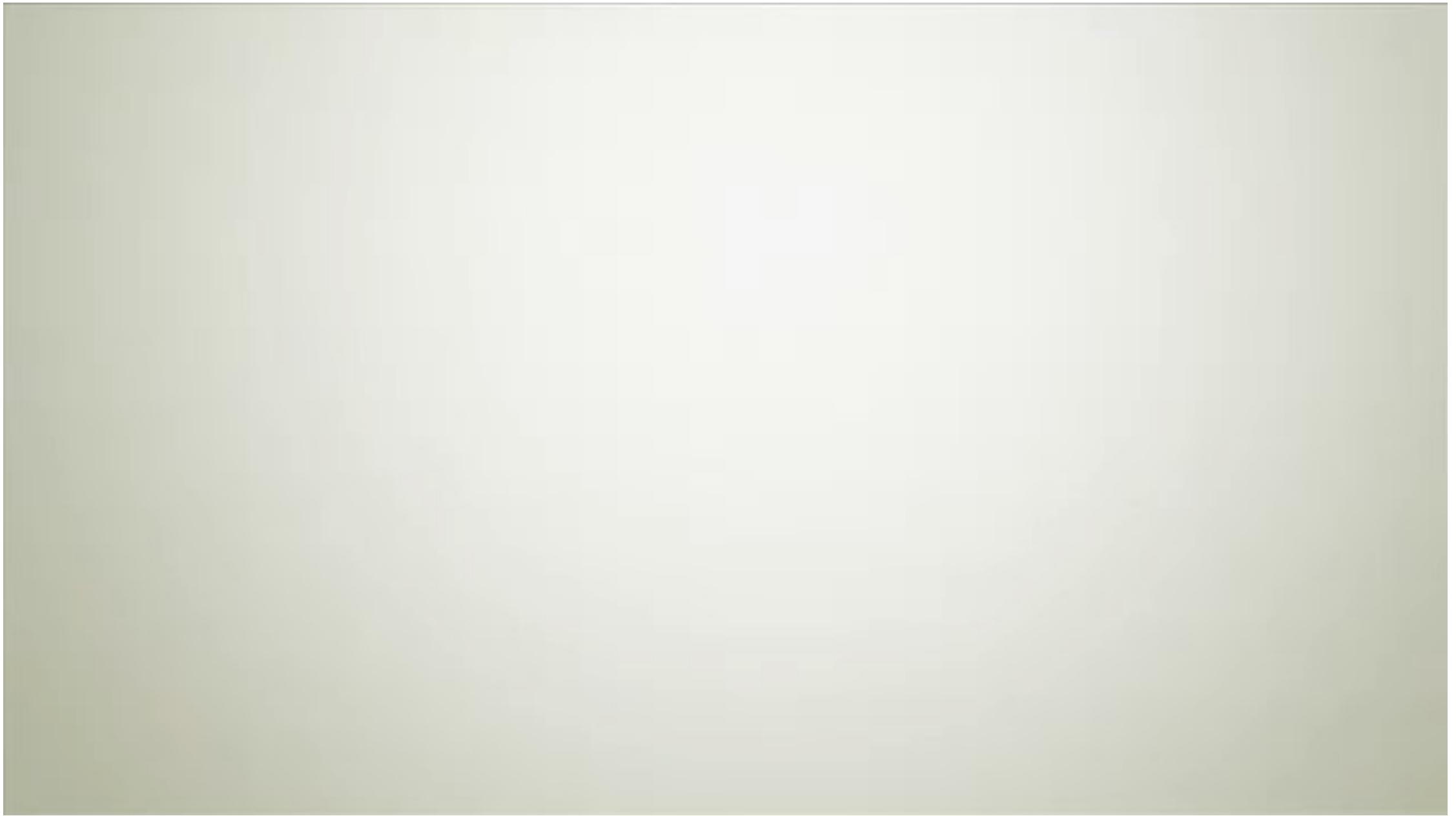
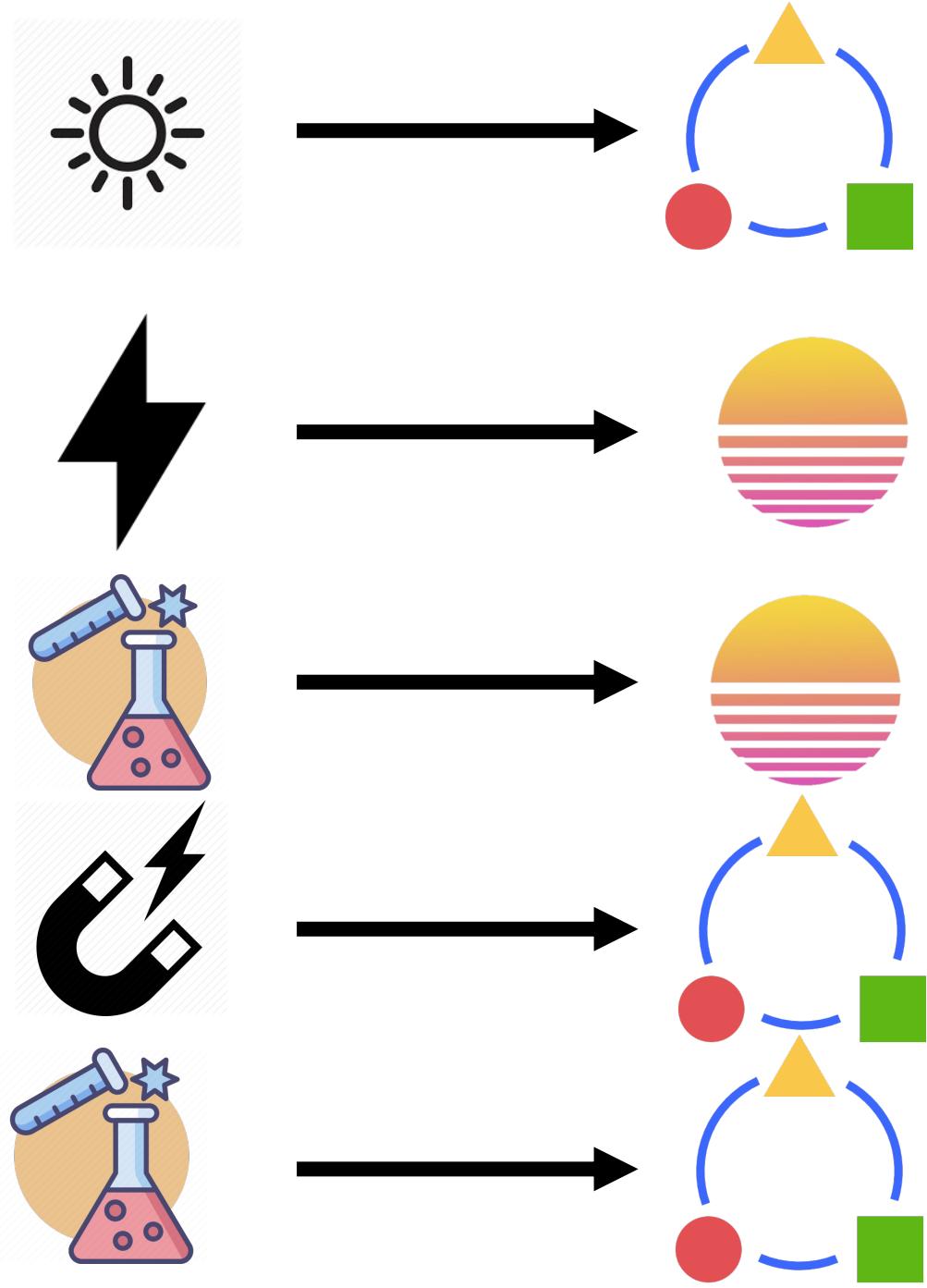
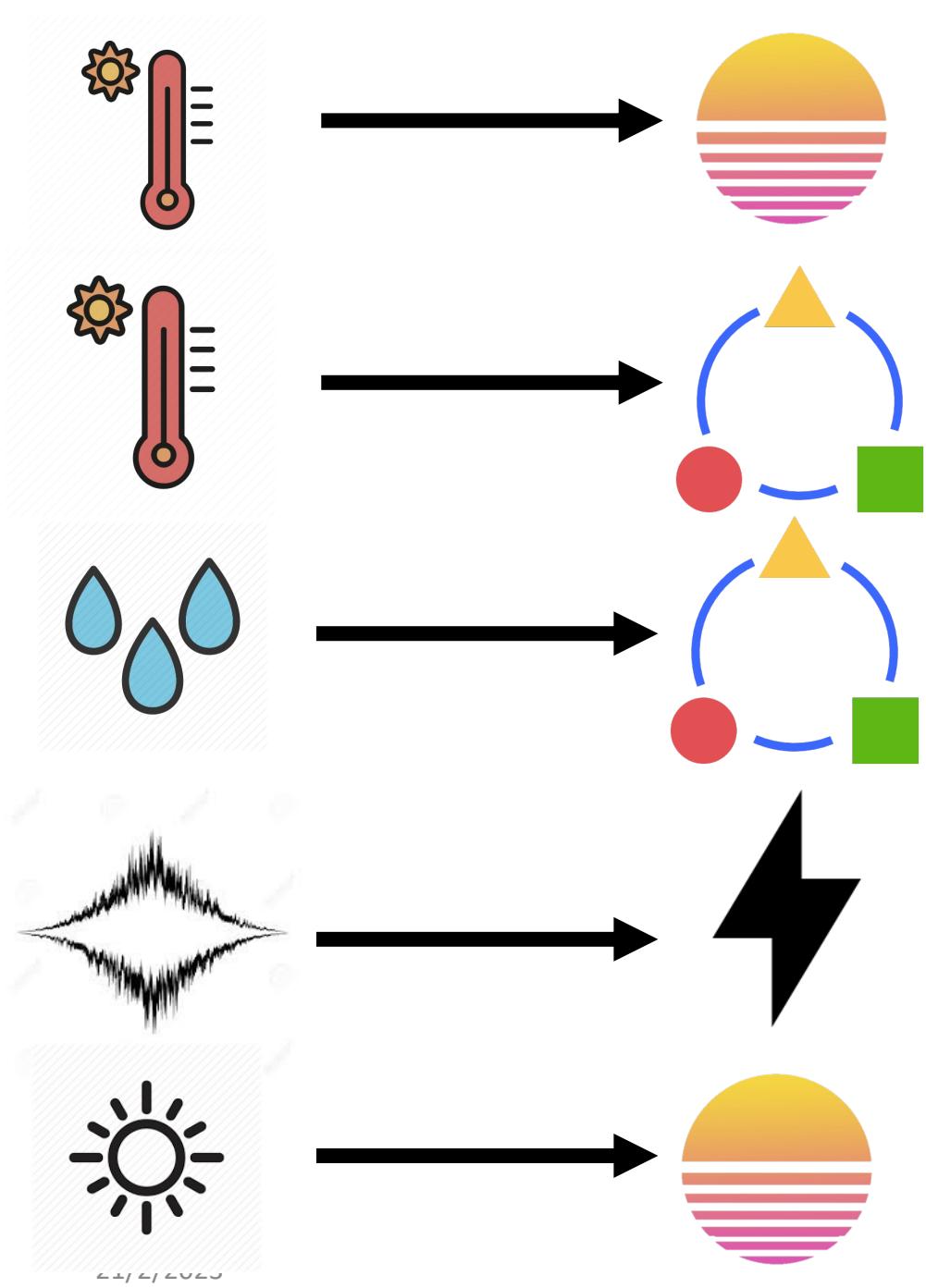


Smart Material I: Heat-Induced Shape-changing Material

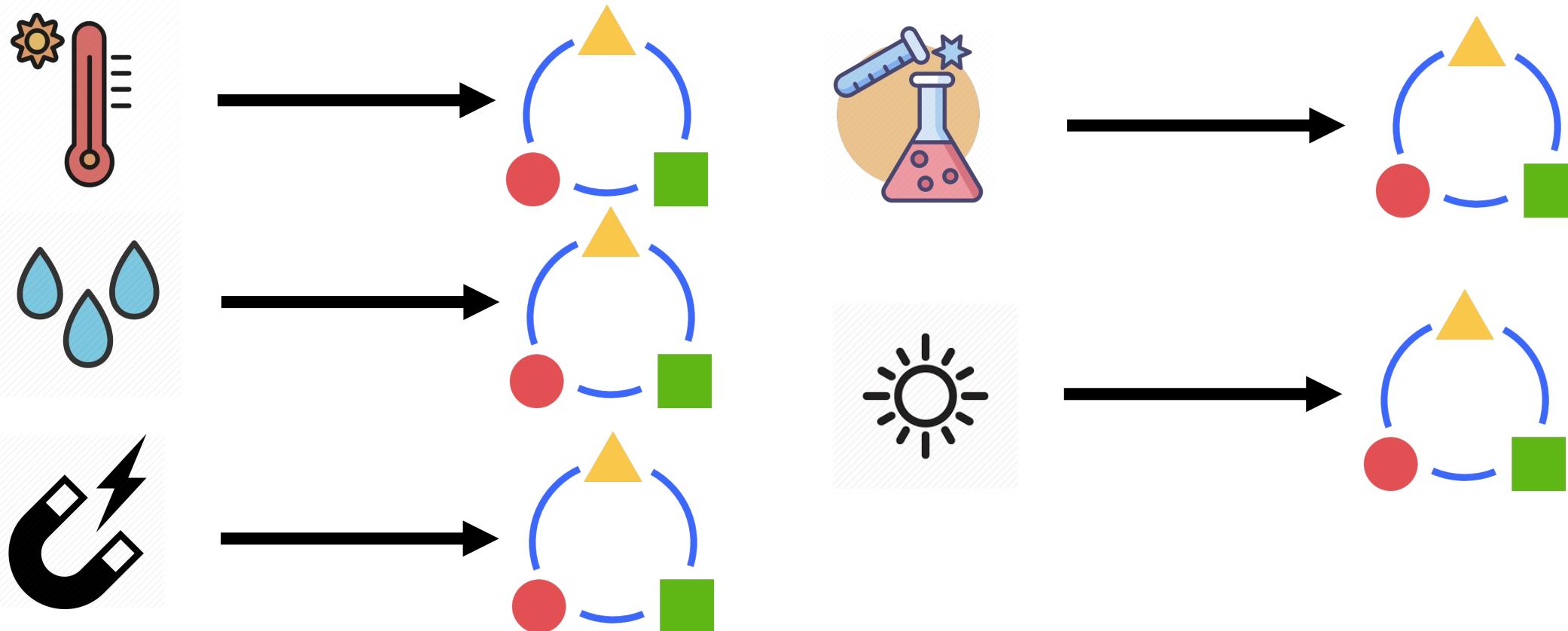
Smart? Responsive/Reactive

- Smart materials are the materials that can significantly alter one or more of their inherent properties due to the external stimuli.
 - Stress/Force/Pressure
 - Temperature
 - Moisture
 - Electric Fields
 - Magnetic Fields
 - Etc.
- Usually, the smart material can return to the original status after the stimulus is removed.





