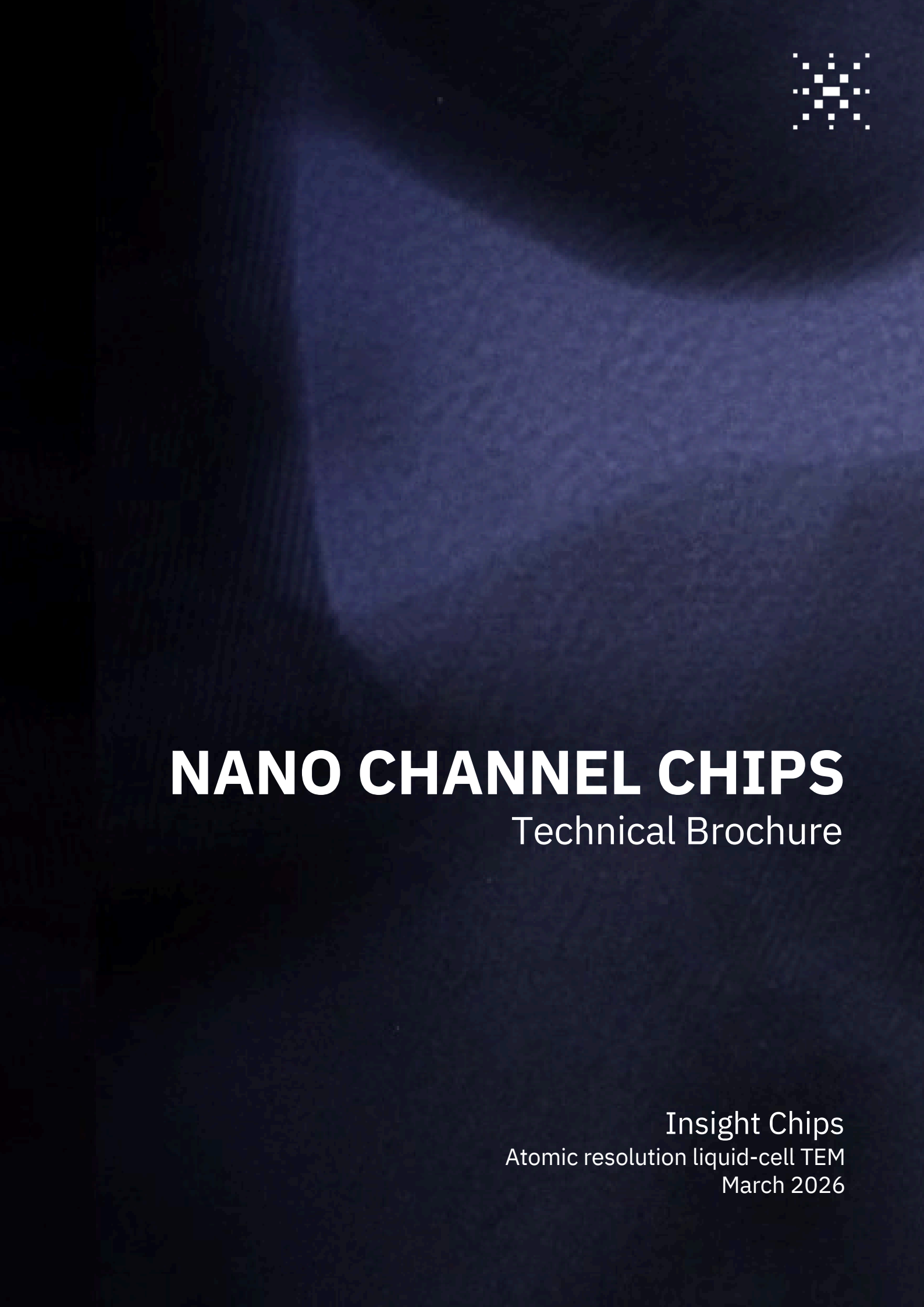


NANO CHANNEL CHIPS

Technical Brochure

Insight Chips

Atomic resolution liquid-cell TEM

March 2026

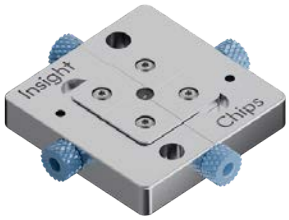
1. INTRODUCTION

All you need to know about the Nano Channel Chip The world's first monolithic chip – for use in TEM, SEM and optical microscopy.

The Nano Channel Chip is based on 10 years of research and development at the Technical University of Denmark, before being introduced as a commercial solution in 2022. Insight Chips aims to introduce a higher level of reproducibility, resolution, flow control, and ease-of-use than any other solution. The Nano Channel Chip fits in our holders for TEM (JEOL and TFS), SEM and optical microscopes.

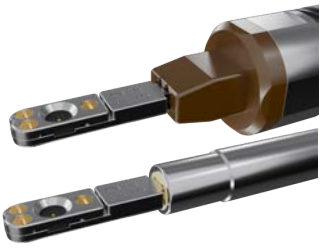
The Nano Channel Chip

Optical / SEM flow holder



Optical / SEM static and storage holder

JEOL and Termo Fischer TEM holders



JEOL high tilt TEM holder

1.1. UNIQUE FEATURES OF THE NANO CHANNEL CHIP

1. **Atomic resolution is reliable with nano-meter precise liquid thickness control**
   The key to atomic resolution is minimal liquid and membrane around the sample. This thickness control is what Insight Chips does better than anyone in the world!
   We can create chips with any liquid thickness, with +/-5 nm precision, and we encapsulate the liquid with SiN membranes down to 10 nm.
2. **No assembly is needed**
   The chips are already assembled in the cleanroom; they are *monolithic.* So, in addition to having all the top unique features listed here available, you also never have to do anything to get it!
3. **No membrane bulging!**
   Membrane bulging is not an issue with Nano Channel Chips. The wider the channel, the more material can bulge out into the vacuum of the TEM column. But our nano channels are typically just 1-2 µm wide and therefore bulge less than 10 nm inside the TEM.
4. **Silicon-nitride membranes down to 10 nm!**
   Our standard chips have 15-20 nm SiN membranes, but we have gone as low as 10 nm and will do it again for customers who really need to go that far with resolution.

5. **Four individually controlled in/outlets in the chip**
   This creates two bypass channels inside the chip. Two of them can be used as inlets, the other two as outlets. Being very large – 100 µm wide and 15 µm deep, liquids can be flushed into the chip in a second and exchanged in just a few seconds. Several inlets can also be used to insert different liquids into the chip, both visible at once in the TEM.

6. **Unprecedented flow control, liquid exchange, and mixing directly in the field of view**
   Two liquids from each bypass channel can be brought together in the field of view inside nano channels. The Nano Channel Chip is the first ever commercially available liquid cell that can mix directly in the field of view.

7. **No contamination = no cleaning needed**
   The chips are sealed inside the clean room. That means the last environment the insides of the chips have experienced is clean room air! In other words, the chips are very clean inside. They stay clean until use because each inlet of the chip has a thin membrane which takes about 10 seconds to poke open before use. When that happens, it's the first time the inside of the chip experiences normal air - and if normal air is an issue, the chips can simpy be prepared for TEM in a glove box.

8. **Robust and reliable**
   You can drop the chip on the floor, and it survives. You can flip it upside down as many times as you like, and you can grab it with your tweezers any way you like. Breaking the chip is not happening unless you find something very sharp and pointy, and deliberately insert it into the small window in the middle of the chip!

   Furthermore, the chip has been tested up to 38 bar pressure! Not all our chips can handle this pressure, as it depends on the mechanical shape and robustness of the specific channel design, but the point remains that no other chip in the world comes close when it comes to robustness.

Watch how simply the chip is loaded with a liquid and prepared in our TEM holder:

"Reduces the sample preparation time to 5 minutes"

Dr. Andrew Stewart
University College London
November 2022

1.2. COSTUMERS STATEMENTS

"This system is fantastic!"

Prof. Marc-Georg Willinger
Technical University Munich
March 2025

"In my opinion the best liquid TEM experience, in terms of usability and ease of use, currently available"

Dr. Andrew Stewart
University College London
November 2022

"Using the Nano Channel Chips from Insight Chips, we were able to achieve reliable imaging of various nanoparticle samples—including metal nanoparticles and quantum dots—regardless of solvent type. The chips enabled consistent sample loading and stable liquid thickness across different sample conditions, which was critical for high-quality liquid-phase TEM imaging."

Prof. Jungwon Park
Seoul National University
March 2025

"The reliability and reproducibility of the liquid-cell chips, as well as the ease of implementation in every laboratory, will undoubtedly bring LC-TEM to a brand-new level"

Dr. Haoyuan Qi
Ulm University
February 2023

"The Nano Channel Chips have enabled my research group to test up to eight different samples with different liquids ranging from organic solvents to biological materials in aqueous solution over the course of just a few hours."

Dr. Aeron Tynes Hammack
Molecular Foundry, Lawrence Berkeley National Laboratory
November 2024

"The control of thickness is crucial for any comparative study or quantitative analysis in liquid cell electron microscopy. The chip is easy and quick to load, which is essential for working with samples sensitive to air in a glove box and for processes that are time-sensitive."

