enables neuroscientists to study the brain circuits encompassing up to four regions of the central nervous system in freely behaving animals. The main reason we call it a multi-region miniscope is the capability to simultaneously study neuronal activity in multiple brain regions. Our first product, Quartet®, enables longitudinal imaging of GFP-tagged neurons in up to four brain regions in various behavioral paradigms, such as open-field, various mazes, swim tests, simultaneous brain imaging of more than one animal in social interaction, and imaging one region in four animals for high-throughput screening.
>
> - Dr. Yasaman Soudagar

In simpler terms, a multi-region miniscope is an optical fluorescence imaging system that enables neuroscientists to look at neuronal circuitries in relation to various experimental parameters, such as behavior.

Furthermore, they contribute to The Brain Research Through Advancing Innovative Neurotechnologies Initiative (The BRAIN Initiative). This initiative shares a common goal of accelerating the development of innovative neurotechnologies to produce a revolutionary new dynamic picture of the brain that, for the first time, shows how individual cells and complex neural circuits interact in both time and space.

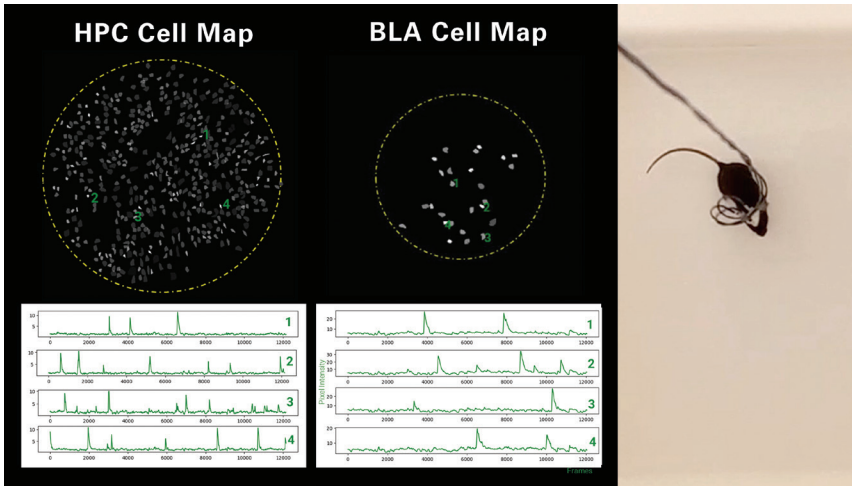


Quartet is an end-to-end hardware-software multi-region imaging solution with four ultra-light, flexible imaging fiber bundles.

Overcoming Obstacles to Answer Fundamental Research Questions

A big challenge neuroscientists face in their research is creating translatable and reliable data. Roshni talks about how multi-region miniscopes are equipped to help researchers make the most out of every single experimental subject to overcome many of these challenges and successfully explore their research questions.

> "The improvement of these technologies is that you're increasing the amount of data that you get from the same animal, which you can use as a control, disease model, and then treatment. Since you're following the lifecycle of this one animal through all these phases, there is more reliable data. From one region, you get multiple imaging readouts, which increases reliability and translatability. There's a three-tier principle: reduce, refine, and replace. That is what you are doing when you get maximum data out of one animal. I'm sure most of my fellow neuroscientists also believe we increase translatability because our systems are designed to enable combination with other modalities, such as MRI. This may solve our research problem or the bottleneck that we are facing."
>
> - Dr. Roshni Christo



The Quartet system is optimized for multi-region calcium imaging and was used to create this HPC-BLA brain data from a mouse during its naturalistic behavior.

Now that researchers can reduce, refine, and replace their data more efficiently, more complex experiments can be conducted that study the relationship between individual cells and neural circuitries in space and time.

Filling the Gap in Neuroscience Research

When asked what gaps in research multi-region miniscopes are hoping to fill, Yasaman turned to the need to understand any circuitry that encompasses multiple brain regions. Typically, researchers need to use electrophysiology to understand circuitry in multiple regions, but that is not neuron-specific, and it doesn't have great spatial resolution. Yasaman and Roshni both elaborate on the benefits of imaging multiple regions for behavioral studies.