Shape-changing Material



Thermo-reactive Shape-memory Alloy (SMA) 形狀記憶金屬





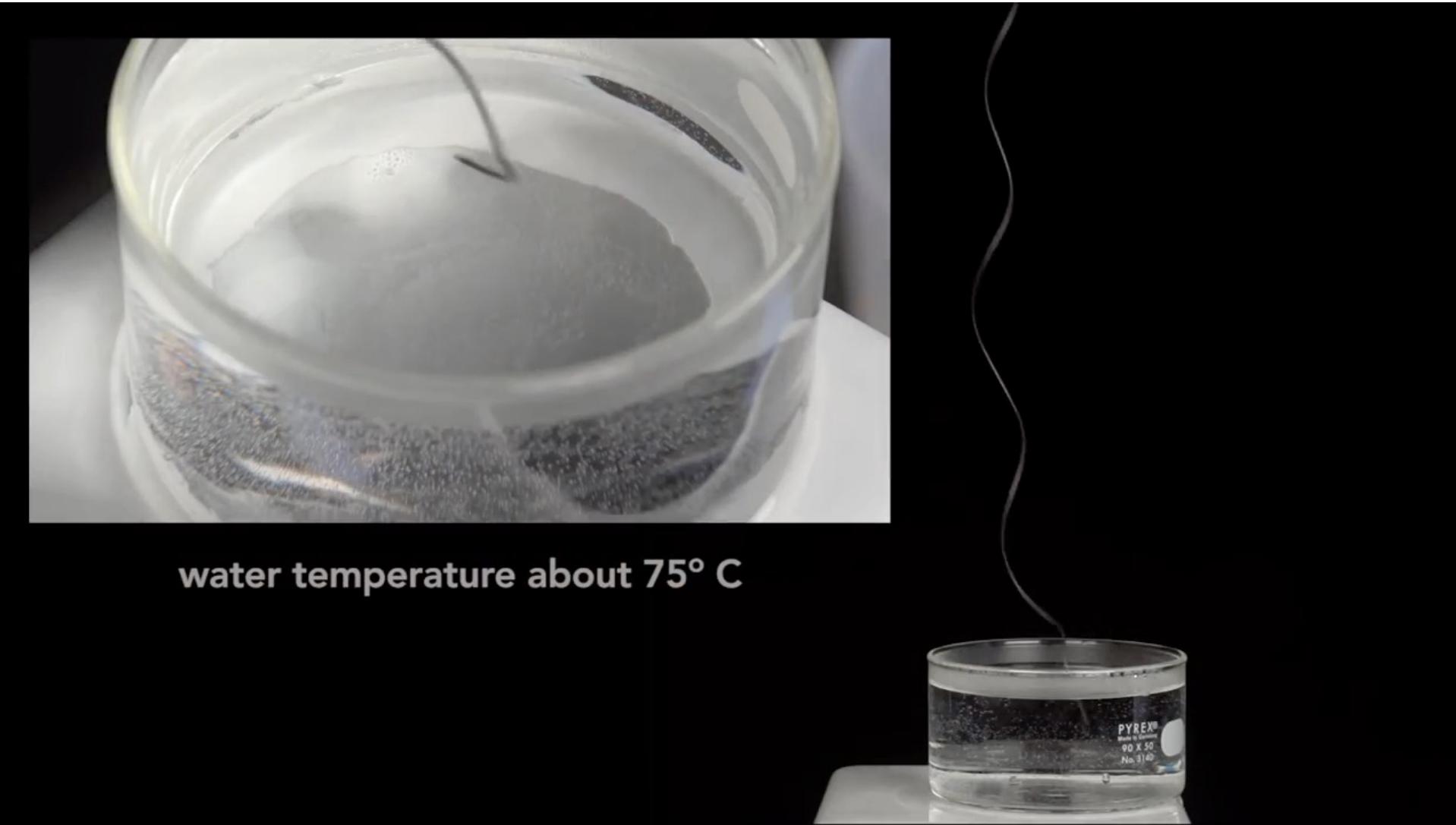


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<http://youtube.com/watch?v=231O7jlgwxI>



water temperature about 75° C



<https://www.youtube.com/watch?v=wI-qAxKJoSU>

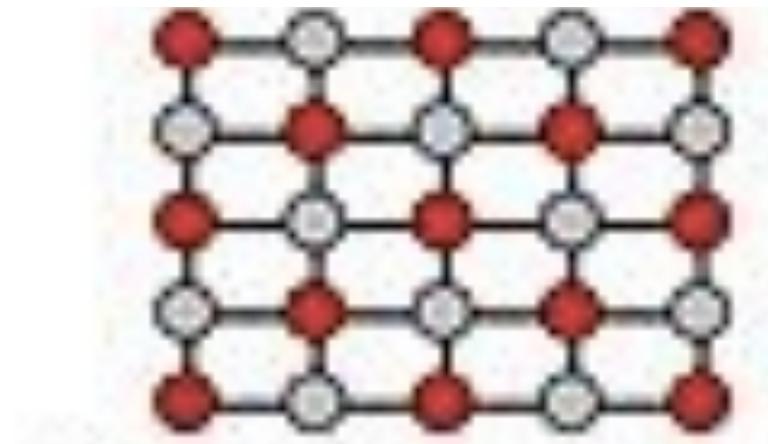
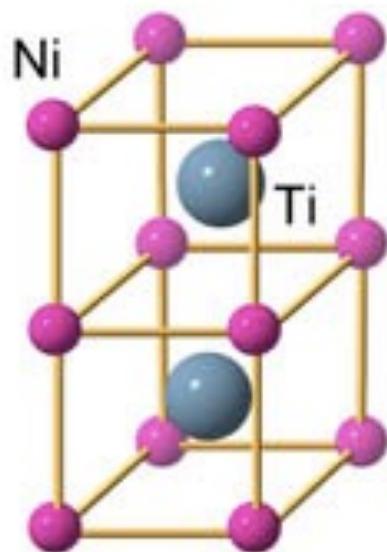
The Science Behind..

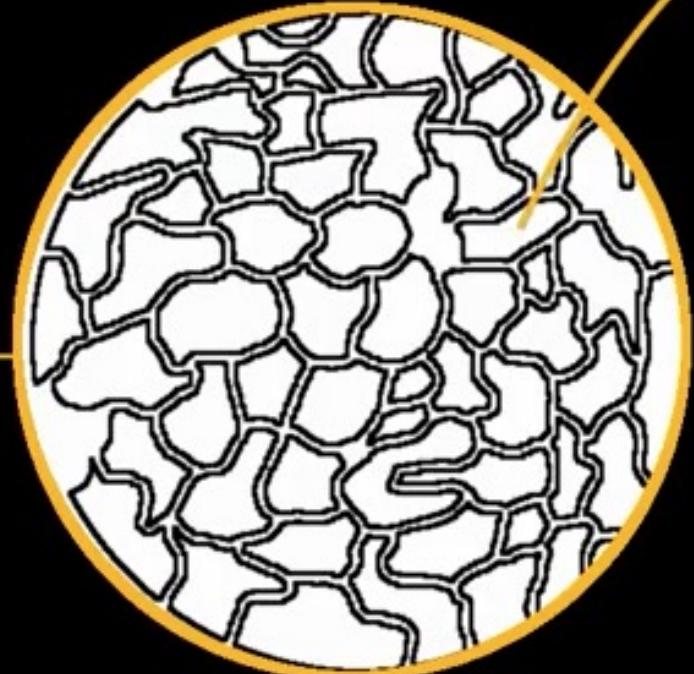
- Nitinol Alloy



The Science Behind..