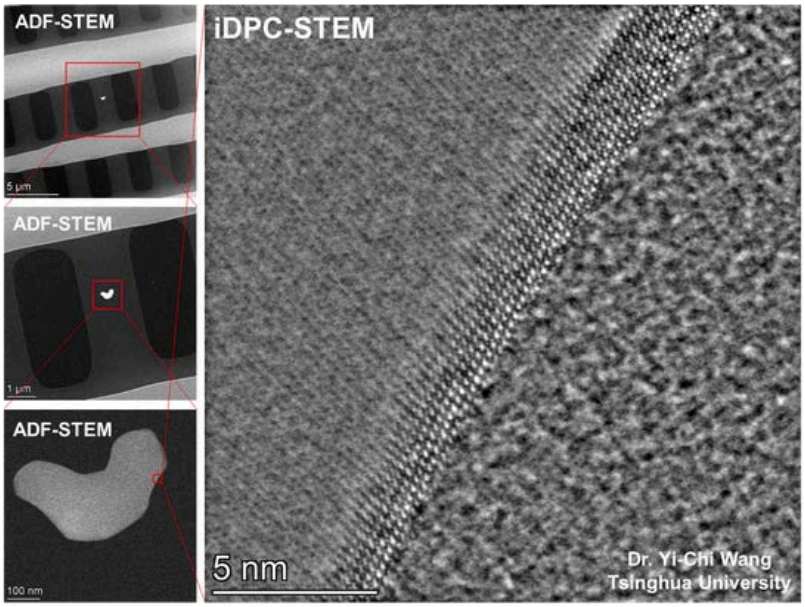
Dr. Patricia Abellan
CNRS, Nantes University
July 2024

"The unique wafer-bonded design of your chip reliably defines water film thickness, enabling reproducible experiments"

Prof. Sascha Schäfer
Regensburg University
July 2024

2. ATOMIC RESOLUTION WITH THE NANO CHANNEL CHIPS

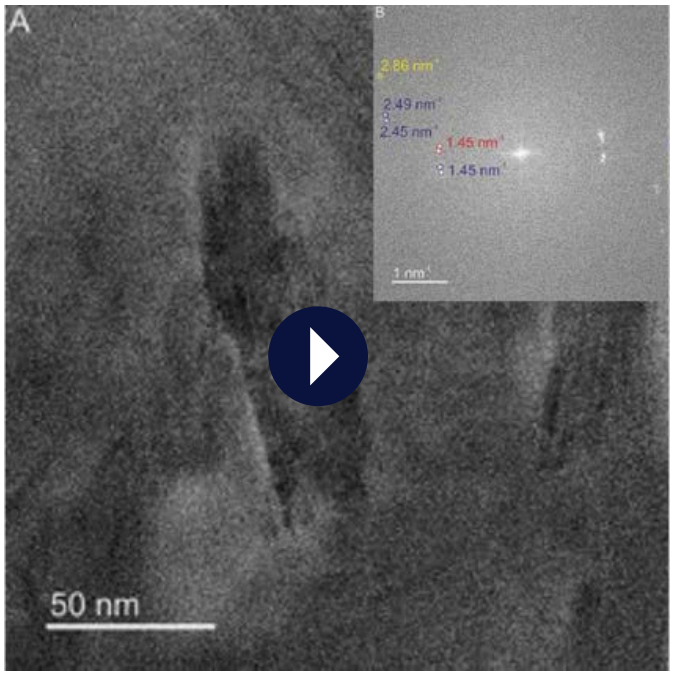
2.1. EXAMPLE #1: Metal particle imaged in iDPC-STEM mode



Dr. Yi-Chi Wang
Tsinghua University

From a product demo at Tsinghua University in Beijing, China.
On the first day out of two, the atomic resolution images were already piling up!

2.2. EXAMPLE #2: MOF growth in situ with atomic resolution



Prof. Ute Kiaser
University of Ulm

Dr. David Mücke
University of Ulm

David Mücke from Prof. Ute Kaiser's group at the University of Ulm, showing that it is possible to mix two liquids together to observe the growth of a MOF in the TEM with atomic resolution.

Read the paper here!

By the way, Prof. Kaiser's group was Insight Chips' very first customer after we started our company in Summer of 2022!

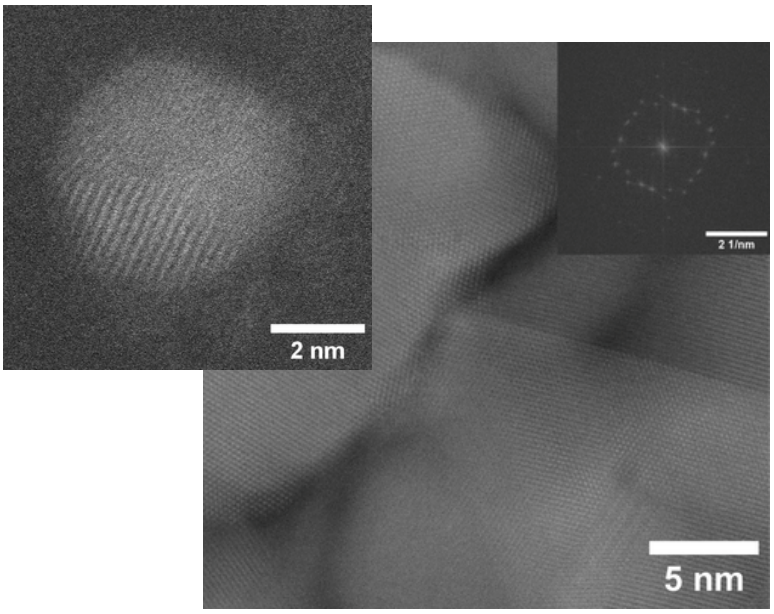
2.3. EXAMPLE #3: Palladium

Prof. Rolf Erni
EMPA

Dr. Marta Rossel
EMPA

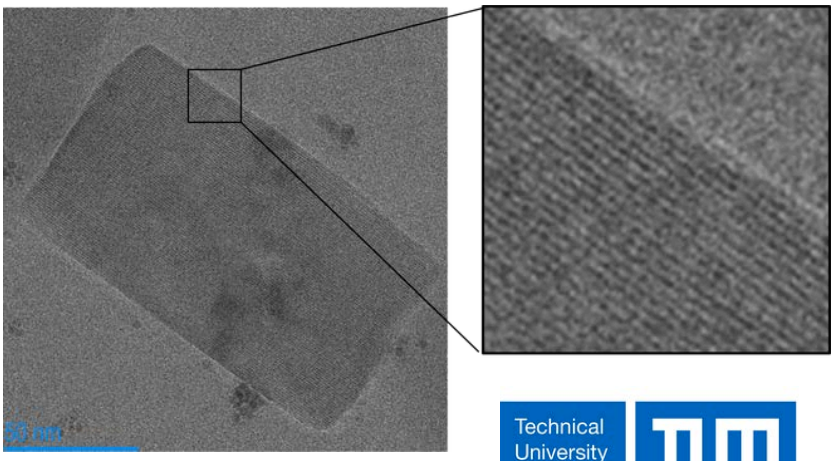
Dr. Walid Dachraoui
EMPA

Empa



During the first few hours of a product demo at EMPA, atomic resolution images were captured of beam-induced palladium grown in the Nano Channe Chips.

2.4. EXAMPLE #4: Ettringite



Technical University of Munich

Prof. Marc-Georg Willinger
TUM

Dr. Olivia Rindle
TUM

Prof. Torben Gädt
TUM

Dr. Elena Willinger
TUM

Another example of atomic resolution imaging, acquired on the first try with the Nano Channel Chips!

Ettringite is a bit special because it *has* to be imaged in water, as over 50% of its structure is water.

So, here you see the first-ever atomic resolution image captured of ettringite, which is a crucial component of cement.

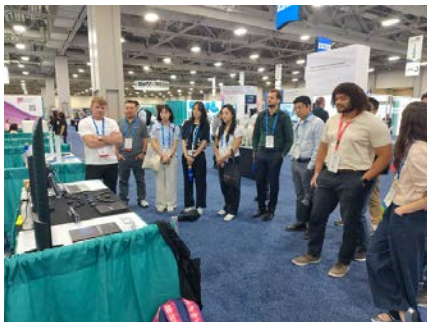
This first-ever result made it into a publication with Dr. Olivia Rindle as first author - read it here!

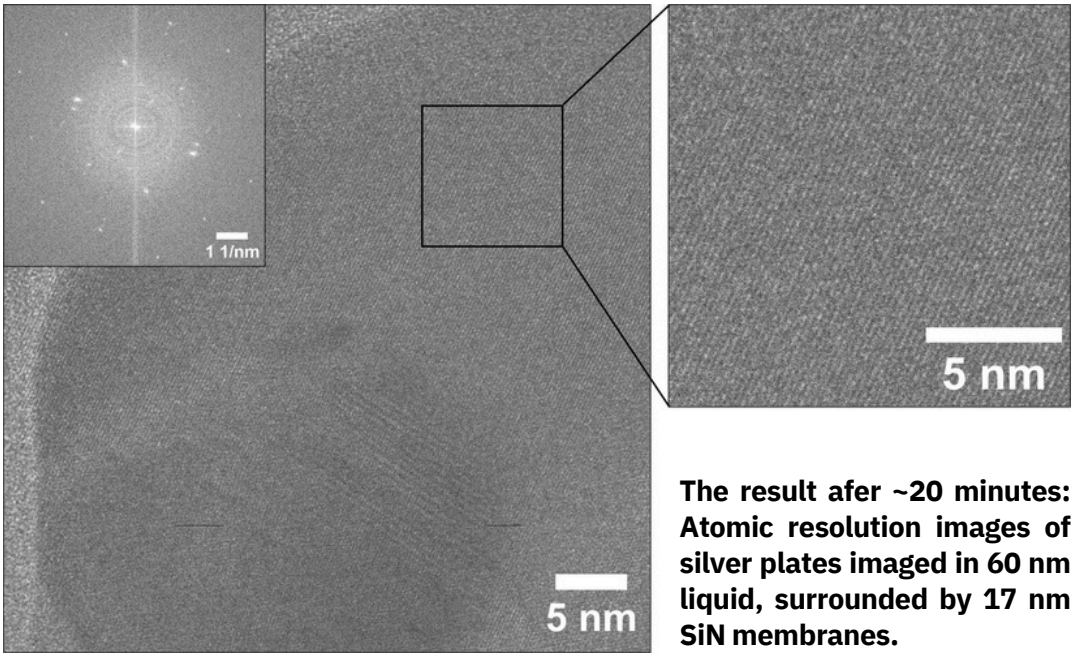
2.5. EXAMPLE#5: Atomic resolution any time, with a live crowd!

