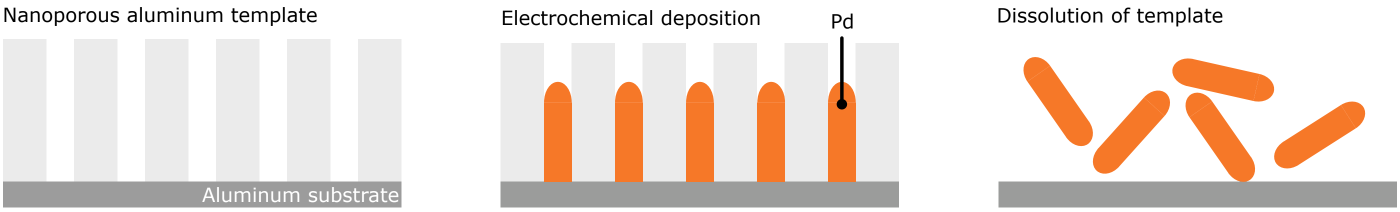
# TINY TENSILE WIRES

In situ observation of strain in growing nanowires

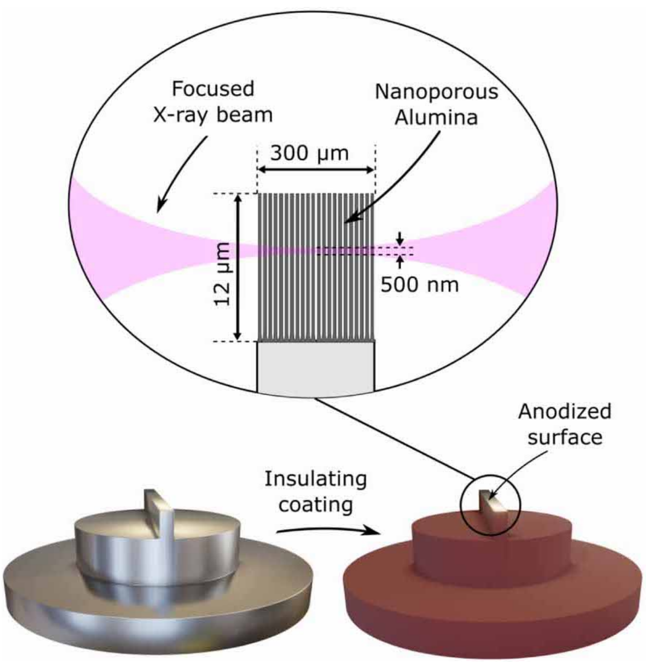
Nanowires are tiny filamentous structures that are 1000 times thinner than a human hair. Because of their small thickness, electrons can freely travel along the wire. Their motion in the other two directions however is governed by quantum mechanics. As a result, nanowires have extraordinary properties that are exploited in a number of technologies, such as magnetic storage devices, solar cells, electrocatalysts, and electronics. These potent fibers are produced either by extraction from a bigger piece of material, or by electrochemial growth in templates, such as nanoporous aluminum oxide. During growth, the nanostructures assume certain physical properties, like strain, which influence their performance. Now researchers have observed in situ how these properties develop during nanowire growth.




Production of nanowires in a nanoporous template.

## EXPERIMENTAL SETUP

In their experiment, the researchers from Sweden, Denmark, and Germany scanned palladium (Pd) nanowires during growth inside a template in an electrochemical cell. For this, they used synchrotron radiation at the In situ and Nano Diffraction beamline (P23) at PETRA III (DESY). The X-ray beam was focused onto a 500 nm spot at the sample location in a transmission geometry. The diffraction signal was detected with a LAMBDA 750k GaAs camera. **"The main benefit we saw of using the LAMBDA detector was the small pixel size, which allowed us to achieve a high resolution diffraction pattern necessary for us to detect small structural changes in the nanostructures we studied"**, said Alfred Larsson, lead author of the study.

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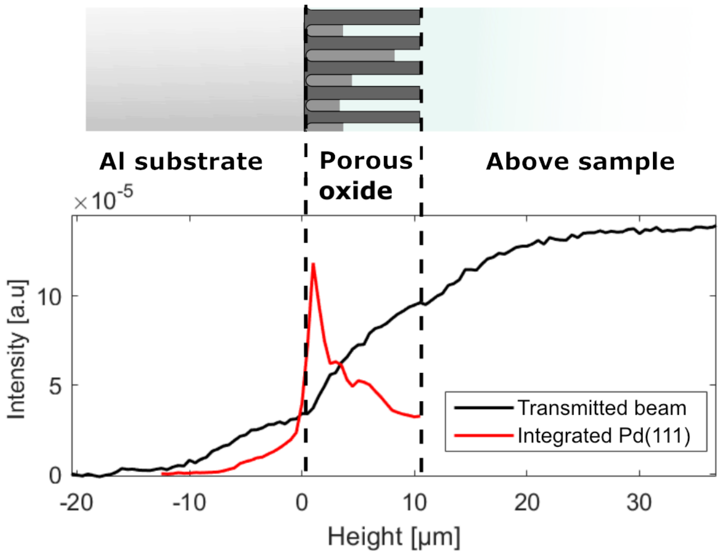
| Setup | PETRA III, DESY (Germany), P23 beamline |
| Camera | LAMBDA 750k GaAs detector |
| Resolution | 786,432 pixels with 55 µm |
| Acquisition frequency | 1 Hz |
| Photon energy | 18.275 keV |

The aluminum template receiving an insulating coating and anodized surface is shown at the bottom. The top inset displays how the focused beam hits the sample and how it is scanned in the vertical axis.

## RESULTS

From their data, the researchers were able not only to observe the growth of the nanowire in situ, but also to track the development of certain properties in the process. They specifically studied the strain, both in the direction of growth and perpendicular to it. They observed tensile strain along the long axis and, to a lesser degree, in the confined axis as well, which is likely an effect of the template. The researchers also identified a region of higher strain in the nanowires near the bottom of the template. The entire lattice was expanded in this in situ study if compared to previous ex situ measurements, which the researchers attributed to the absorption of electrochemically produced hydrogen. They expect their work to advance the understanding of nanowire growth with the ultimate goal to enable atomic scale tailoring of such nanowires.




Intensity of the transmitted beam signal and the integrated Pd peak after 40 minutes of growth.


## REFERENCE


- A. Larsson, G. Abbondanza, L. Rämisch, W. Linpé, D. V. Novikov, E. Lundgren and G. S. Harlow. In situ scanning x-ray diffraction reveals strain variations in electrochemically grown nanowires. Journal of Physics D: Applied Physics, Vol. 54 (23): 235301, 2021. https://doi.org/10.1088/1361-6463/abeb3d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