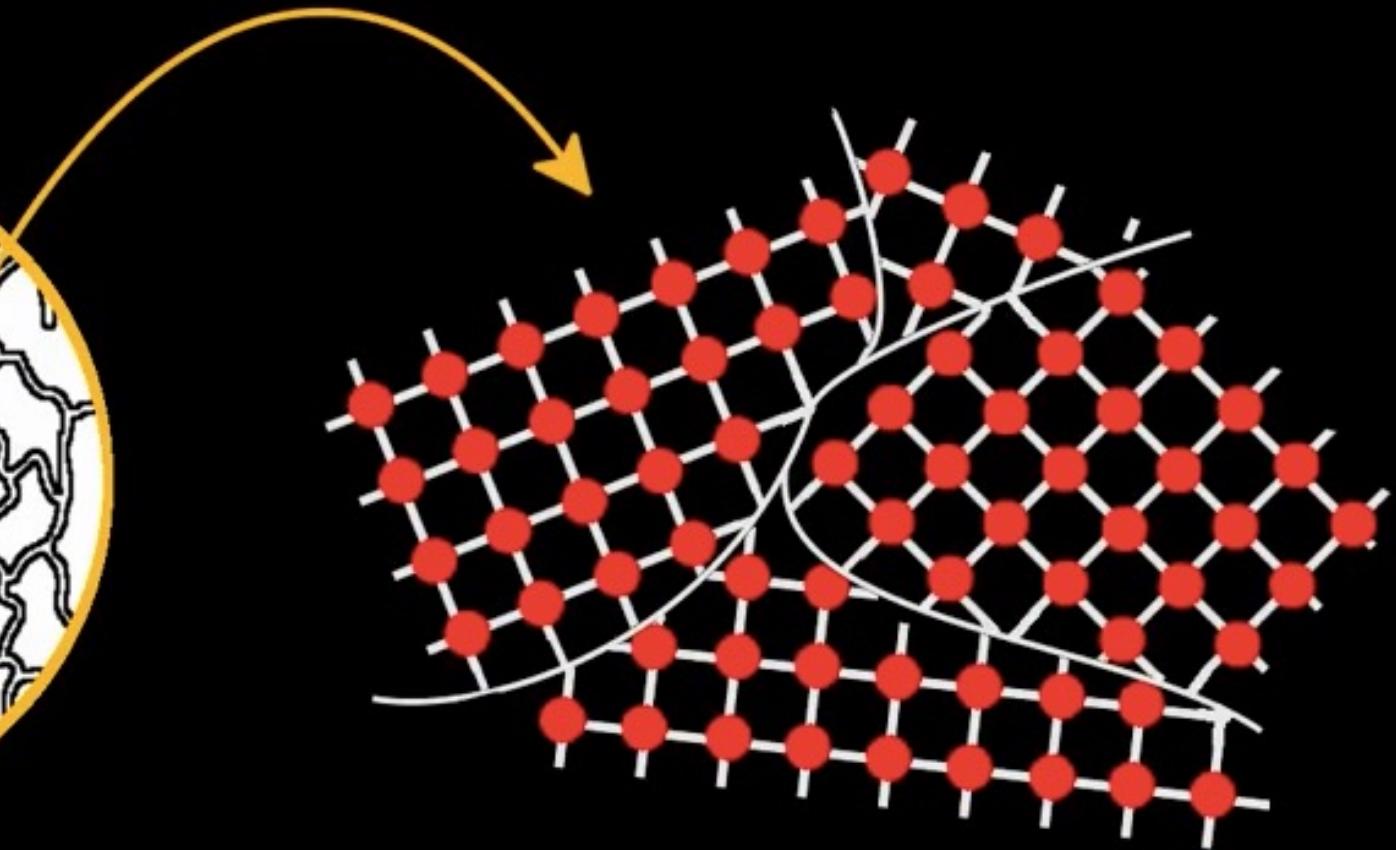
- Nitinol Alloy



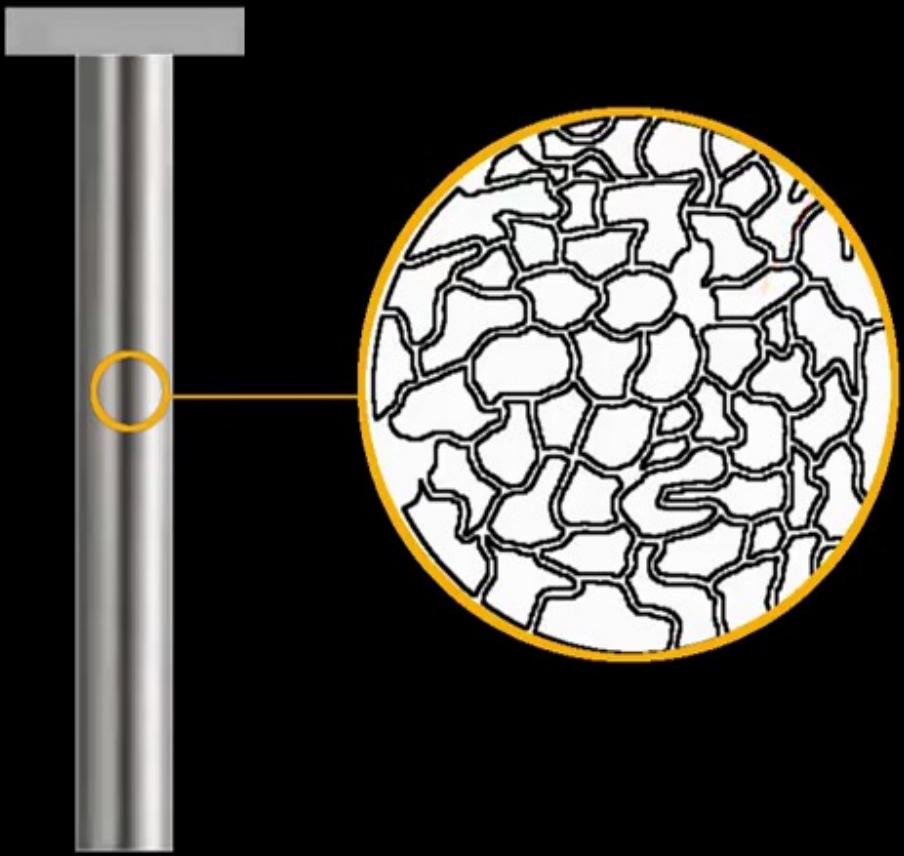


grains

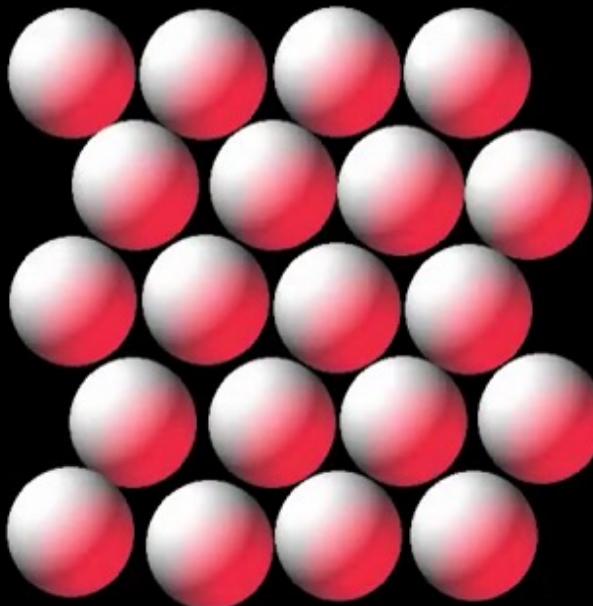
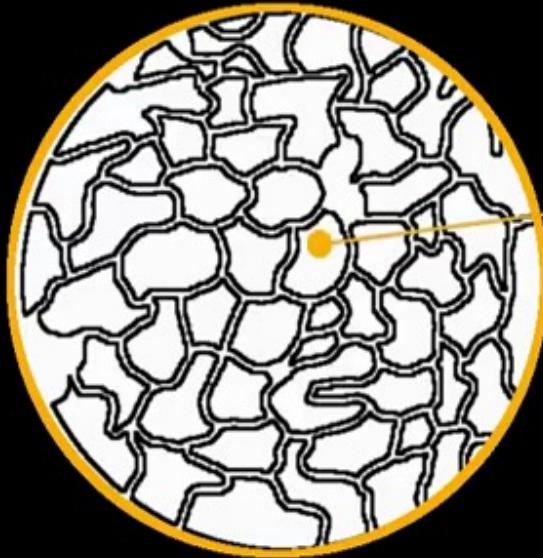
size: nanometers to microns

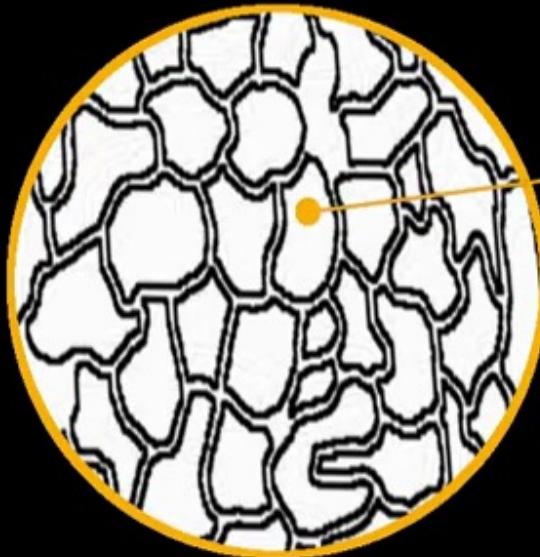


atoms
inside grains

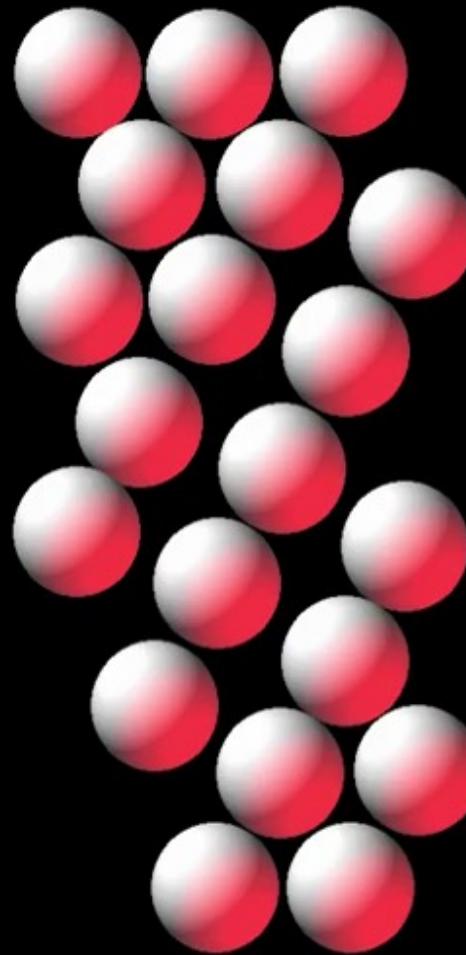






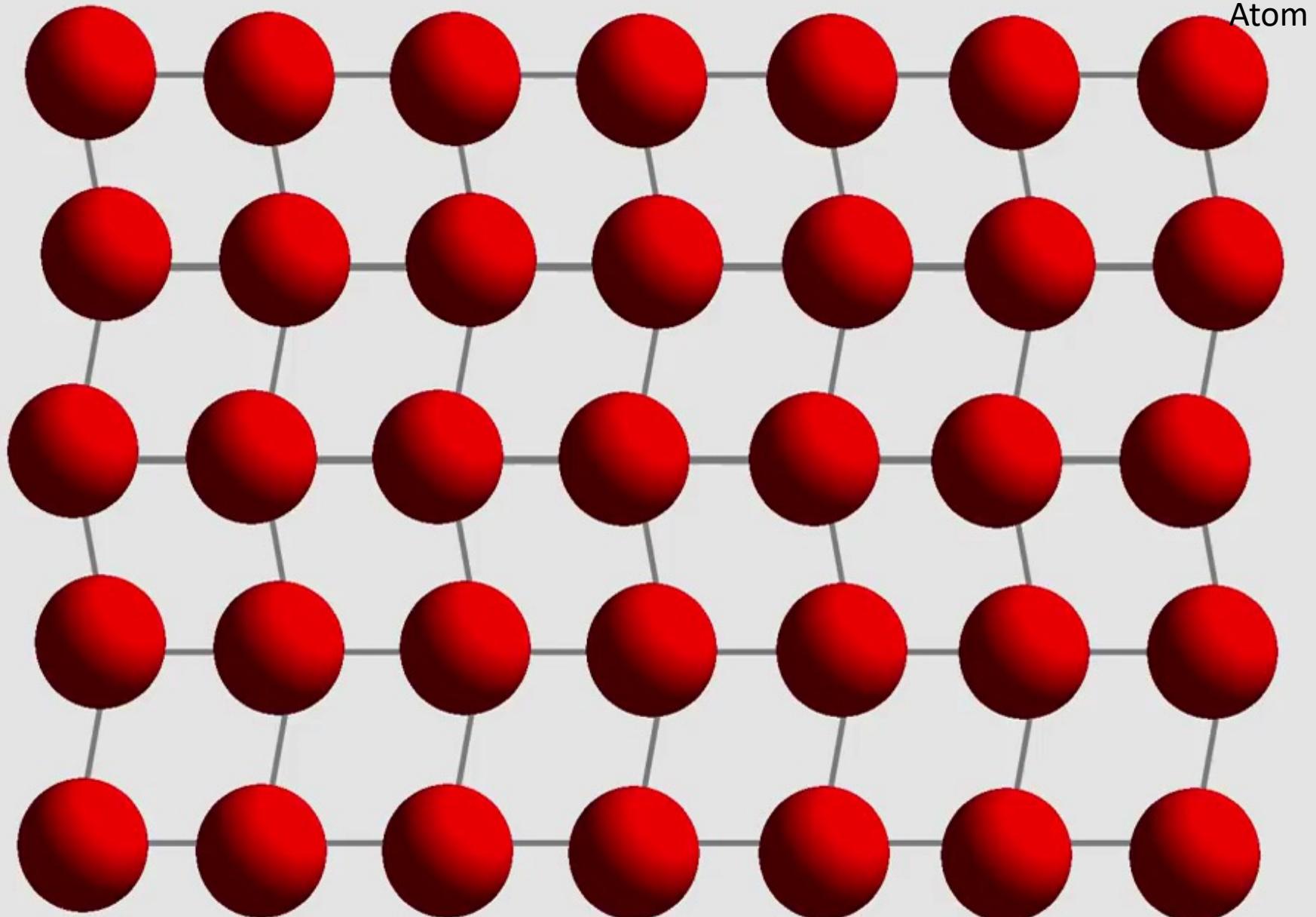


Slip



But then how SMA works

In room temperature ($\sim 20 - 24^{\circ}\text{C}$)