Atomic resolution imaging is not some rare occurrence with the Nano Channel Chips. It's expected.

At the M&M 2025 conference in Salt Lake City, we confidently invited a crowd to watch as we promised to show atomic resolution live from the lab, in less than 30 minutes!

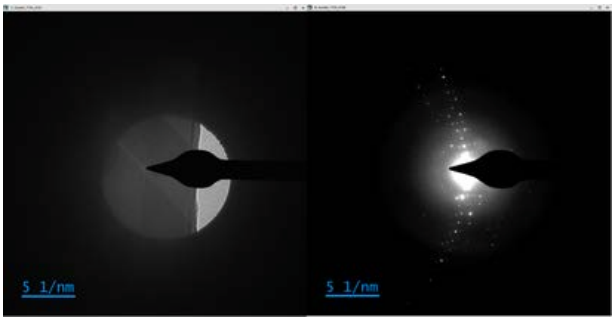
Live on the screen, broadbasting from The Technical University of Denmark, co-founder Murat Yesibolati and Insight Chips engineer Mervan Ramadan, took the audience through preparing a sample in our chip, loading our holder into the TEM, and showing the first visible lattice fringes all in about 20 minutes - and this was including the 10 minute pump time in the Thermo Fischer Titan TEM.





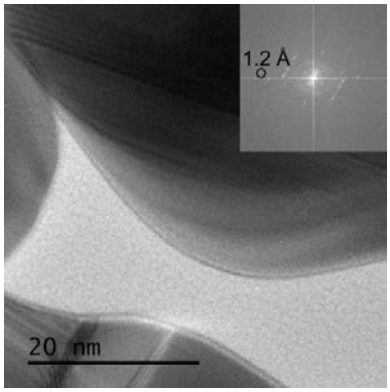
The result afer ~20 minutes: Atomic resolution images of silver plates imaged in 60 nm liquid, surrounded by 17 nm SiN membranes.

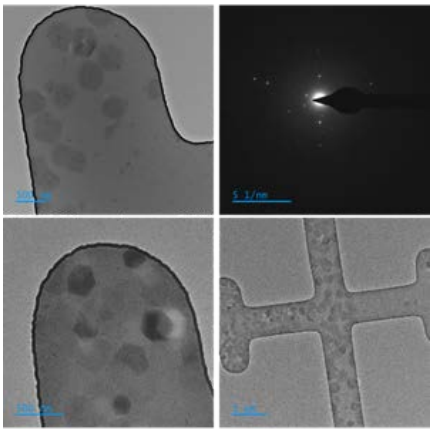
2.6. MORE ATOMIC RESOLUTION IMAGES IN LIQUID



Example #6: **Zeolites**, imaged by Assist. Prof. Murat Yesibolati at the Technical University of Denmark

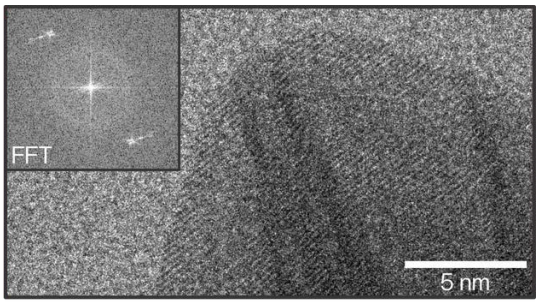
Example #7: **Gold**, grown from interaction with the beam. Credit to Prof. Ute Kaiser, Dr. Haoyuan Qi, and Dr. David Mücke at the University of Ulm

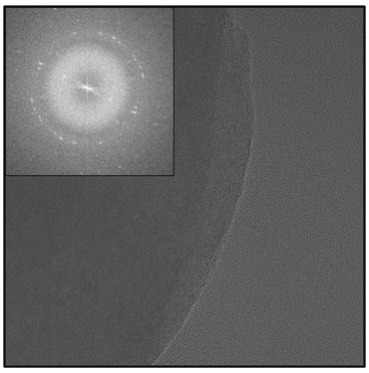




Example #8: MOF sample (**ZIF-8**) imaged by Joakim Lajer and Dr. Justin Mulvey, under guidance from Prof. Kristian Mølhave from DTU and Prof. Joe Patterson from UC Irvine.

Example #9: The first ever atomic resolution image acquired with the Nano Channel Chips back in 2021, by Insight Chips' CEO Emil Jensen and co-founder assist. Prof. Murat Yesibolati. using a Tecnai! The sample is beam-induced **gold** crystal.





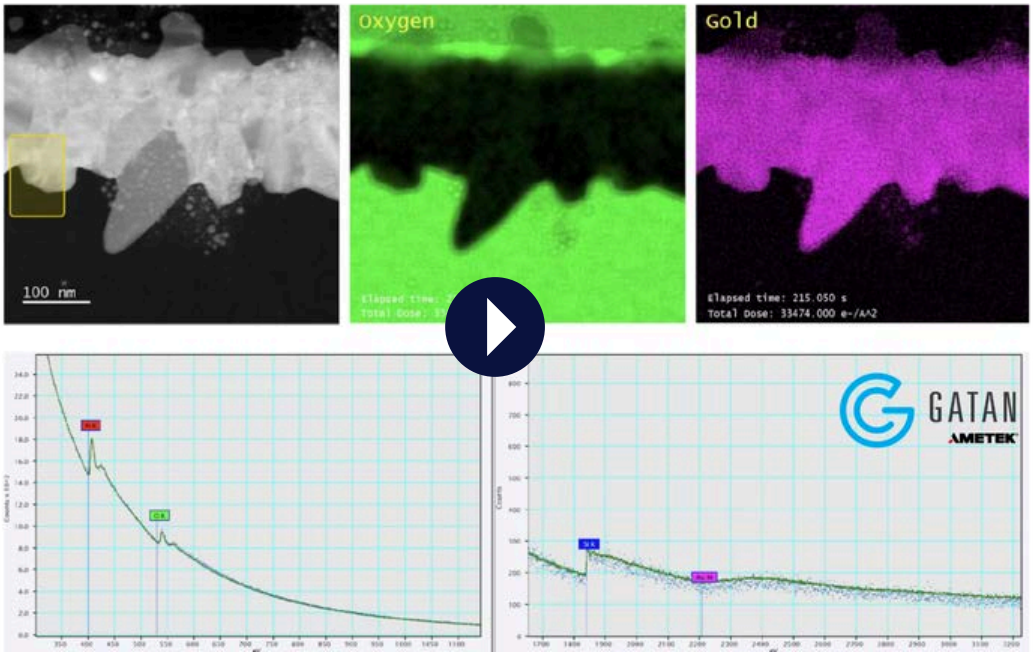
Example #10: **CaCO3** grown in the channels using our patent-pending temperature control solution. Image was taken by assist. prof. Murat Yesibolati for a product demo with Prof. Xiaodong Zou from Stockholm University.

3. NEW FEATURES UNLOCKED

3.1 EELS IN LIQUIDS

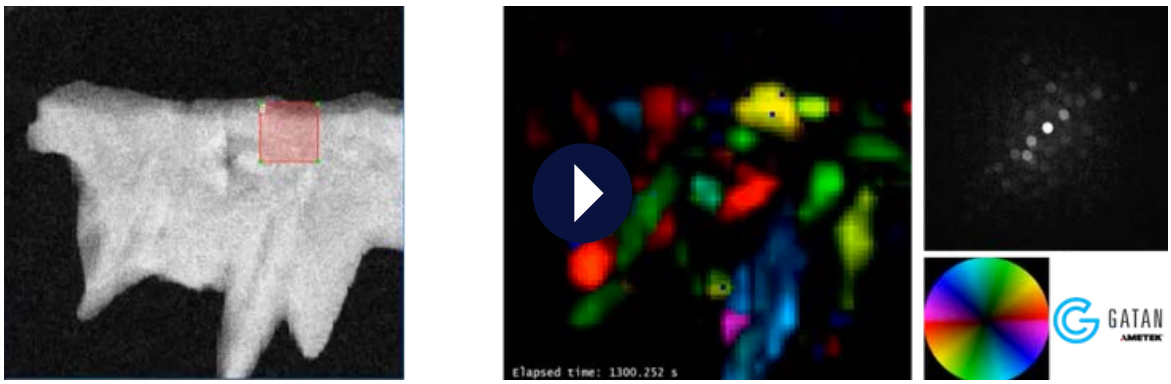
Due to reproducible and reliable liquid thickness down to <5 nm, Insight Chips delivers an EELS capable system with ease of use.

These results show Au crystal growth in 40 nm liquids, captured in collaboration with Gatan using the GIF Continuum K3 on a JEOL F200 TEM.



3.2 4D-STEM IN LIQUIDS

Using the same chips and the same detectors, 4D-STEM results were also gathered in collaboration with Gatan.



4. HOW DOES THE NANO CHANNEL CHIP WORK?

The Nano Channel Chip turns a common microfluidic flow-cell structure into a truly nanofluidic one and makes it adaptable with electron microscopes.

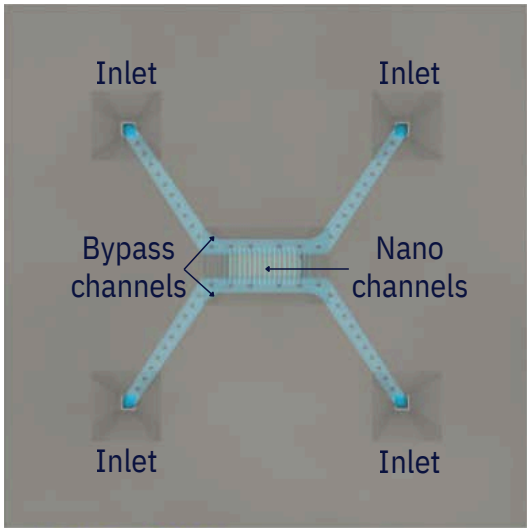
The chip has four inlets and an internal flow structure with two micron-sized bypass channels with nano channels connecting them. When a higher pressure is applied to one bypass channel, the liquid flows through the nano channels into the other bypass channel, and vice versa.