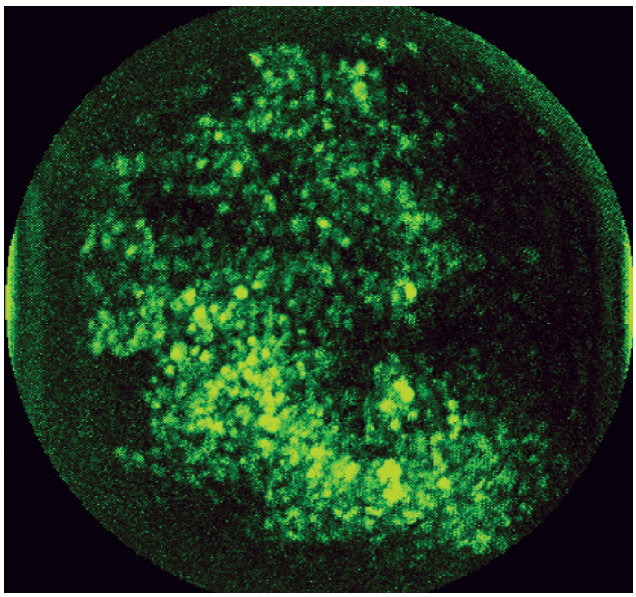
> "We close the gap so that now neuroscientists can answer questions that encompass more than one brain region. So, they can get data for brain circuitries encompassing up to four brain regions. Before our systems, the only way of doing that was electrophysiology, which doesn't have the spatial resolution and it doesn't have neuron specificity."
>
> - Dr. Yasaman Soudagar

> "So, when we have a technology that gives you so much power to see these multiple regions simultaneously, it quickly turns into translatability. Learning and memory circuitry, fear circuitry, reward circuitry, all these basic circuitries can be visually based."
>
> - Dr. Roshni Christo

Since multi-region miniscopes can visualize multiple brain regions during longitudinal studies in freely behaving animals with high spatial resolution and neuron specificity, researchers have the ability to address countless research questions. Exploring these questions is the goal of many in the field and continues to be a source of inspiration for Yasaman and Roshni, as well as the Bruker life sciences team.

Looking to the Future with Bruker

The holy grail goal is understanding the brain entirely, but a more specific aspect is the fundamental questions surrounding brain computation. Yasaman brings up the example again of how our brains learn and remember some things with a single exposure. This is one of the countless questions that researchers can address with multi-region miniscope systems, and this exploration of the brain can actually contribute to and go hand-in-hand with the development of artificial intelligence.



Quartet software allows complete movie processing, selection of neurons in the brain movie, and extraction of trace activity of neurons for secondary analysis. Above is the maximum projection of HPC created by the Quartet software depicting more than 150 individual neurons.

> "How does the brain learn with just one sample? Can you imagine the contribution of that to the field of artificial intelligence? There are two sides, one is understanding biology but then, on the other hand, there is this whole field, which is literally getting inspiration from how the brain works. So, it is a two-way communication between neuroscience and AI, and they really feed off each other. It is really exciting to be part of that because, with our systems, you can truly understand what is going on in the brain at the neuronal circuit level."
>
> - Dr. Yasaman Soudagar

These innovative multi-region miniscopes are not only contributing to the field of neuroscience, but they can positively impact and drive the development of several scientific disciplines.

As Yasaman, Roshni, and the rest of the Bruker team continue to develop and improve multi-region miniscopes, and as more researchers begin to utilize this novel neurotechnology in their labs, we can gain a fuller understanding of how the brain functions. The brain is fascinating with its ability to rapidly form memories, make connections, and recognize patterns among countless other capabilities. The entire Bruker team is excited to see what findings will come from the scientists who utilize multi-region miniscopes in their labs.

Learn More

To learn more about multi-region miniscopes and Bruker's Quartet system visit here

Author

Melissa Martin
Bruker, Life Science Writer
melissa.martin@bruker.com

Bruker Fluorescence Microscopy
Madison, WI • USA
Phone: +1.608.662.0022
productinfo@bruker.com

Miniscope Microscopy | See Brain Circuitry in Action

www.bruker.com/miniscopes