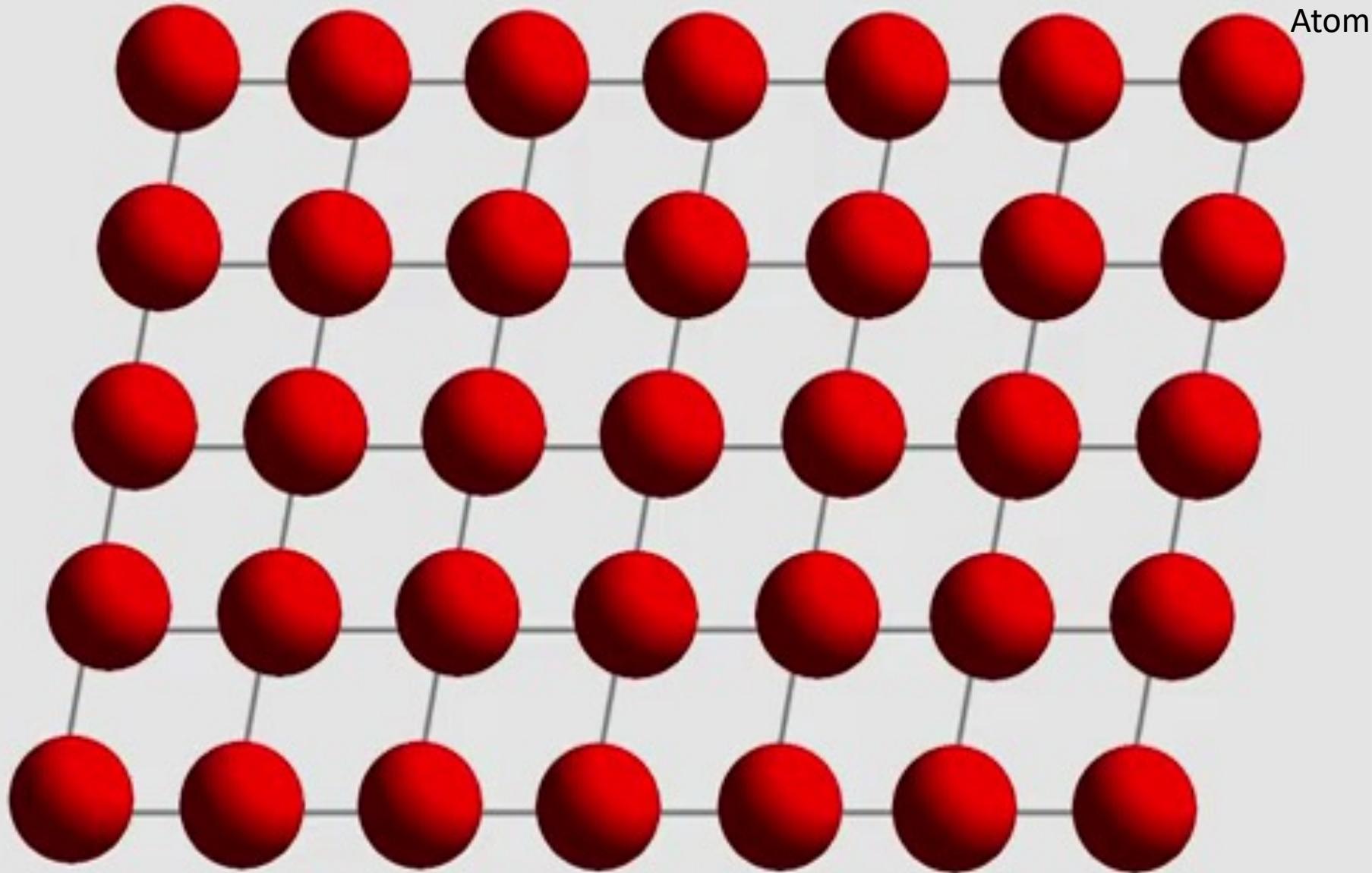


Atom

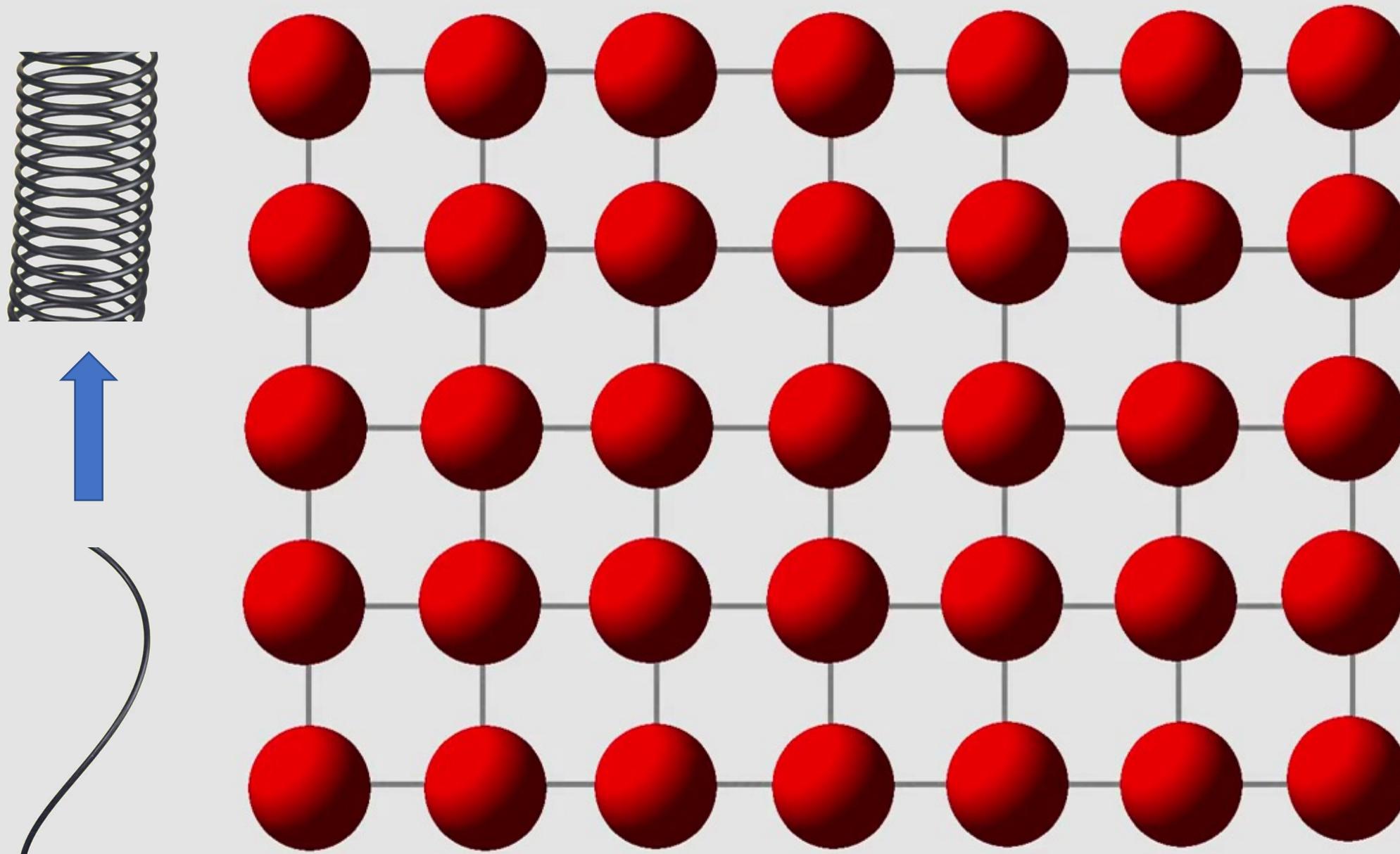
In room temperature ($\sim 20 - 24^{\circ}\text{C}$)