Only the nano channels are visible in the field of view, whereas the larger micro/bypass channels are hidden away inside the chip to protect the TEM from leakage of a larger volume of liquid.

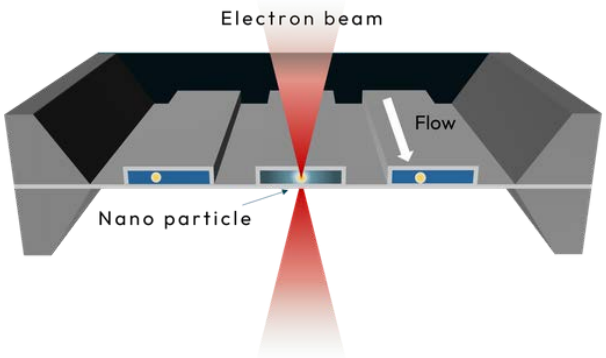
The volume of a nano channel is on the order of femtoliters and poses no risk of breaking the vacuum in the column on its own. Even when a nano channel fractures during a TEM experiment, the column vacuum remains intact.

The four inlets are sealed with O-rings in the tip of the holder and held in place with a lid. Tubes connect inlet ports in the backside of the holder to each of the four inlets in the chip.

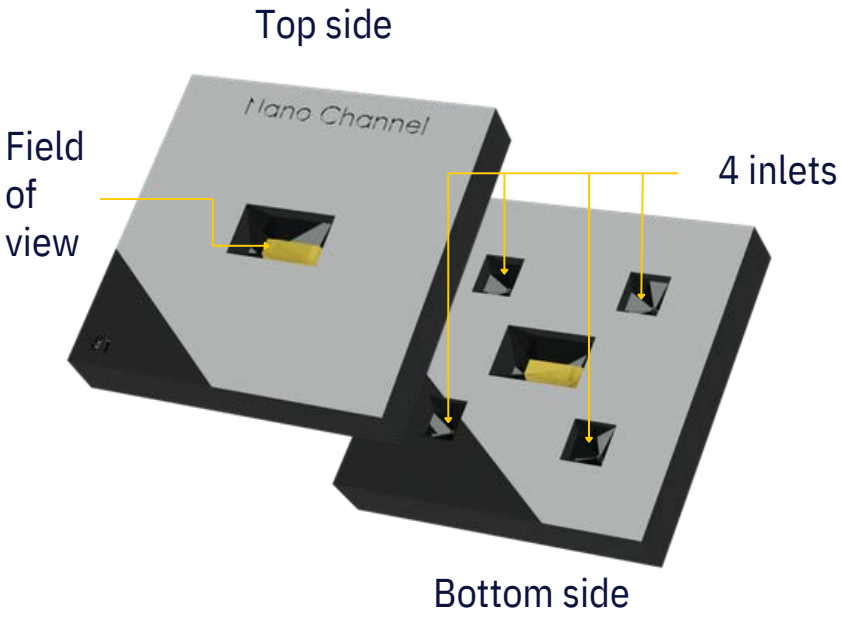
From there, the holder can be controlled with syringes or a pressure-based pump system. For this, we recommend using **Fluigent's EZ Flow** which can be used to control each inlet separately and precisely.

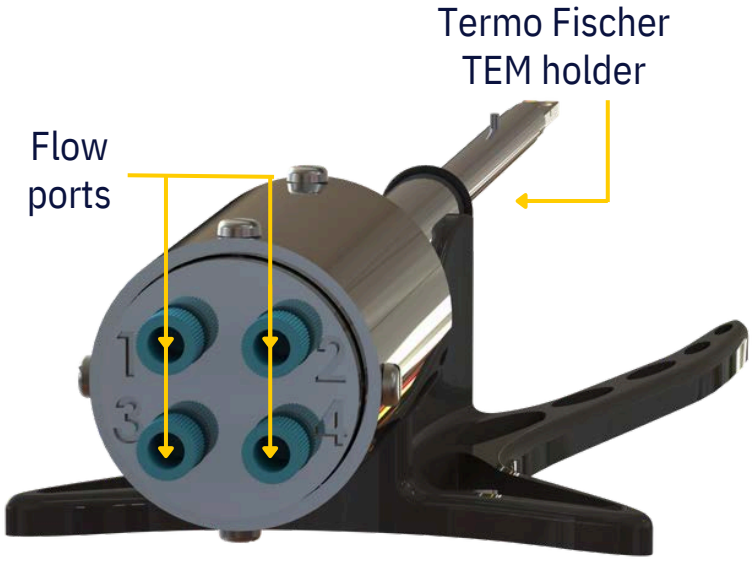


Transparent view of the Nano Channel Chip, showing the internal bypass channels



Cross-section of the window: Single nano channels are suspended on a large SiN membrane

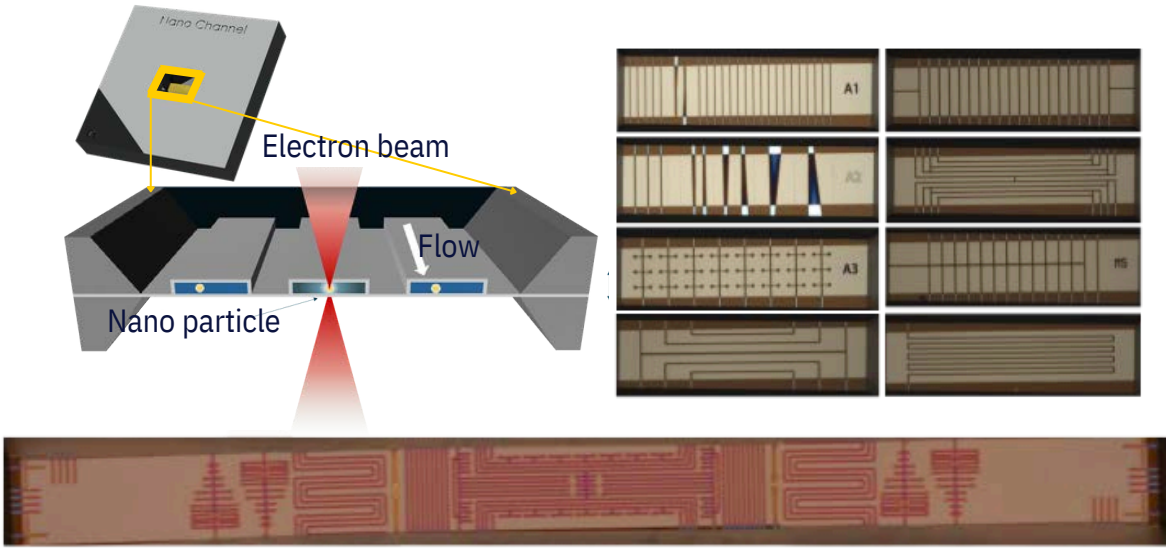

Top side
Nano Channel
Field of view
4 inlets
Bottom side


Termo Fischer TEM holder
Flow ports
1
2
3
4


1
2
3
4

4.1. MANY NANO CHANNELS IN A LARGE FIELD OF VIEW

The chip has a large, suspended membrane, up to 1,250 x 200 µm, made of Silicon-Nitride. The entire membrane is electron transparent and visible in the TEM. Across this membrane are as many nano channels as we want to make, in any pattern, down to 1 µm resolution. We use maskless lithography to make the channel patterns, so design changes are easy from batch to batch, and we can make any number of different designs in one batch. Different channel designs yield different types of flow in the channels, suitable for flushing out radiolysis, trapping particles, or mixing two liquids together in the field of view.



Top left: Sketch of the field of view.
Top right and bottom: 20x optical microscope images of 9 different channel designs from one batch, showing a small glimpse into the many design ideas we have tested over the years.

4.2. HIGH RESOLUTION ENSURED WITH WELL-DEFINED LIQUID THICKNESS AND MEMBRANES

The nano channels are well-defined from the fabrication stage. It is therefore always possible to use a chip with the right liquid thickness, for each experiment. For example, if one wishes to study particles that are 10 nm large, it is possible to use Nano Channel Chips with channels that are only 20 nm thin, making enough room for the particle to flow into the channel, but without compromising on the resolution with a much thicker than needed liquid.

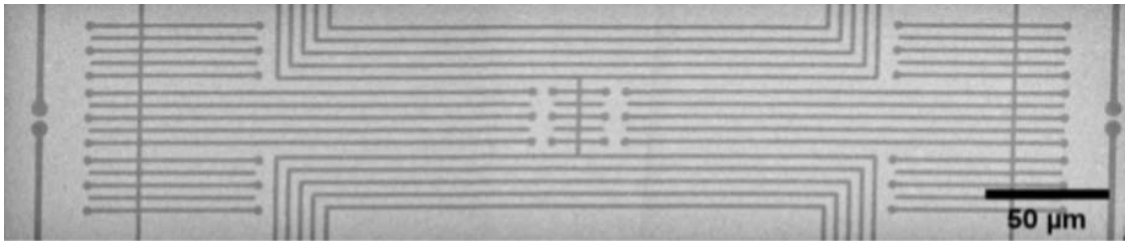
If one wishes to study larger particles, say 100 nm, one simply uses a chip with a liquid thickness of 120 nm. We can control liquid thickness in this way with each batch of chips, with 5-10 nm precision.

The membranes of the Nano Channel Chip are made of silicon-nitride (SiN) and we have successfully made chips that are down to 10 nm thin!