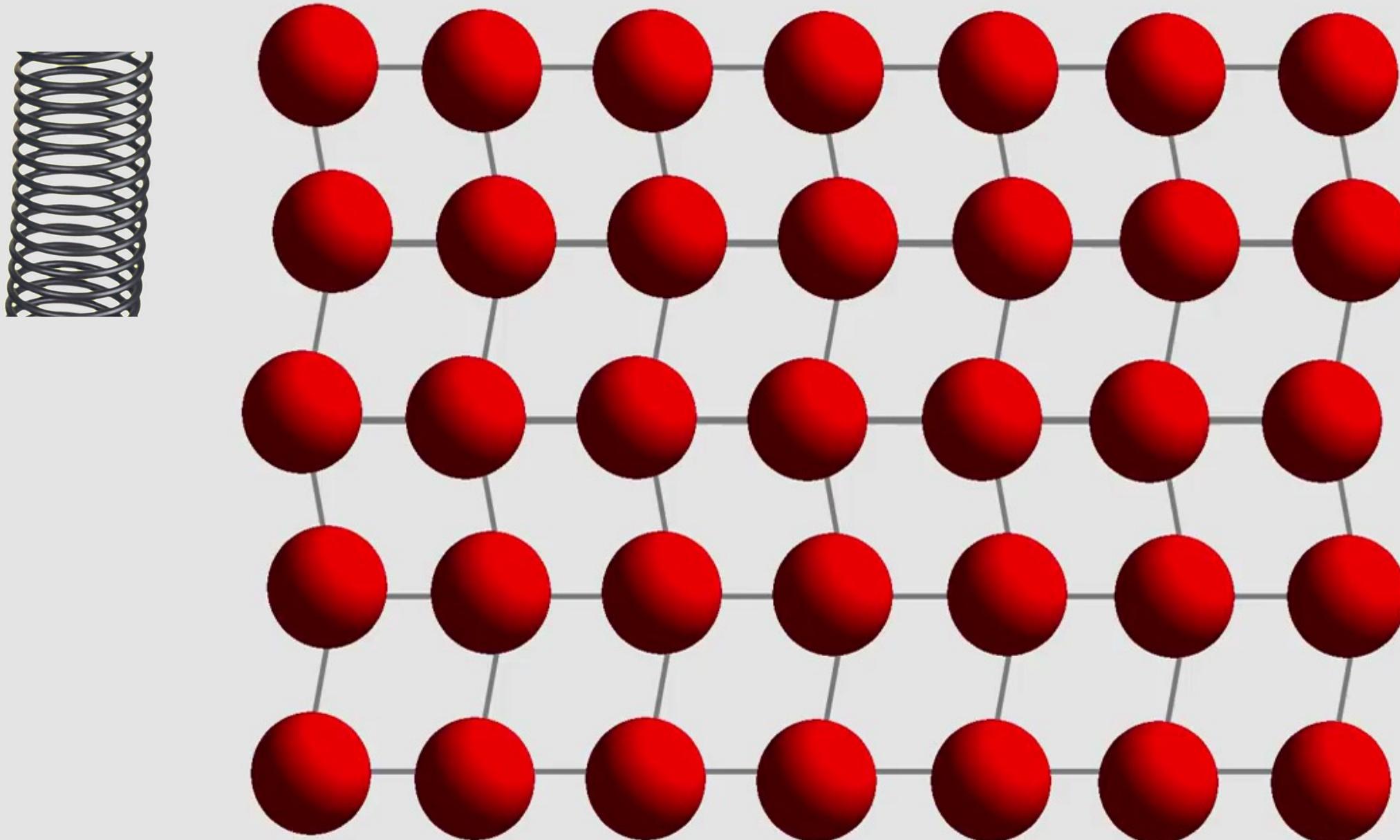
Pull by
external
force

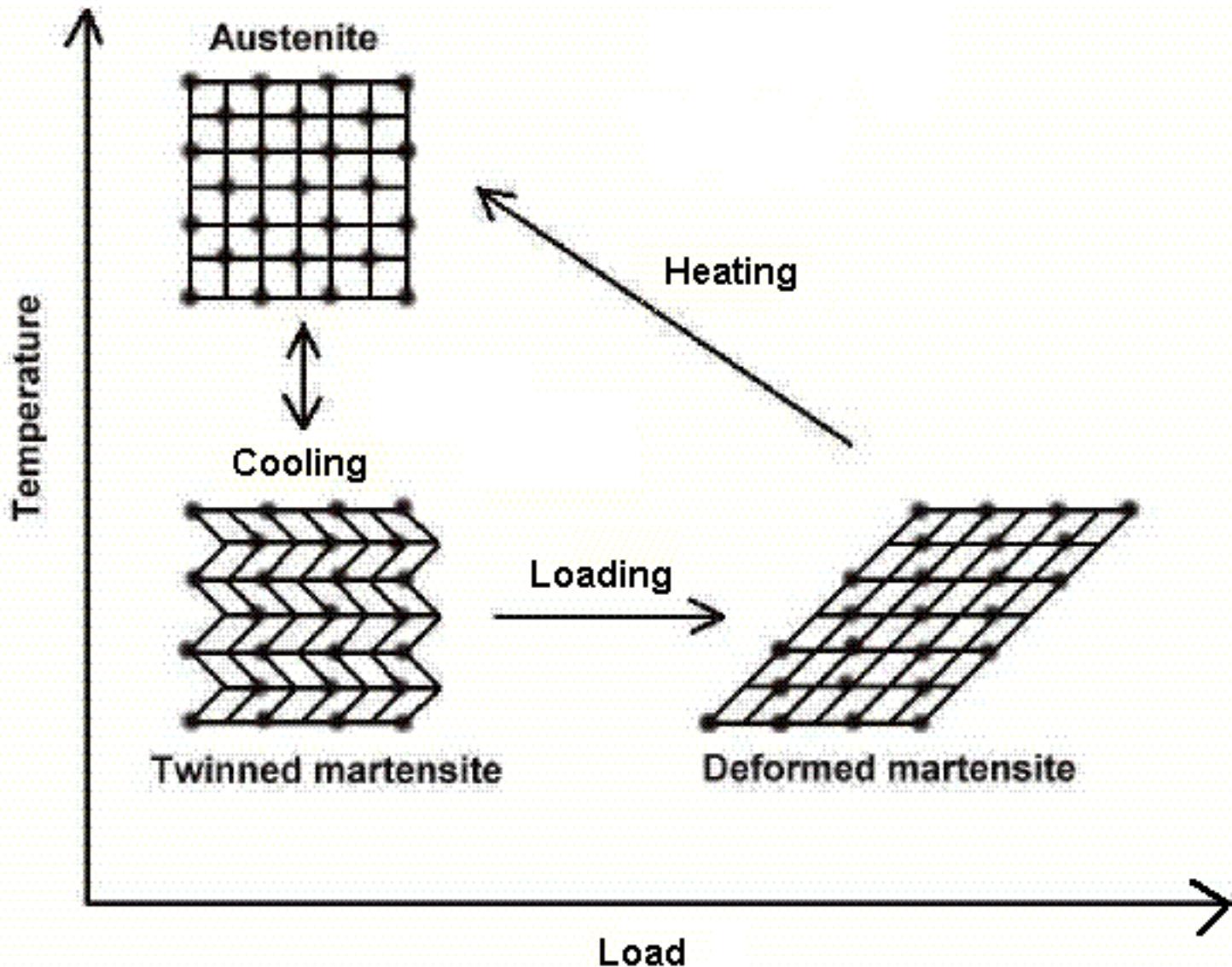


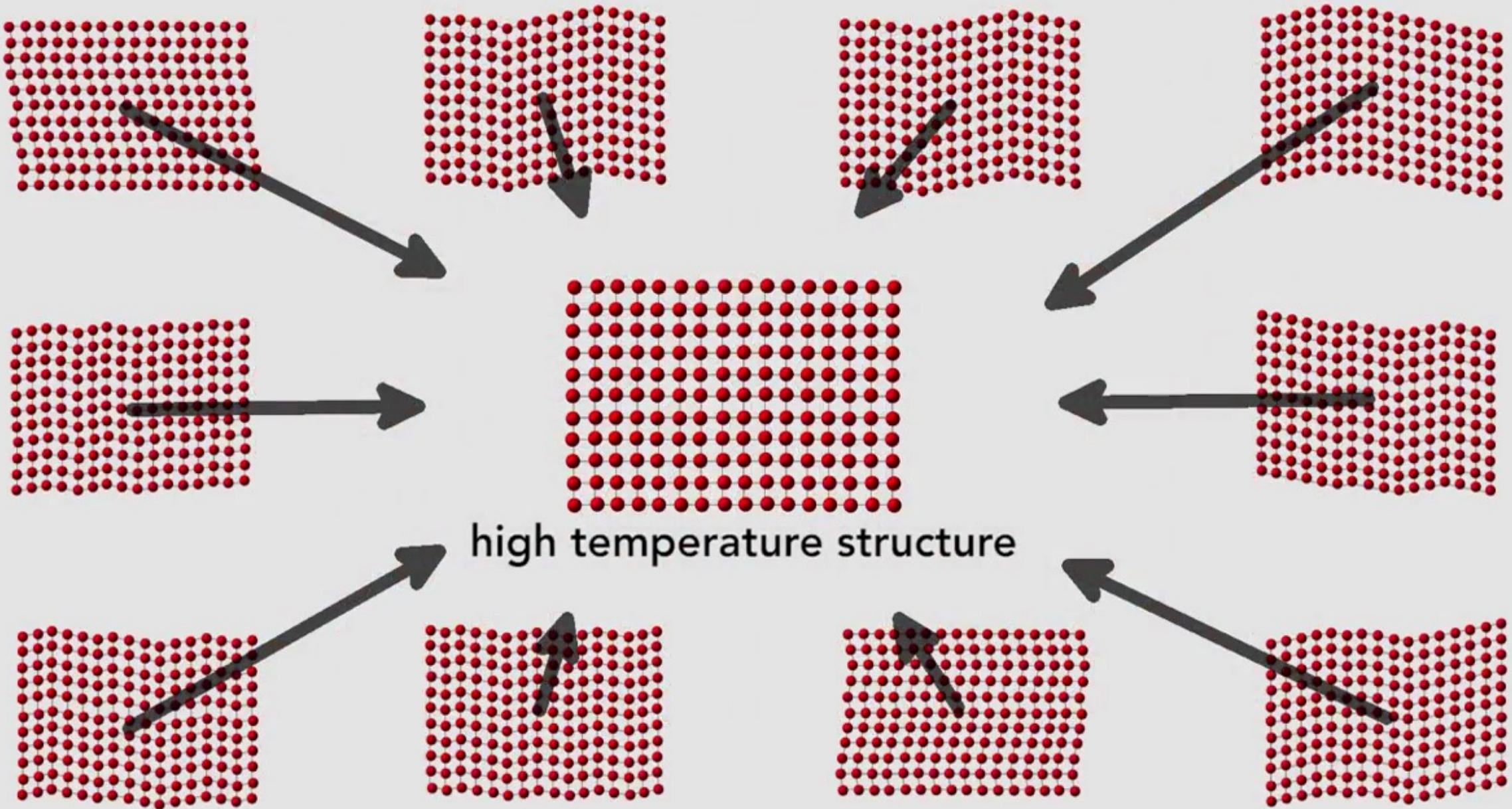
Heat up (~50 – 60°C)



Cool down. The atoms move a little bit back to usual, but the shape doesn't really change here.







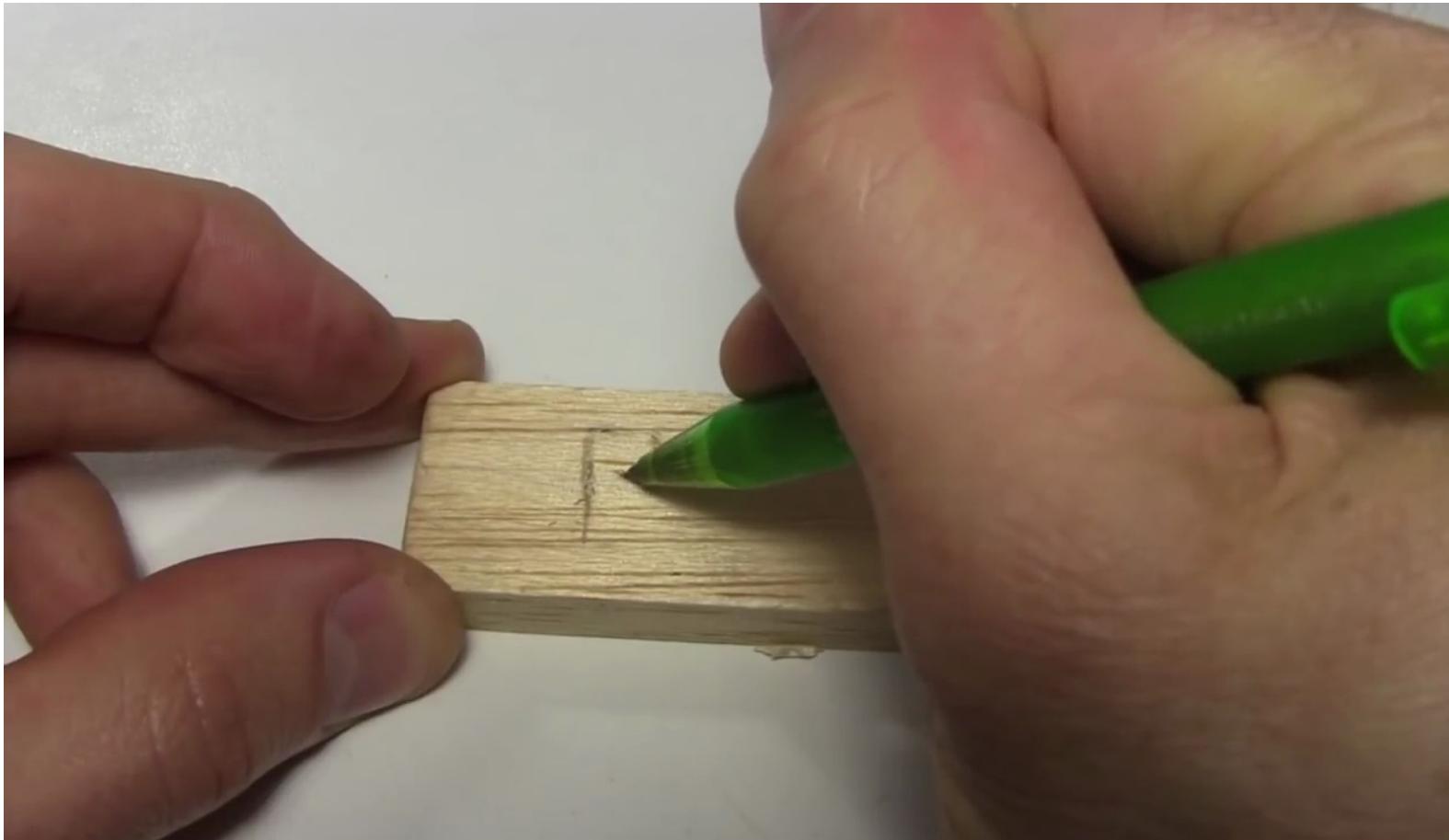
So the alloy can memorize/learn its shape.

Learning ->>> Intelligence

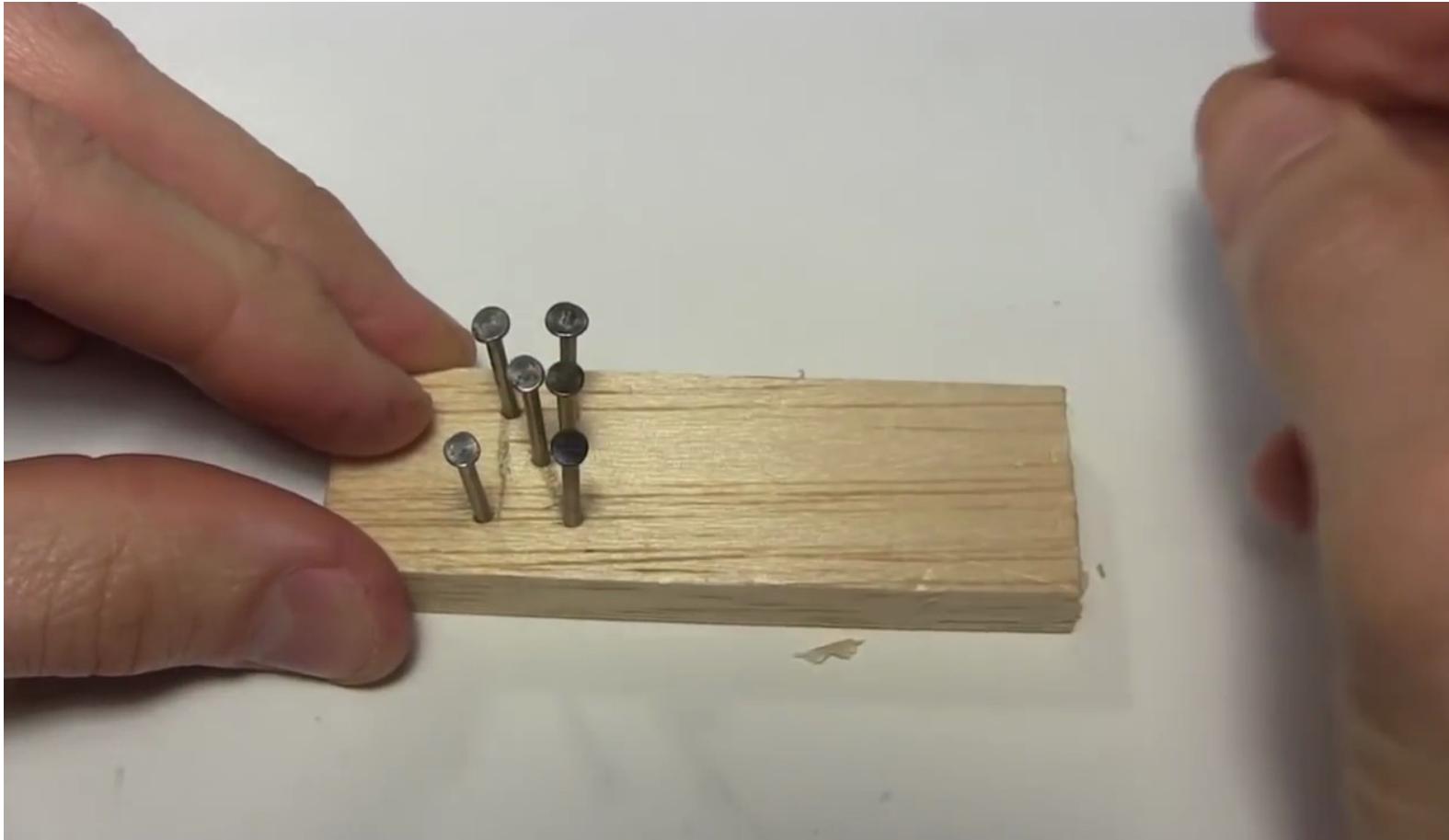
How to train the memory?

We need much higher temperature!

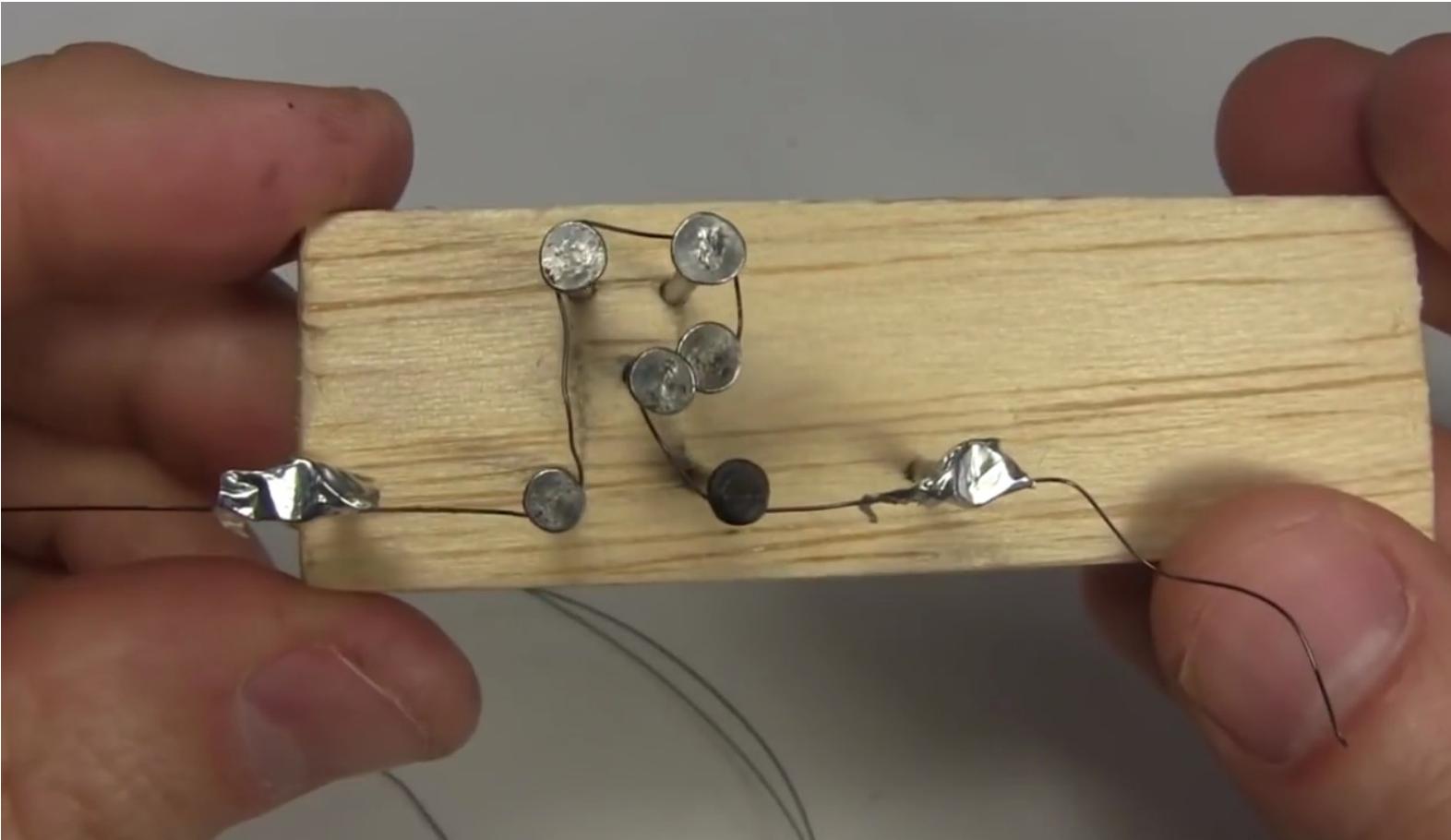
Training SMA: Design the shape



Training SMA: Make the jig



Training SMA: Wire the alloy



Training SMA: High-temperature Heat treatment till red hot



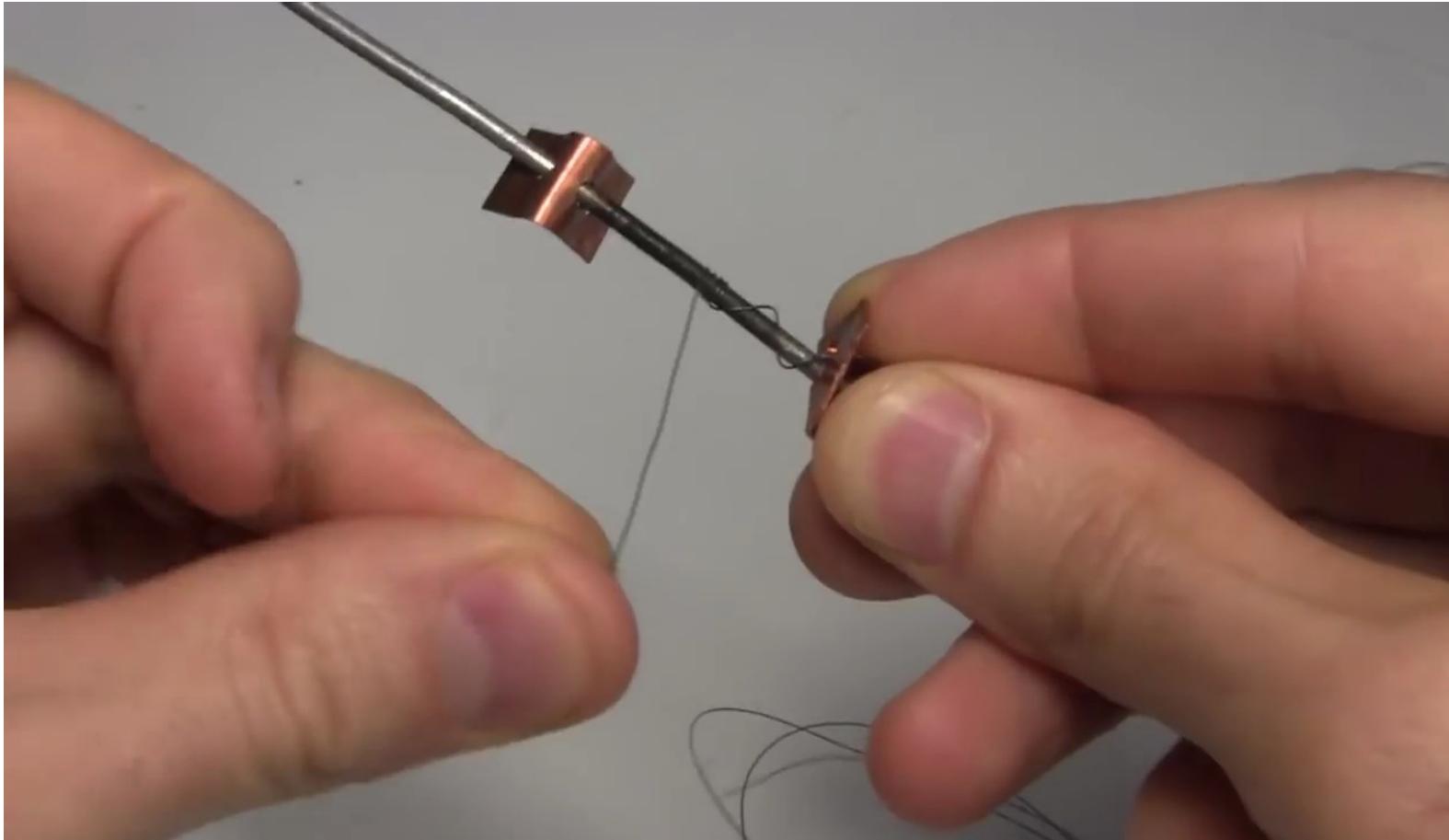
So the wire memorizes/learns the shape!!

Training SMA: Water-cool down



So the wire memorizes/learns the shape!!

Making spring



Making spring



What kind of heat source?



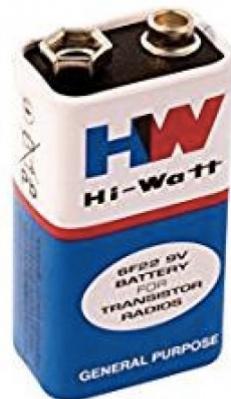
VectorStock®



??