4.3. FILLING, FLOWING, AND MIXING IN THE NANO CHANNEL CHIP

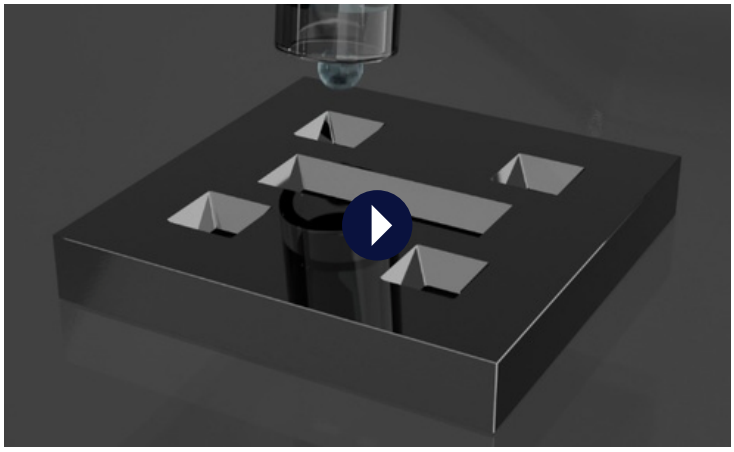
4.3.1. Filling

Liquid can be entered into the chip in two ways: 1) Via drop-casting a droplet onto the chip before loading the chip in the TEM holder, or 2) by inserting a dry chip into the TEM holder and injecting liquids into the chip using the tubes that go through the holder.

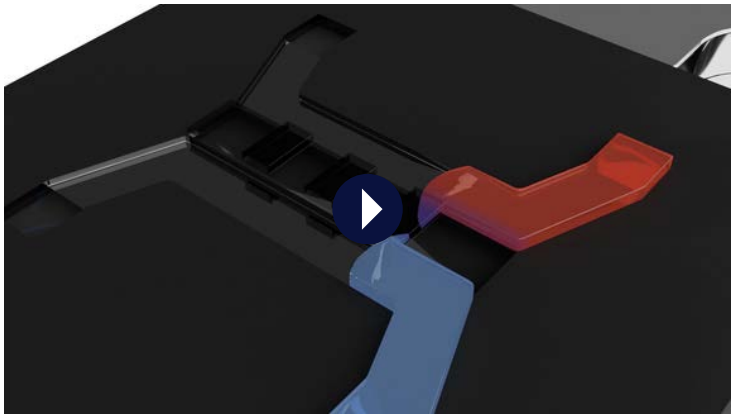


Low-magnification TEM image of the full field of view. The nano channels are fully filled with water.

This animation video visualizes how liquid is drop-casted into the chip before loading



And this anmimation video shows how two liquids are injected into the chip when the chip has already been loaded into the TEM holder:



4.3.2. What about bubbles?

This is a question we get a lot and luckily the answer is positive! Because bubbles are usually 'squeezed' out of the liquid and dissolve into it due to high capillary forces in the channels. A video of the filling of channels, slowed down, can be seen here. In this video, you can see 'dead-end' channels being filled with water, trapping air/bubbles. Within about 10 seconds, most of these bubbles have disappeared.

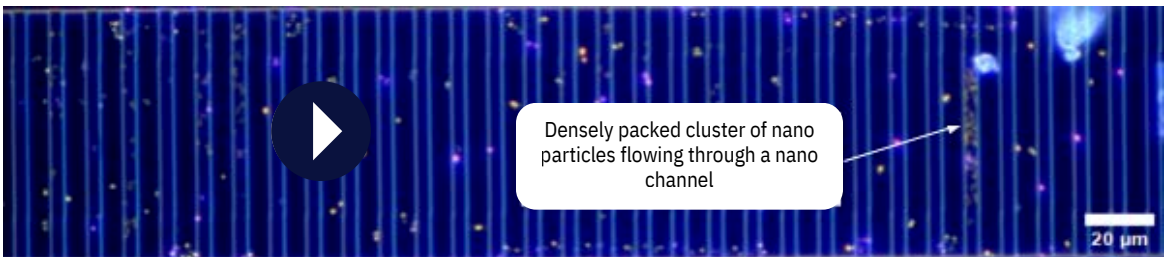
Radiolytic bubbles may be created again if the electron beam is too intense. But in this case, simply move to another nano channel and continue the experiment in fresh conditions.

4.3.3. Flushing out radiolytic byproducts

In a TEM experiment, it may be beneficial to have a constant flow through the channels to avoid the buildup of radiolytic byproducts. With a Fluigent pressure setup, the pressure can either be set to a constant value, typically 100-500 mbar, or even programmed if different flow rates are desired throughout the experiment.

4.4. FLOW IN THE NANO CHANNELS

After the liquid has filled up the chip, the capillary forces are no longer acting on the liquid, it is now in a completely balanced, steady state. Now, the pressure applied to the micro/bypass channels will determine the flow inside the channels: A larger pressure on one bypass channel will push the liquid through to the other bypass channel, and vice versa.



It is impossible to actually see the flow in the channels if there is nothing moving in them. Therefore, to verify flow in the channels and to establish flow procedures, we have often used nano particles which can be assumed to move precisely along with the liquid.

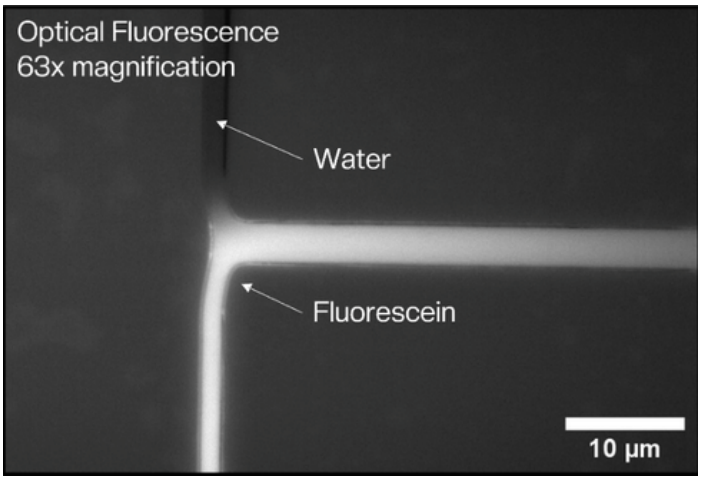
In the video above, you can see an example of how nano particles can be tracked in the channels. In this case, we used a syringe to adjust the position of nano particles in the channels.
They are controllably flown in one direction in the channels until they are centered, after which the applied pressure is stopped, leaving the particles diffusing around in the field of view.

Here you can read an application note on our website, about how the flow can be precisely controlled in the nano channels using hydrostatic pressure.

4.5. MIXING IN THE FIELD OF VIEW

4.5.1 Bringing two liquids together in one channel

- One of the most unique features of the Nano Channel Chip is its ability to bring two channels, containing different reagents, together directly in the field of view so their chemical reactions can be observed in real time. The basic principle is beautifully illustrated with this below image of fluorescent fluorescein and water coming together from two nanochannels, into one:



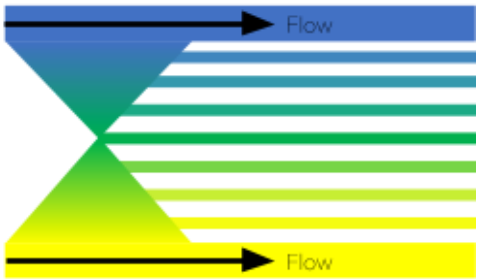
The above image clearly verifies the concept of mixing in the field of view. However, it is a challenge to mix liquids reliably in the TEM using this method since it requires very precise balancing of pressures in both micro/bypass channels at once. Even tiny differences in viscosities or potential micro-agglomerations of particles will have a big effect when it comes to nanofluidic channels containing only femtoliters of fluid!

4.5.2. The ”Butterfly Mixer”

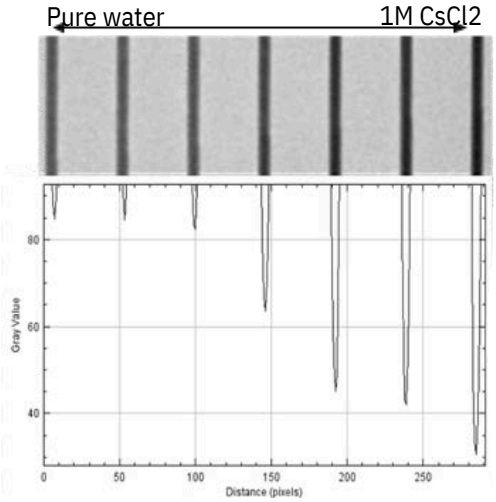
To create more robust mixing methods, we’ve created a design that is less sensitive to having exactly matching pressures in both micro/bypass channels. We call it the “Butterfly

Mixer” due to some internal channel structures that look like the wings of a butterfly. This design is more dominated by diffusion, which is very reliable compared to pressure control in a nanofluidic flow cell.

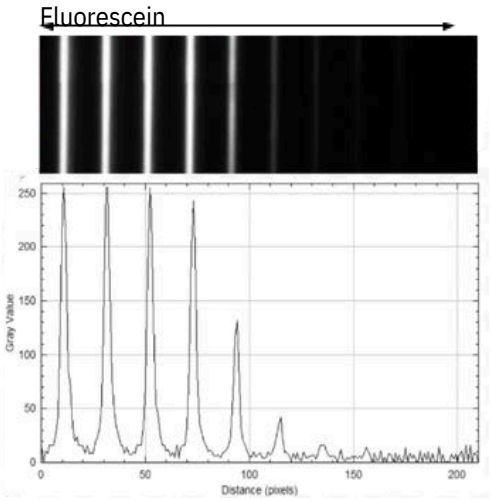
Illustration of the Butterfly Mixer: Two liquids are flown in in each micro/bypass channel and mix very little through a small connection point between them. The point is so small that pressure differences between the bypass channels never drive a very large flow between them. Therefore, the mixing in this area is primarily driven by diffusion, which is slower, and also very stable in nanofluidic channels.



We have verified the Butterfly Mixer chip both in optical microscope and TEM. In optical, we've again utilized the fluorescent agent fluorescein to record images of the channels with varying degrees of mixing with pure water. In the TEM, we have used a solution of 1M CsCl2, a heavy compound solution showing up as almost black in the TEM, against the more light-gray pure water. We have seen repeatedly that we get an array of varying mixing conditions in the array of nano channels.



TEM image of the Butterfly Mixer in action. To the left, pure water is coming in through one bypass/microchannel. To the right, 1M CsCl2 is coming in through the other bypass/micro channel. The intensity plot in the bottom shows how the intensity is roughly 50% of max right in the middle. Image credit: Tayyaba Malik.

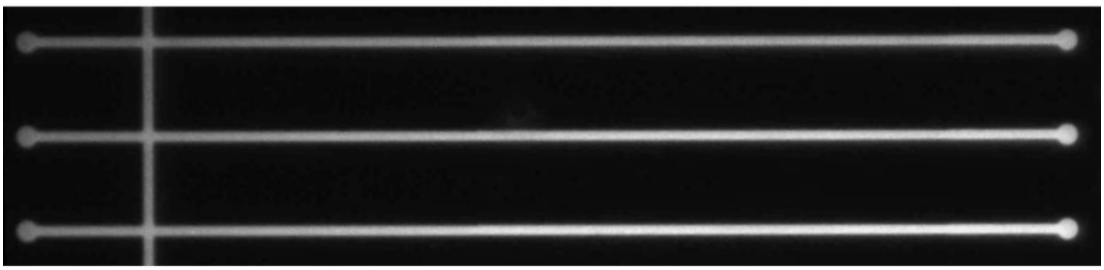


Fluorescent optical microscope image of the Butterfly Mixer with fluorescein coming in from the left and pure water coming in from the right. Image credit: Tayyaba Malik.

4.5.3. The sequential diffusion mixing method

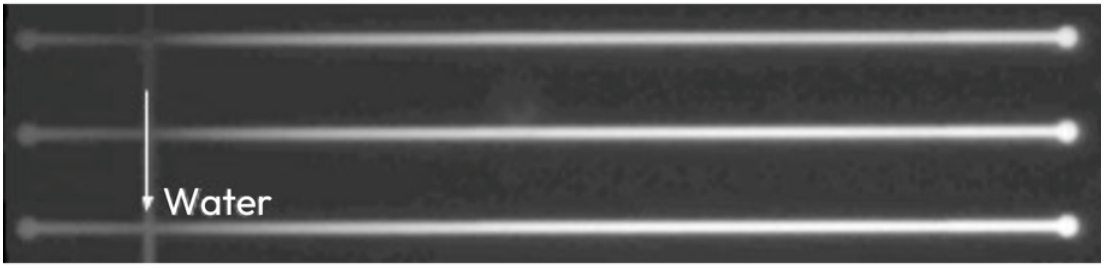
As you can see above, the Butterfly Mixer does not guarantee a perfect 50-50 mixing right in the central channel. To create a fool-proof mixing method that works every time and guarantees stable and well-known initial conditions, we also utilize dead-end channels (which have zero flow) to mix, relying 100% of diffusion and less on the precision of applied pressures to the system. This method utilizes the guaranteed no-flow conditions of dead-end channels and works as follows:

1. The first reagent is injected into the nano channels and fills up every available space, also the dead-end channels. Even bubbles are squeezed out of the liquid due to the high capillary pressure.



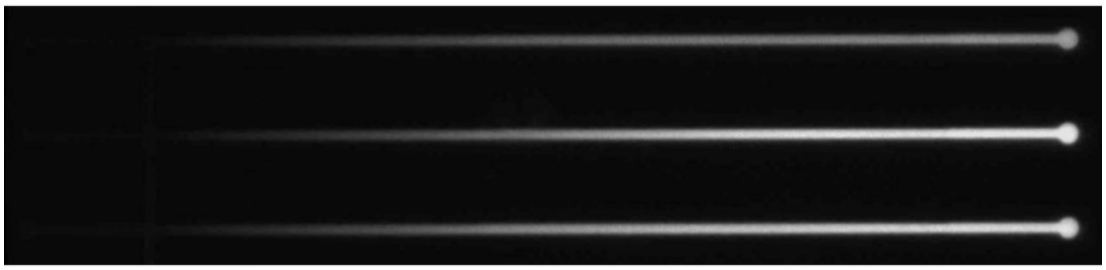
That first liquid could be fluorescein as is shown above, evenly filling all parts of the nano channels, both short and longer dead-end channels. The concentration is known with 100% accuracy.

2. A second reagent is flushed in, pushing the first reagent out of the channel which is connecting the two bypass channels. The first reagent stays stuck in the dead-end channels.



In this example, water can be seen pushing out the fluorescein from the channel coming down through the flow channel. Almost immediately, the fluorescein in the short dead-end channels (to the left) diffuses out and gets carried away with the ongoing water flow. In the longer dead-end channels, however, plenty of fluorescein remains, slowly diffuse together with the fresh supply of pure water.

3. Mixing occurs between the two points of well-known conditions, via diffusion which can be modelled precisely.

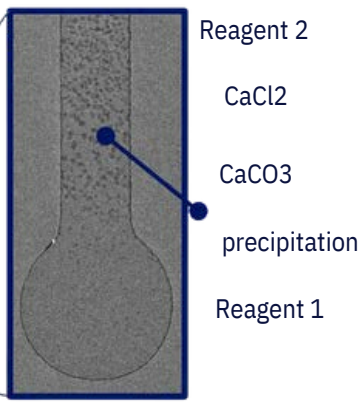


In this case, the left side is now 100% pure water, and the right side is 100% of the fluorescein solution. In between the two points, diffusion will be responsible for a steady reaction site where each point can be modelled precisely in terms of mixing concentrations over time.

An example of this technique used is with CaCO3 crystals grown in the channels from first filling with CaCl2, and then introducing NaCO3 to mix with the first reagent.

The result: CaCO3 growing in the dead-end channels!

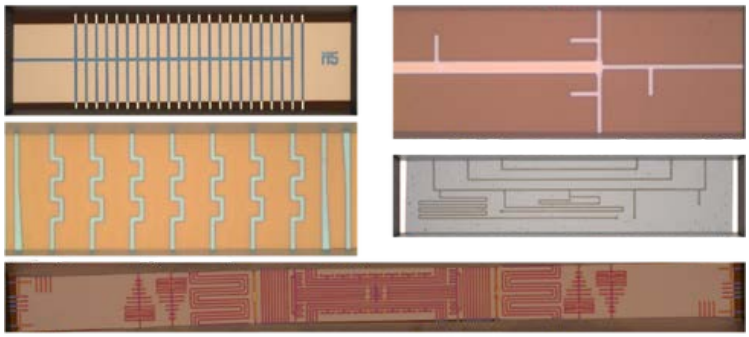
Optical image of the chip design containing many dead-end channels



Low-mag TEM

4.6. WHY ARE THE CHIPS DIFFERENT COLORS?

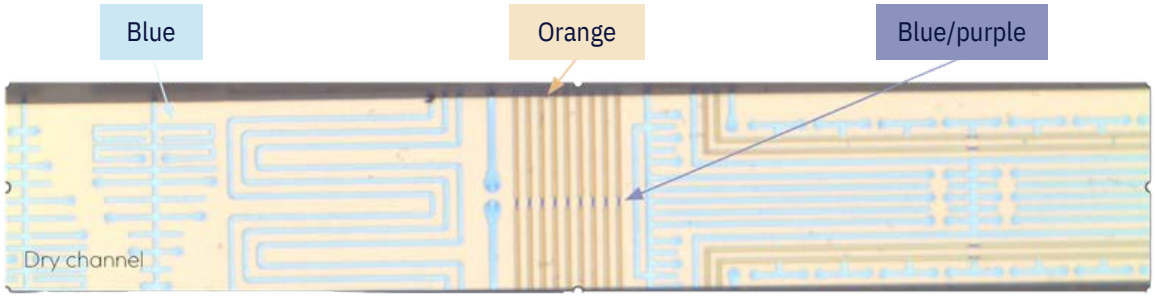
The Nano Channel Chips all look the same to the naked eye, but when put under an optical microscope, the channels can be seen in great detail. The channel patterns obviously are different, but so is the color of the channels, as well as the entire membrane.



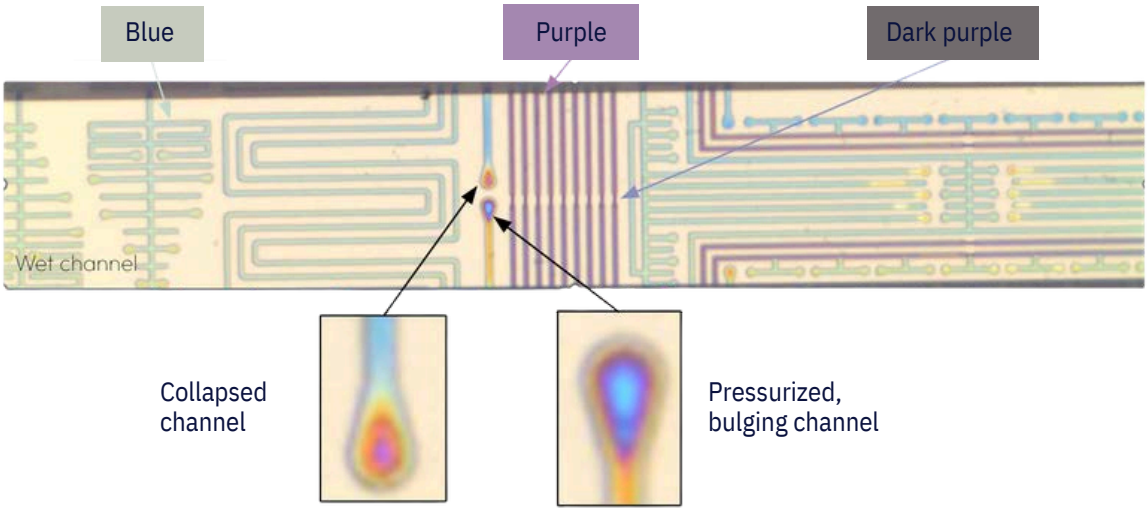
The field of view of different batches of nano channels as seen with a 20x objective.