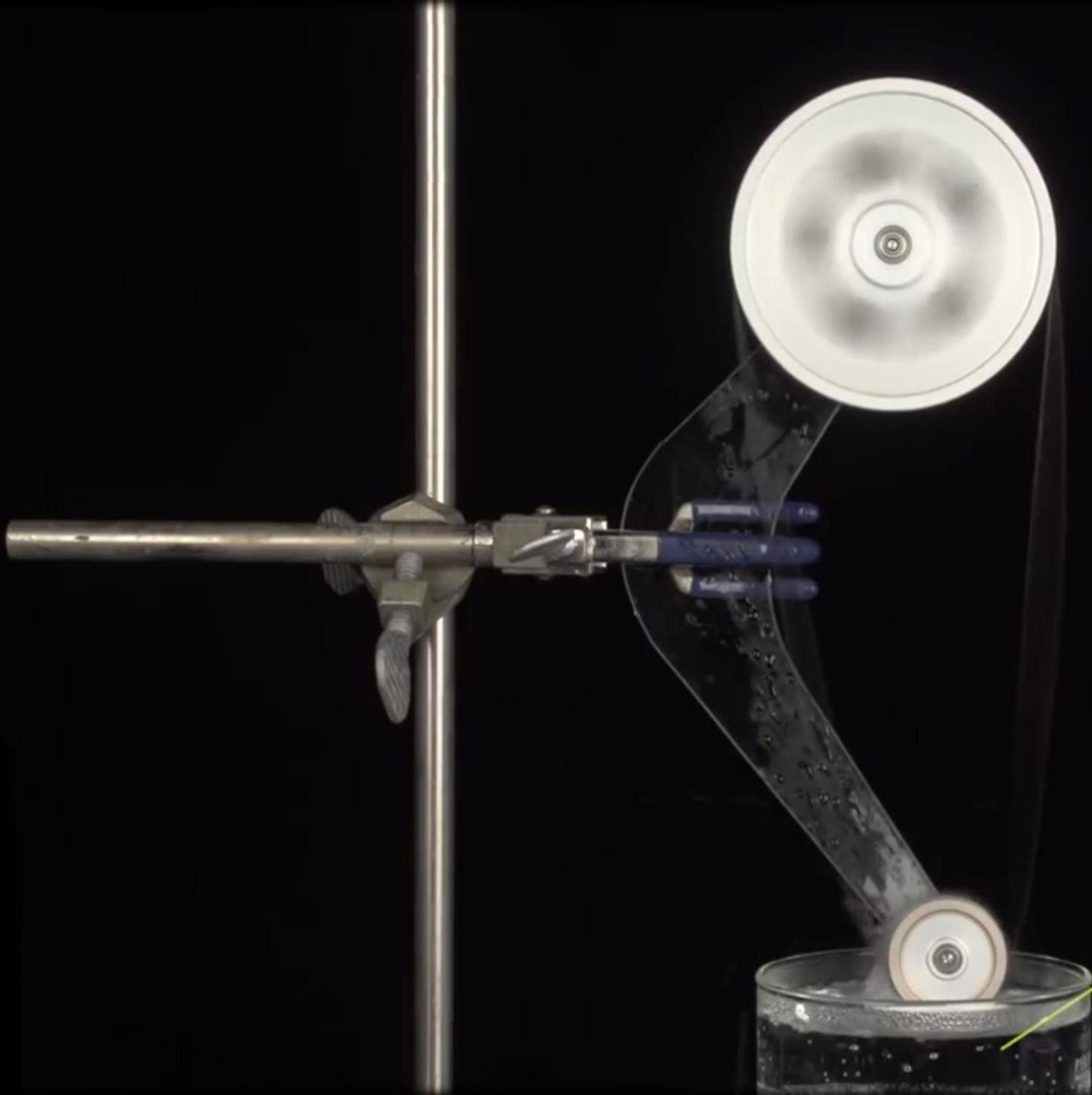
shutterstock.com • 313789790





21/2/2023

<http://youtube.com/watch?v=SXtFZsTx8bE>

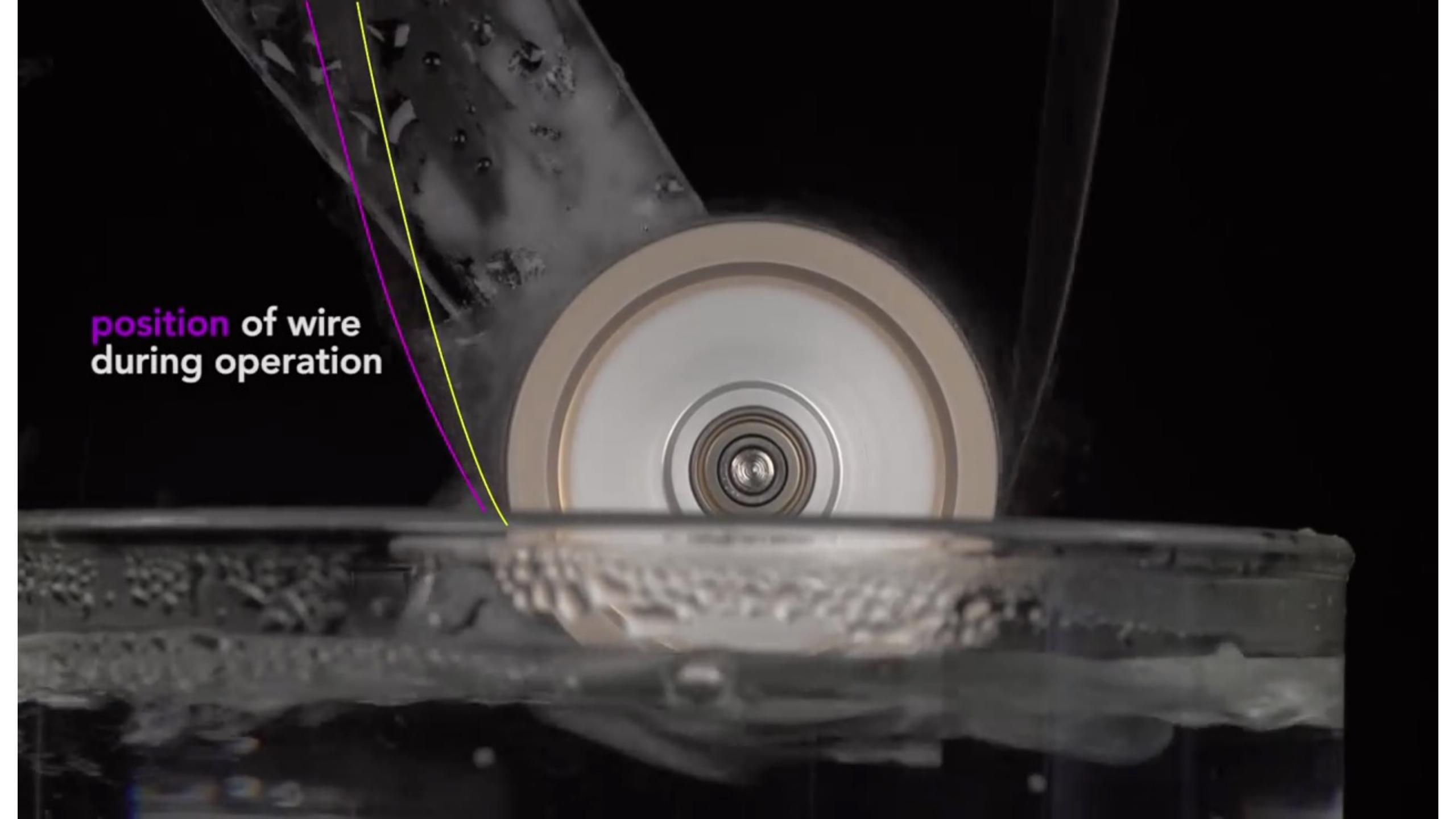


Air at ambient
temperature
about 25° C

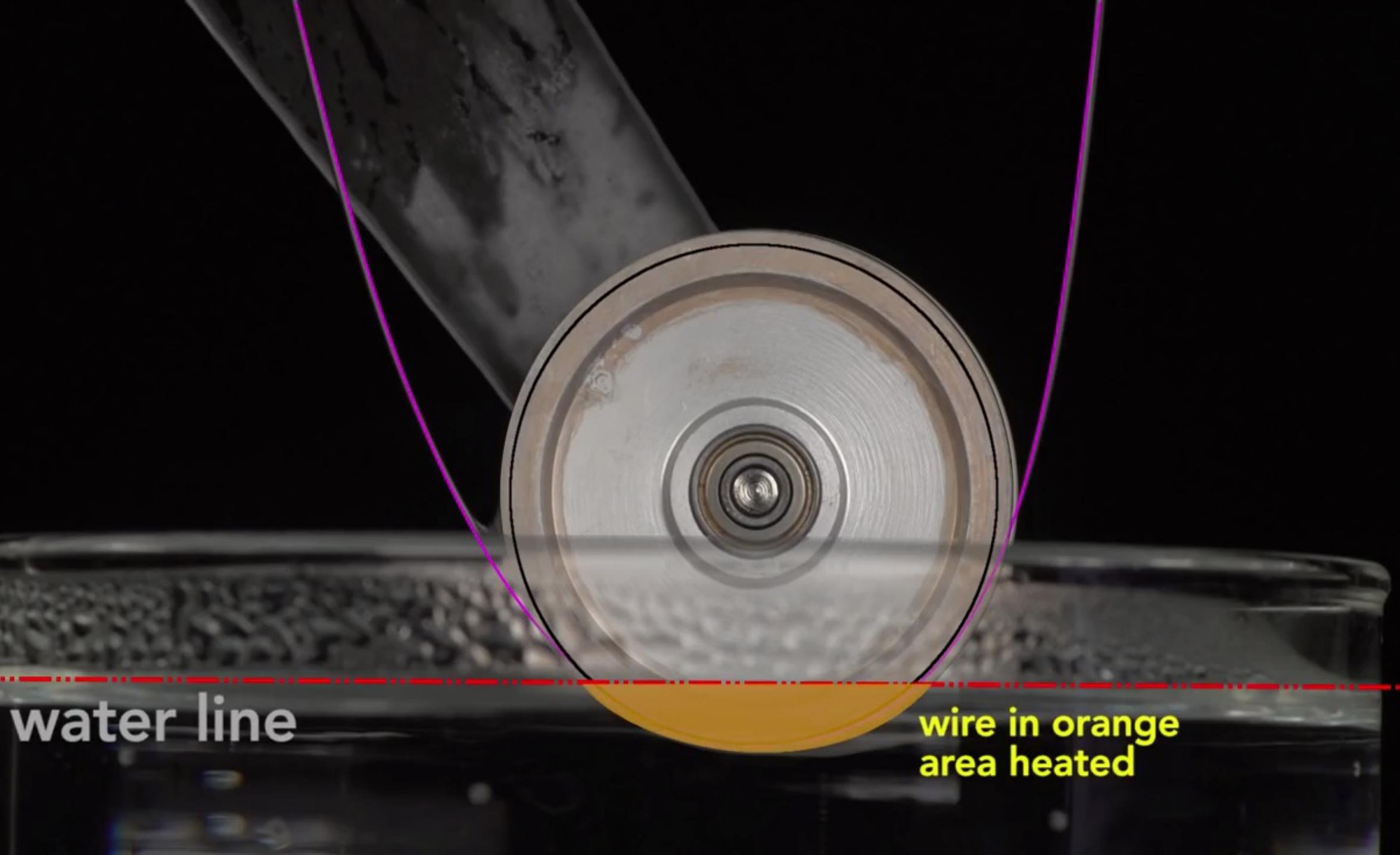
Water at 75° C

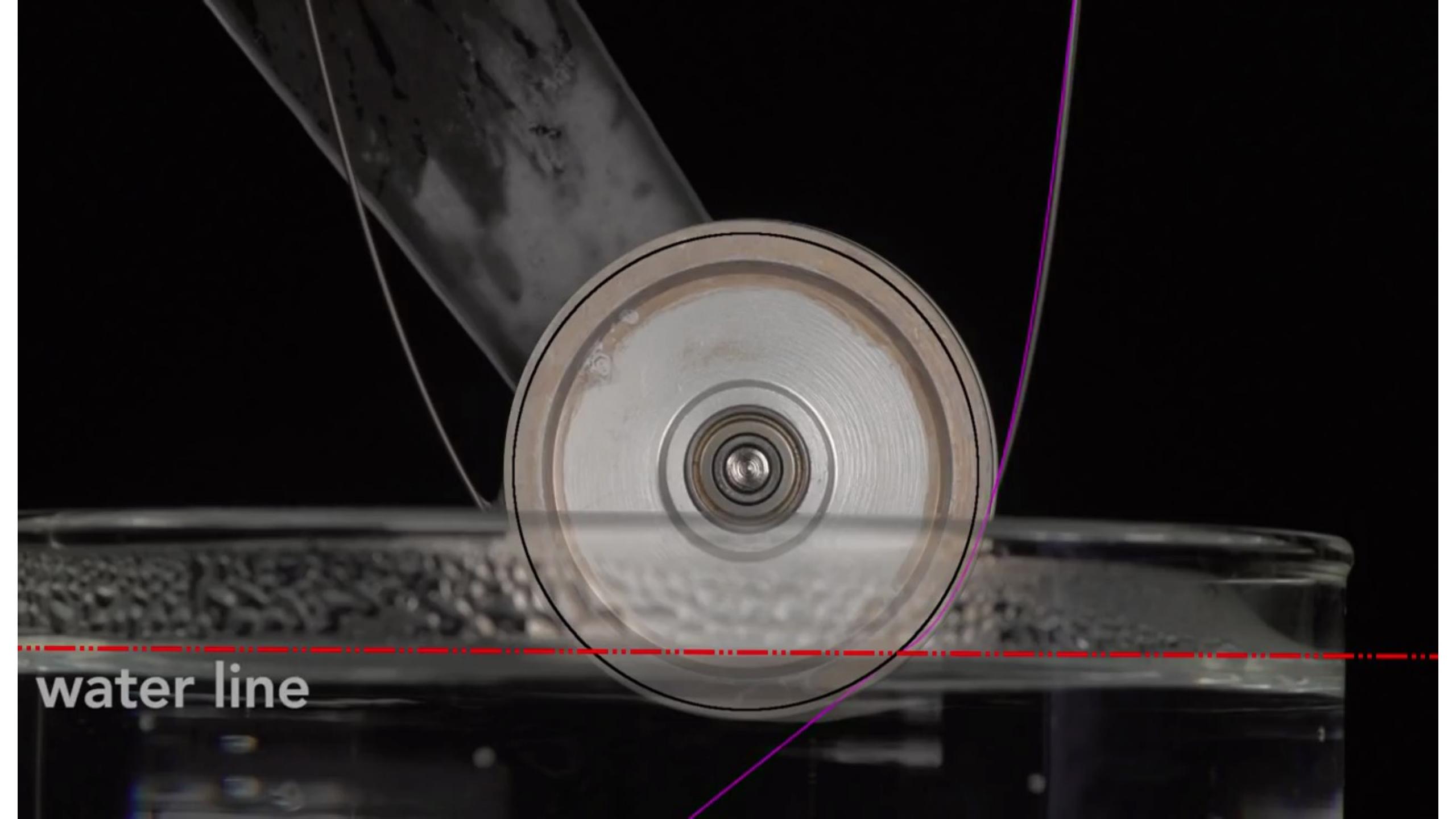
**position of
wire before
operation**



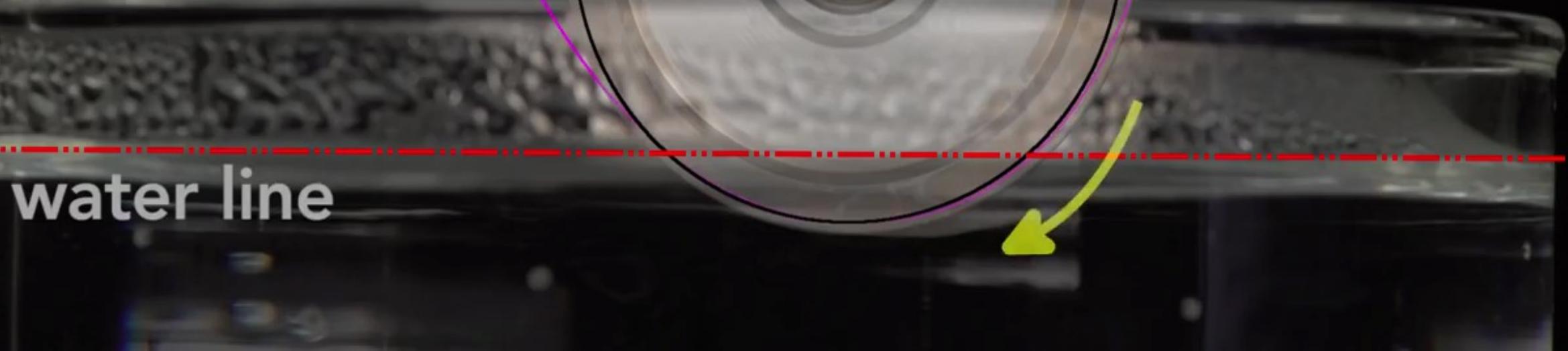


position of wire
during operation

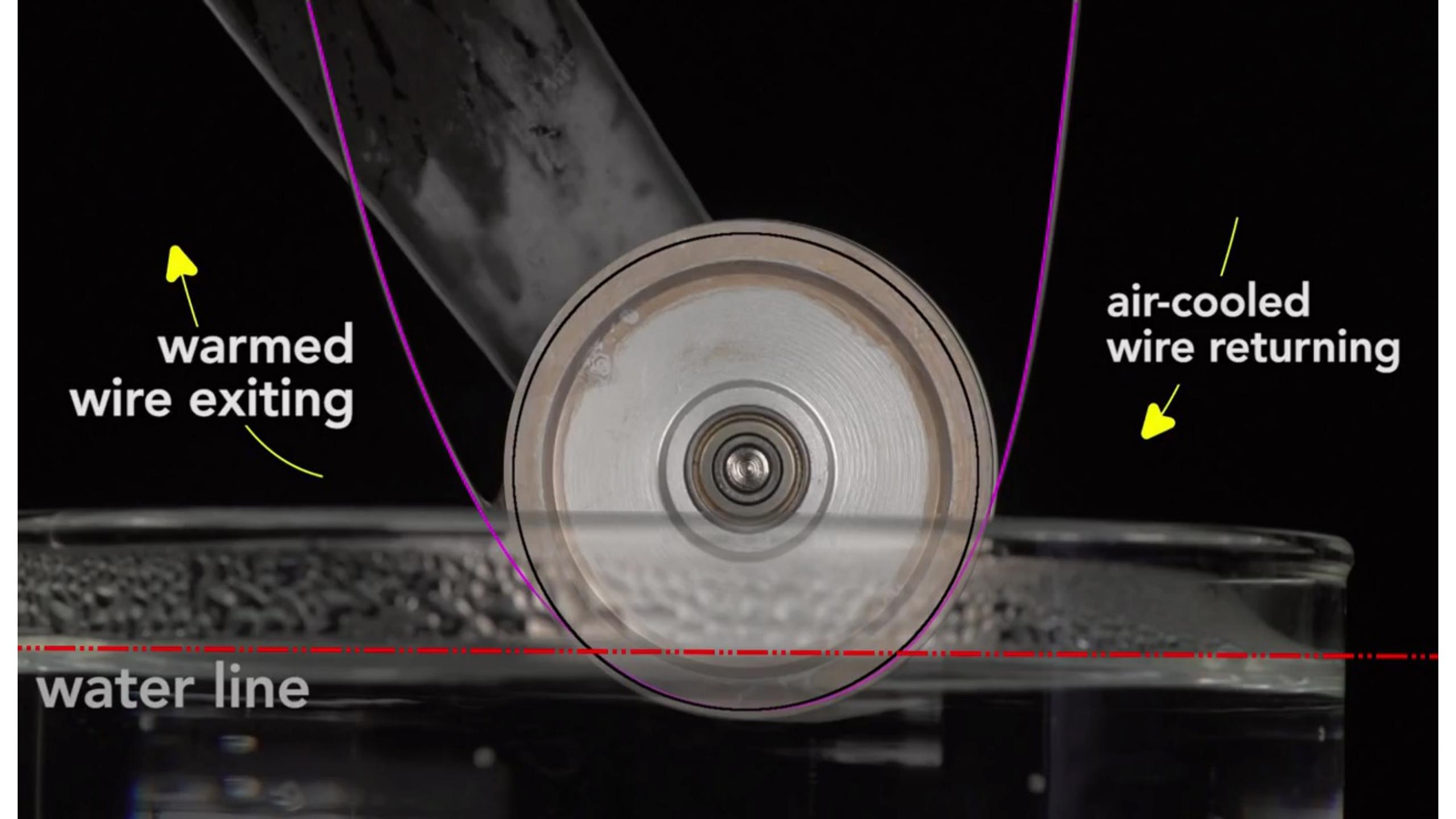




water line



water line



**warmed
wire exiting**

/
**air-cooled
wire returning**

water line

Fulcrum • 支點
Last point of contact
of wire on wheel

lever arm

Force

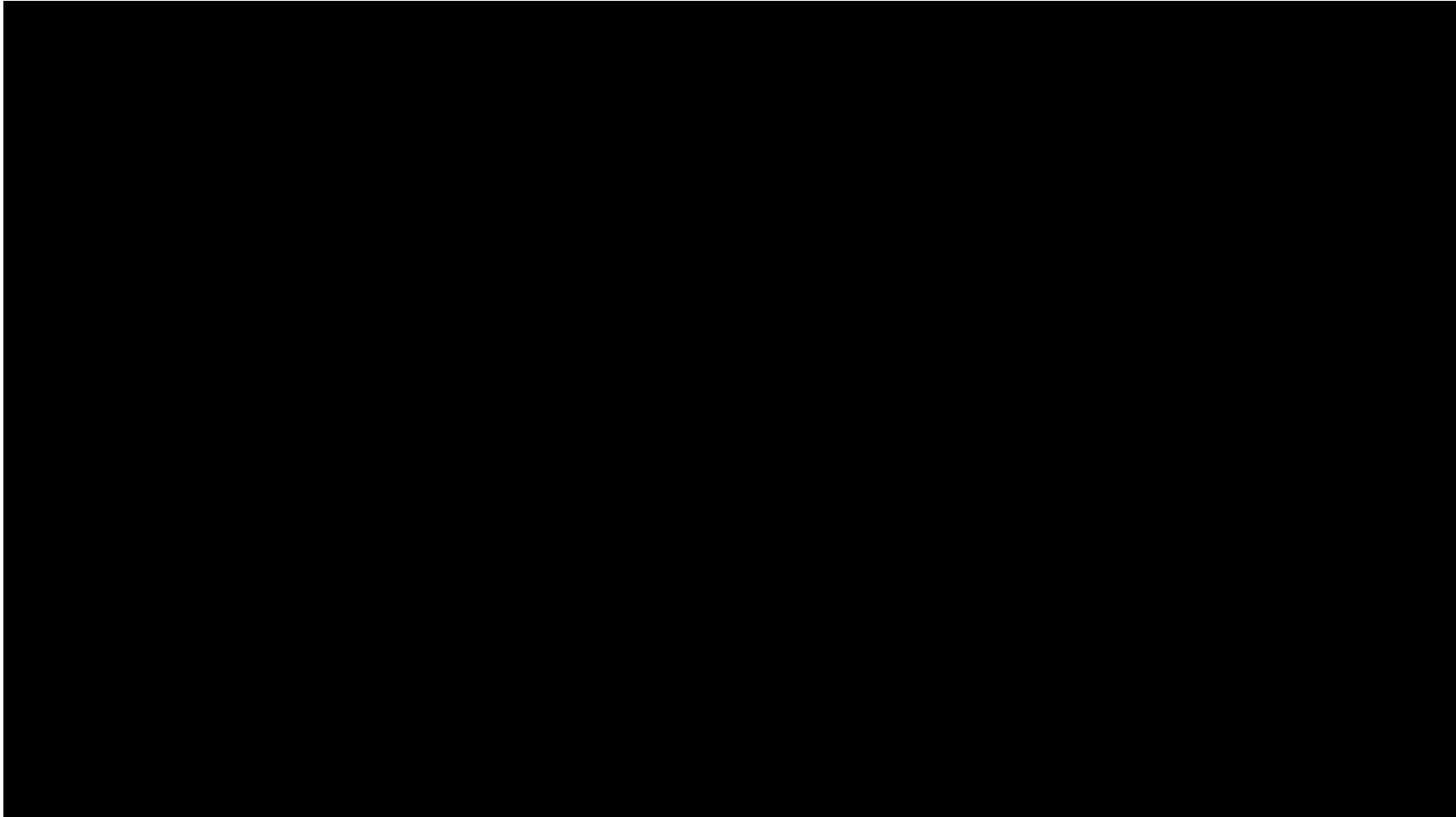


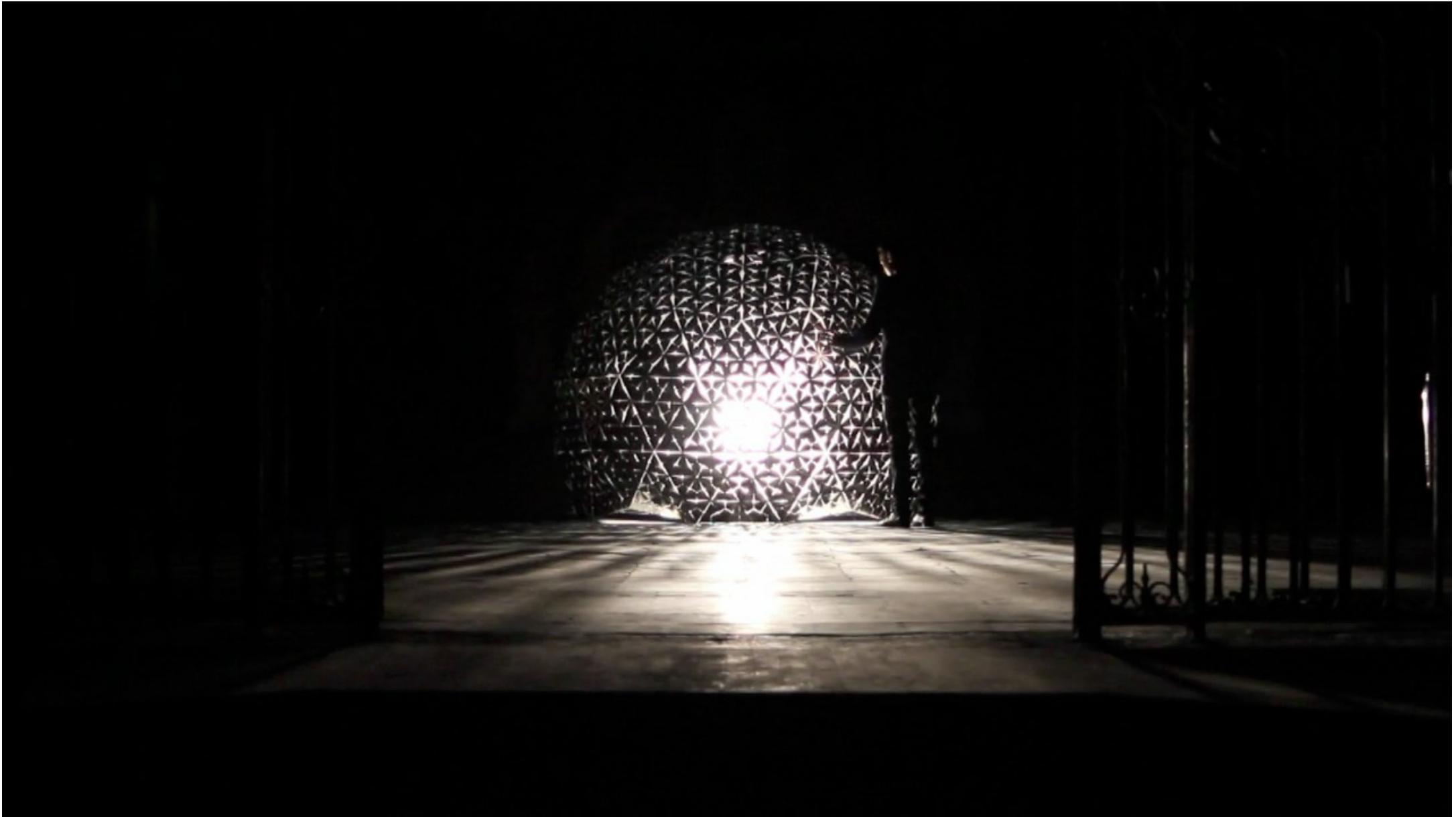
Jie Qi's exploration on SMA with paper

- <https://makezine.com/2012/01/31/skill-builder-working-with-shape-memory-alloy/>

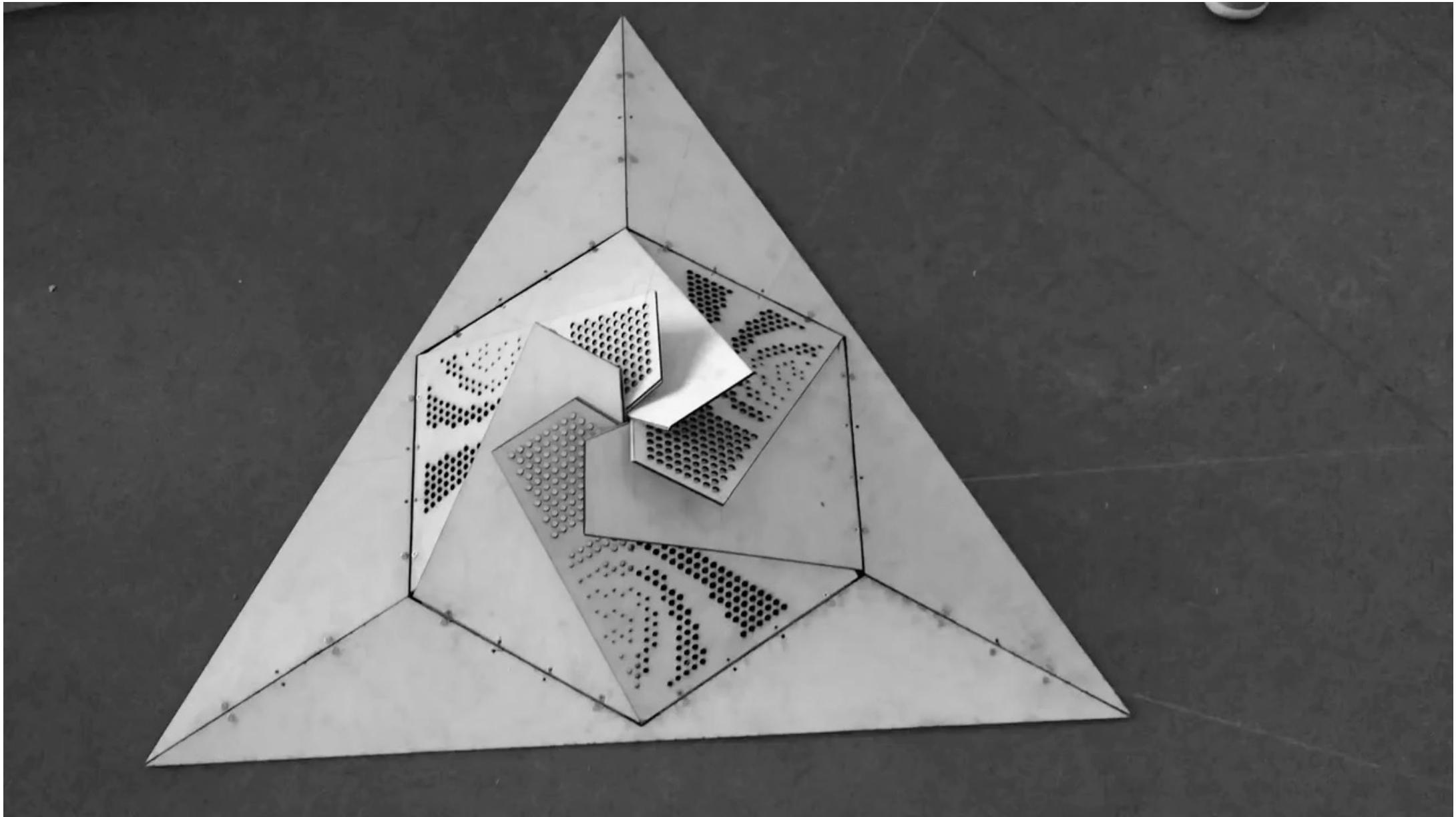
The screenshot shows the Make: Community website interface. At the top, there is a navigation bar with links for "More", "Maker Faire", "Shop", "Maker Share", "Make: Community" (which is highlighted in red), "Magazine", "Videos", and "Partner With Us". Below the navigation bar is a secondary menu with links for "All Stories", "Magazine Projects", "Board Guide", and "Maker Spotlights". On the right side of this menu, there is a call-to-action button that says "Want the full magazine: SUBSCRIBE TODAY!" with a star icon. A search icon is