The reason for this is the change in refractive index as visible light travel through, and reflects, on the membrane. The membrane without any channels will change color based on its thickness and so will the channels based on their thickness, as well as the nitride surrounding them. Additionally, as liquids enter the channels, the refractive index will again be different than when the channels are full of air, which agian will give different color of the channel.

As an example, that shows a lot of color dynamics in one chip, this one below has three different depths of channels which comes out as three different colors. When the chip is dry/filled with air, the turquoise channel are around 150 nm, the orange are about 200nm, and the blue/purple are about 59 nm. These 50 nm parts create traps, which means that particles under 200 nm can be flown into the channels but get stuck at the 50 nm thin part.



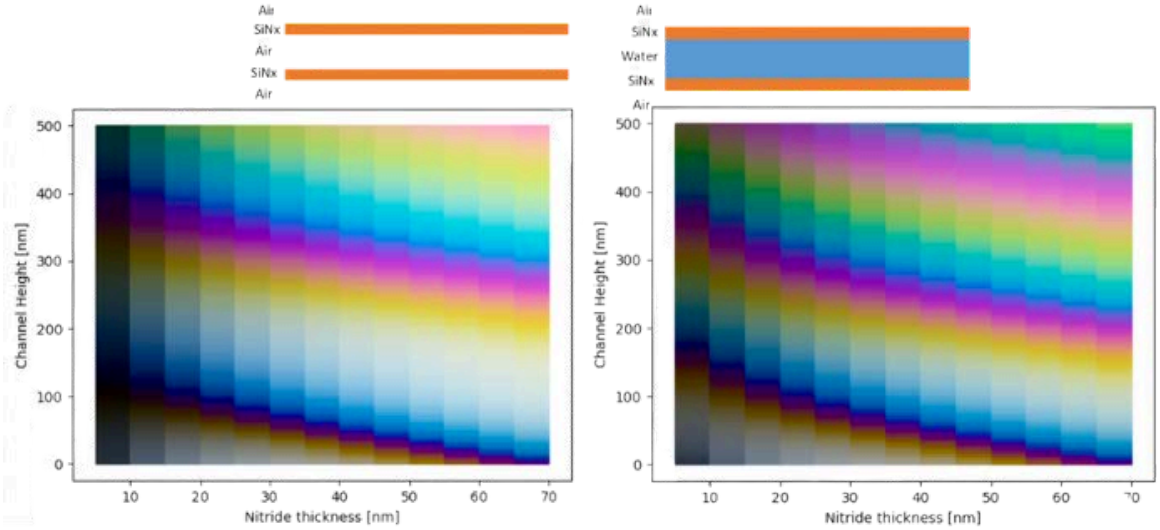
A great difference is seen when the channels are filled with water. All the channels change color due to being filled with liquid:



Further, the dead-end channels around the middle of the image reveals collapsing and pressurization of decoupled channels, which show a gradient of different colors as the channel varies in thickness. The bottom-channel is the pressurized one, and the top channel is still mostly dry (turquoise) but some moisture must have reached the channel via the other nano channels and creates capillary forces that makes the channel collapse.

4.6.1 Color charts

We often use the colors of the chips to verify that they are the expected thickness. Below diagram hangs in our lab at DTU by the optical microscope so that we can always look up and confirm we have the right chip for our experiment – whether it's dry or already filled with water. It only requires prior knowledge of the nitride thickness to read these charts and we'll make sure to provide you with that knowledge with all the chips you receive from us.



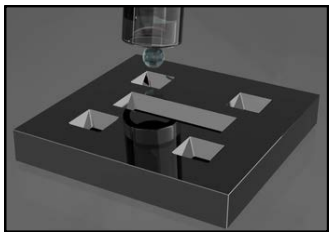
4.7. NANO PARTICLES: The most typical type of sample in the Nano Channel Chips

Working with nano particles is critical in the field of liquid-cell TEM. In the following, we will go over typical use cases involving nano particles, such as how to prepare them, and typical experiments utilizing liquid exchange, flow, or mixing while the TEM experiment is going on.

4.7.1. Getting nano particles into the channels

Since the Nano Channel Chip is a monolithic structure, it cannot be opened up to drop-cast sample material onto the membranes. Instead, all samples must flow into the chips via the bypass structure in the chips.

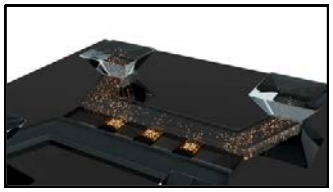
The first of the two animation videos from above illustrates how this works. Here is a breakdown of the process:



1) First, a liquid droplet containing the sample is drop-casted with a micro-pipette onto any of the four inlets in the chip. 0.5-1.0 µL is more than *plenty* as the microchannels in the chip are only of the order of *nano* liters.

2) After the liquid makes contact with the chip surface, very powerful capillary forces will pull the liquid into the micro-bypass channels.

The sample will, of course, flow along with the liquid!



3) The liquid will continue to fill the bypass- and nano channels until they are fully wetted. While this wetting process goes on, particles are continously supplied to the nano channels.

Filling the chip with particle-containing liquid works the same whether it happens through a drop from a pipette, or from the tubing in the holder. Therefore, liquid can just as well be filled through the tubing in the holder.

This will, however, require more sample to spare, as each flow port in the holder has about 5 µL of dead-volume.

4.6.2. The Nano Particle Trap Chips

When nano particle containing liquid fills the chip, there will be a flow of particles running through the nano channels. This means that many particles actually flow all the way through the nano channels, from one bypass channel, into the other.

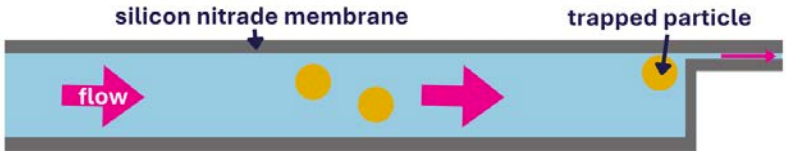
This is not desirable, as particles typically are wanted to stay inside the nano channels, not flow through them.

A solution we have come up with for this issue, is the Nano Particle Traps!

Read our paper showcasing the Nano Particle Trap Chips here

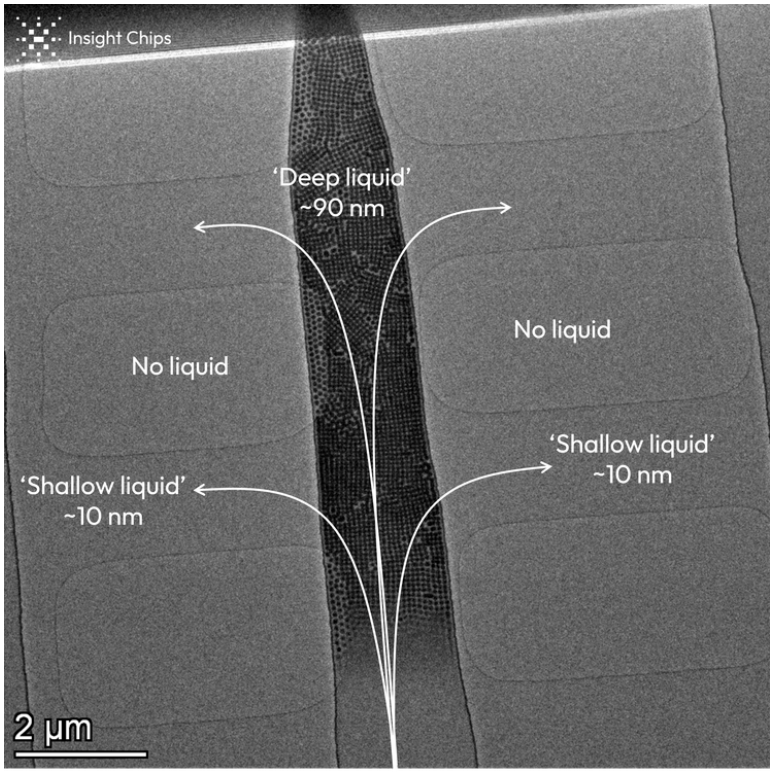
The Nano Particle Trap Chip works by preventing particles from flowing through the nano channels, by creating a confinement in space, through which only liquid can flow.

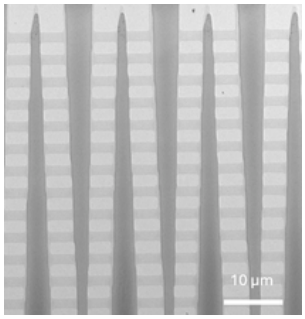
As illustrated in the picture below these channels have two liquid thicknesses. A particle carried by flow enters the thicker region, but its size prevents it from continuing to the narrower section, trapping the particle in confinement zone.

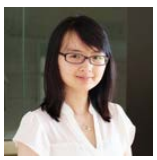


An example of this is seen here, where we conducted a product demo with Prof. Qian Chen's research group at UIUC, the University of Illinois at Urbana-Champaign.

In this experiment, we drop-cast a gold-particle solution into a Nano Channel Trap Chip and watched how the thousands of particles piled up in each of the traps 50 trap channels.





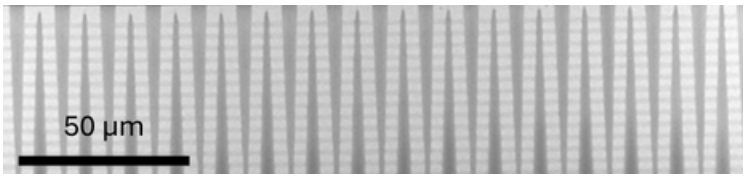


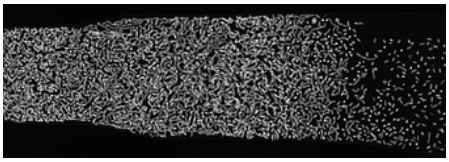
Prof. Qian Chen
UIUC

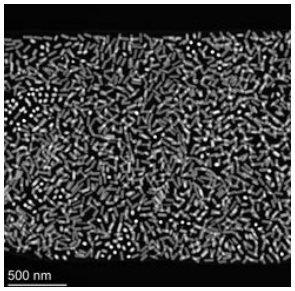
Dr. Oliver Lin
UIUC

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Another example of using these trap chips is from our customers at Stanford University where we, also on the first try, injected gold rods into the Nano Channel Trap Chip, and then performed a **galvanic replacement experiment**!







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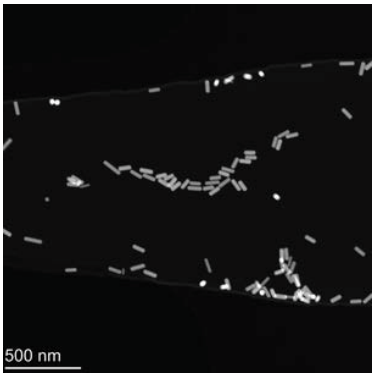
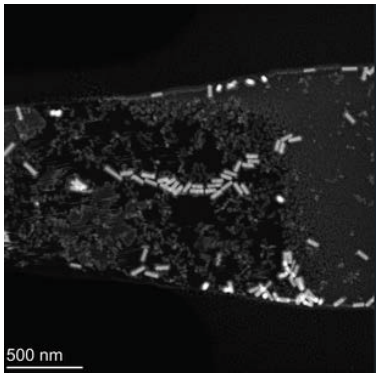
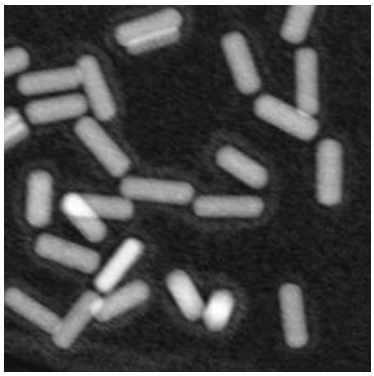


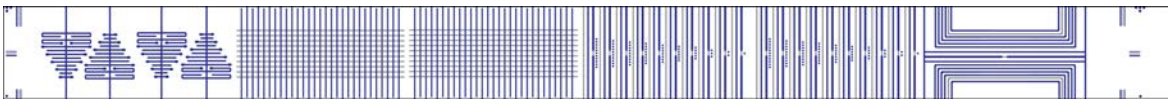




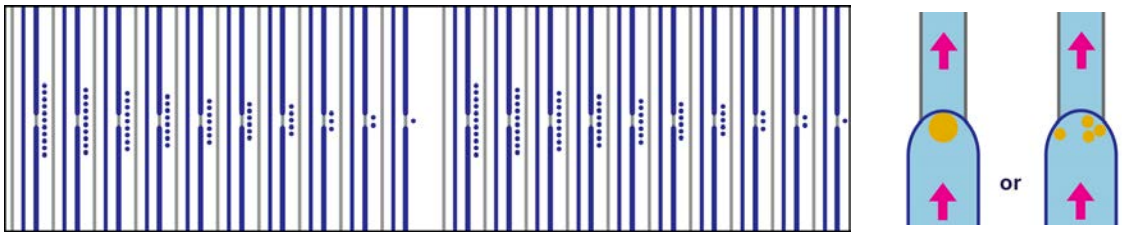
→ Injecting new liquid to initiate galvanic replacement process → Core shell structures are observed in the nano channels

4.7. ALL IN ONE CHIP

Over the years, we have developed numerous nano channel designs with various functions, ranging from flow control and liquid exchange to mixing and particle trapping. We have now combined all these features into a single chip. The new all in one design features four distinct sections, each serving a specific purpose and allowing universal usage.

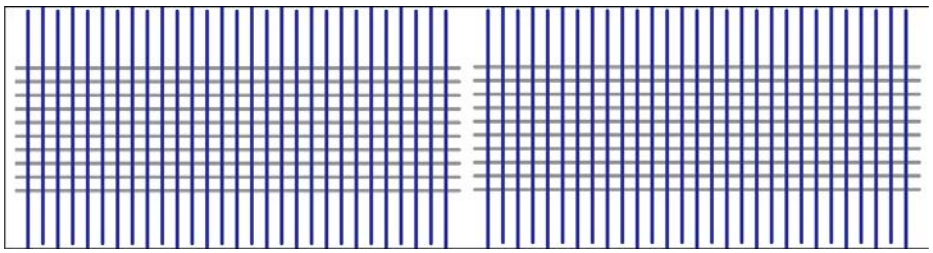


4.7.1. Straight channels and straight channels traps

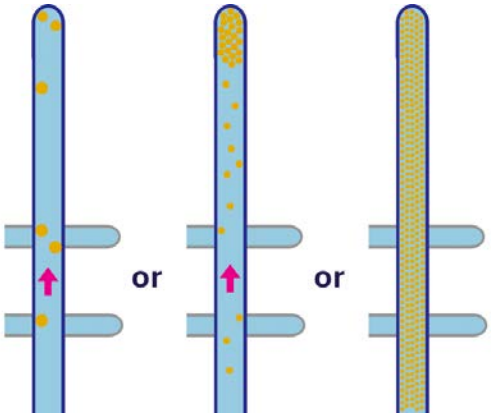


This section includes straight trap channels with confinement zone in the end. These traps are great for trapping single or few particles at the end of the thinner channel. Adjacent straight channels located next to the trap channels can be used for liquid mixing or observation of structure formation. These channels also feature two different liquid thicknesses, enabling direct comparison between the two conditions. The “dots” are navigation channels intended to remain empty during experiments, enabling faster orientation within the microscope field of view. They can additionally serve as a contrast reference to confirm liquid filling in the functional channels.

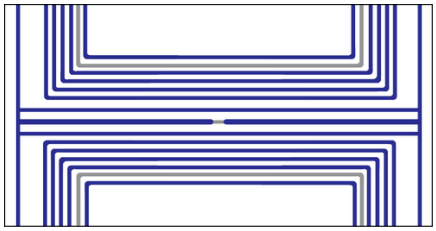
4.7.2. Ricdent channels traps



This design features multiple thinner trap channels that intersect the main channels perpendicularly, enabling the capture of a larger number of particles. The number of trapped particles depends on their size, shape, and initial concentration.

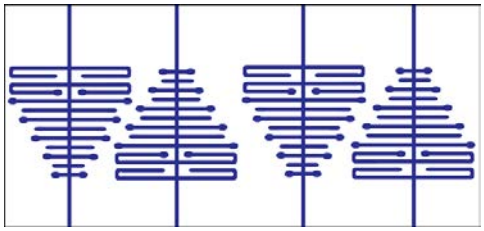


4.7.3. “U” channels



The U-channels are well suited for flowing different liquids through, enabling fluid exchange and mixing, and allowing observation of chemically induced reactions. This section also features two channels with lower liquid thickness and one trap channel.

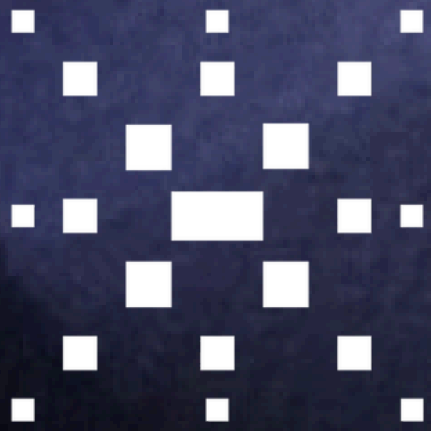
4.7.4. “X-mas tree” channels



The “X-mas tree” channels incorporate multiple dead-end branches of varying lengths. This design is ideal for flow-based mixing: residual liquid remains in the dead ends and mixes with the newly incoming liquid. Dead ends are also convenient locations for particle studies.

5. NANO CHANNEL CHIP GENERAL SPECIFICATIONS

SPECIFICATIONS	NANO CHANNEL CHIP
Chip dimensions	4.2x4.2x0.7 mm
Nano Channel width	1-3 µm
Nano Channel depth	Down to 20 nm
Nano Channel length	Up to 1 mm
Silicon nitride membrane thickness	Down to 10 nm
Al2O3 coating on membranes	Down to 3 nm
Bypass/Micro channel height	10-15 µm
Typical bypass flow rate at 100 mbar	0.1 µL/min
Typical volume of a single nano channel	0.1x1x100 µm3; 10–17 m3; 10 fL
Typical volume of a single bypass /micro channel	1x10x1000 µm3; 10–14 m3; 10 pL
Nano Channel chip material	Si, SiO2 in inlets, Silicon nitride in all flow channels, coated with Al2O3 in all flow channels
Pressure tolerance	Not recommended to use over 2 bar in any SEM or TEM, although some chips can tolerate well over 20 bar
Allowed sample chemistry	The membranes of silicon nitride and Al2O3 appear stable with most dilute acids and bases. Avoid pH lower than 2 and higher than 10. Be cautious with higher concentrations of HNO3, H2SO4, H2O2.



Insight Chips