also present. The main content area features a large, smiling woman wearing glasses. To her left, a close-up of a blue pen or tool is visible. The title of the article, "How-To: Work with Shape-Memory Alloy", is displayed prominently above the image.

AutoGami





Studio Roosegarde, "Lotus Dome" 2012



21/2/2023

<https://vimeo.com/179774804>

<https://tactile-architecture.com/make-material-city-shading-device/>

Reef

Rob Ley
Joshua G. Stein

Springlets: Expressive, Flexible and Silent On-Skin Tactile Interfaces

Nur Al-huda Hamdan - Adrian Wagner - Simon Völker
Jürgen Steimle - Jan Borchers



RWTHAACHEN
UNIVERSITY

SAARLAND
UNIVERSITY 
COMPUTER SCIENCE

hci.rwth-aachen.de/Springlets

Working with SMA

(<https://www.sparkfun.com/products/11900>)

- Demo 1
 - Trigger the shape change with battery/hair dryer
- Demo 2
 - Train the shape
 - Using Power Supply
 - Using Iron

In-class/Take-Home Group Task: Submit by tomorrow midnight (11:59PM)

- Train the shape of your SMA
- Attach it to a type of flexible material (can be paper, soft fabric, and so on)
- Trigger the shape change using a type of heat source
 - Can be battery, really hot water (boiling), hair dryer, and so on
- Video recording the above 3 steps, and upload the video to any video online platform, and submit the link on Canvas

Some more references of works

- <https://www.beautyofscience.com/>
- <https://skunkworks.scm.cityu.edu.hk/index.html>