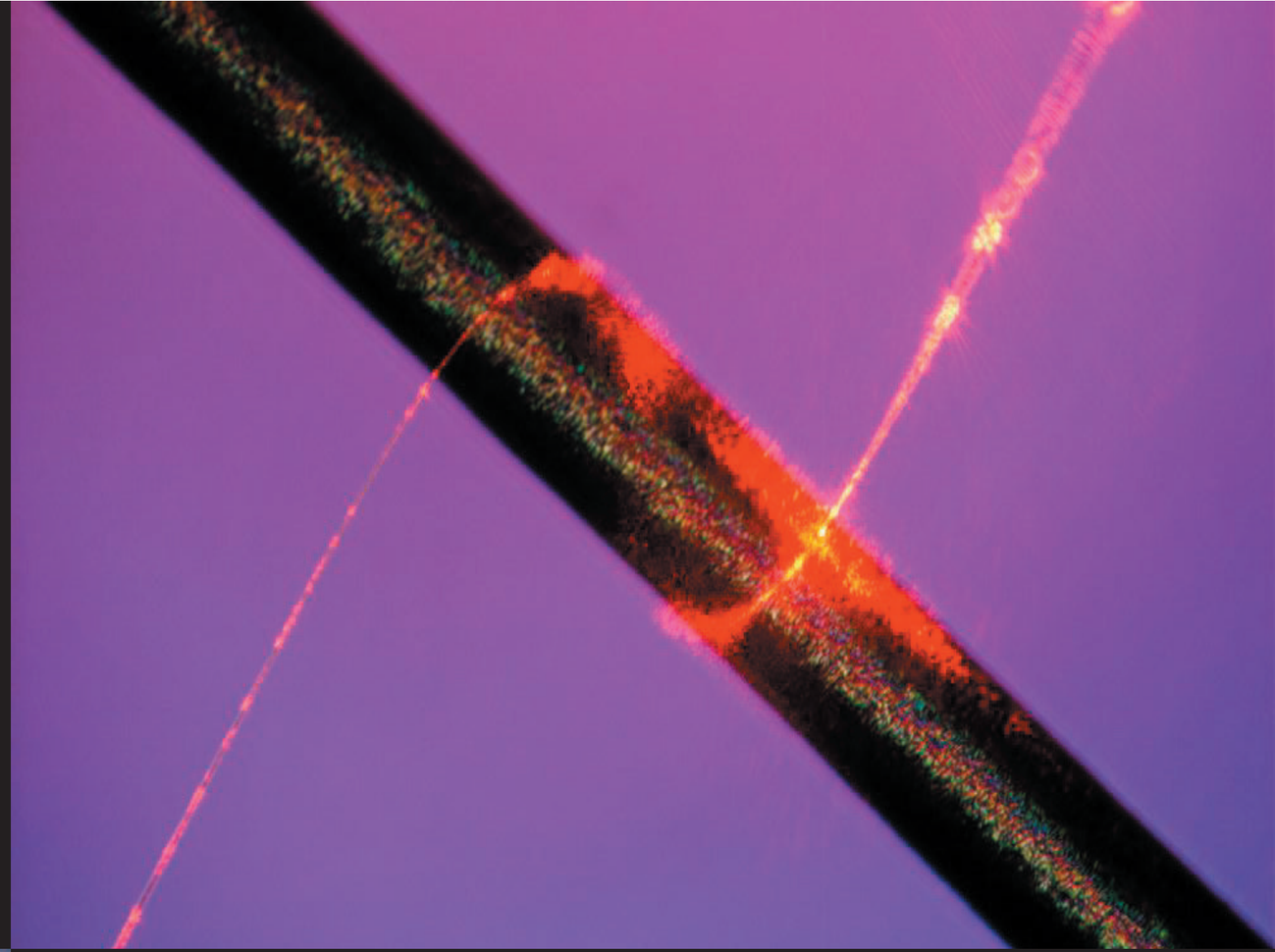
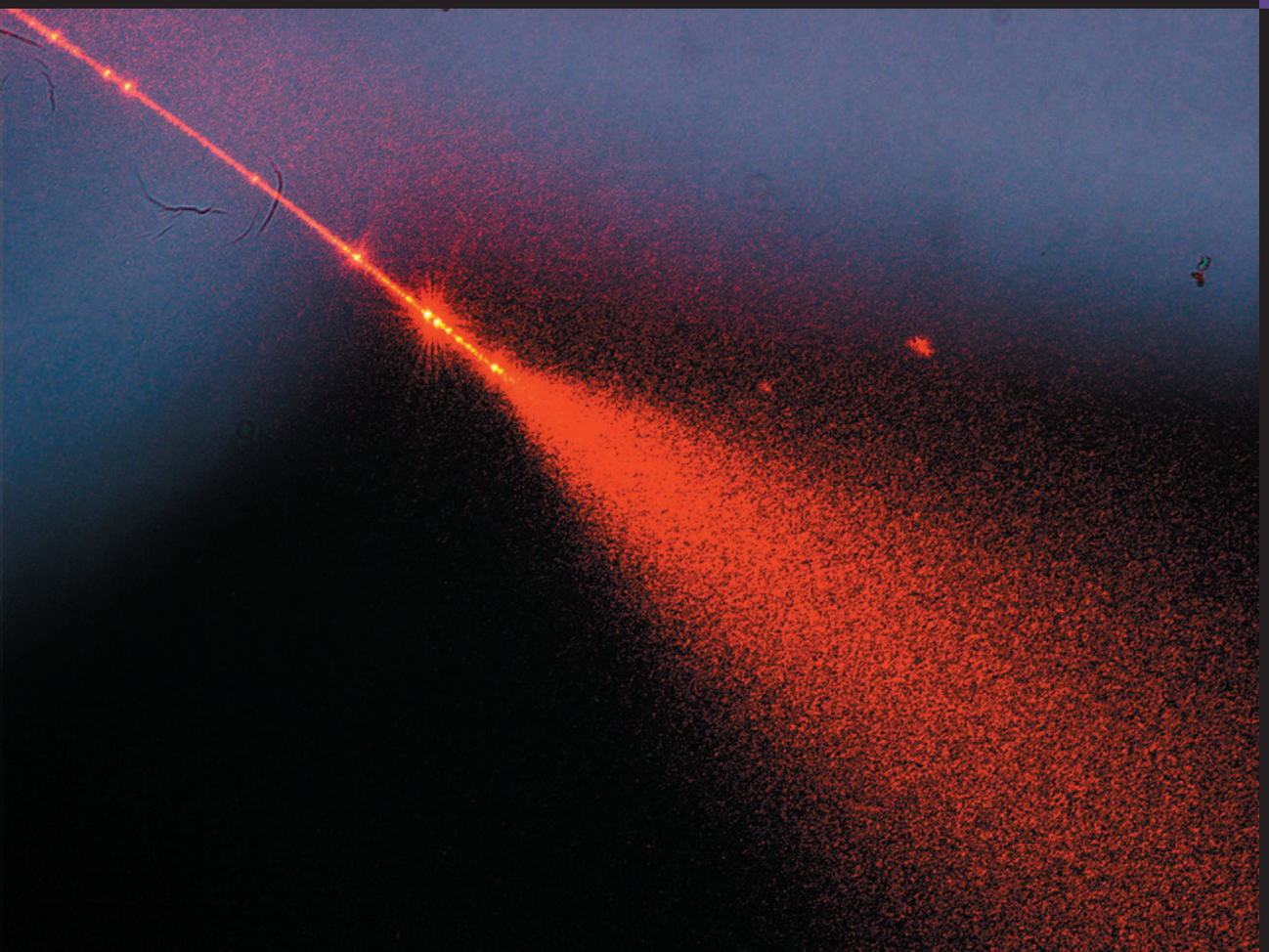
Wrapping light around a hair:

Using light at the nanoscale



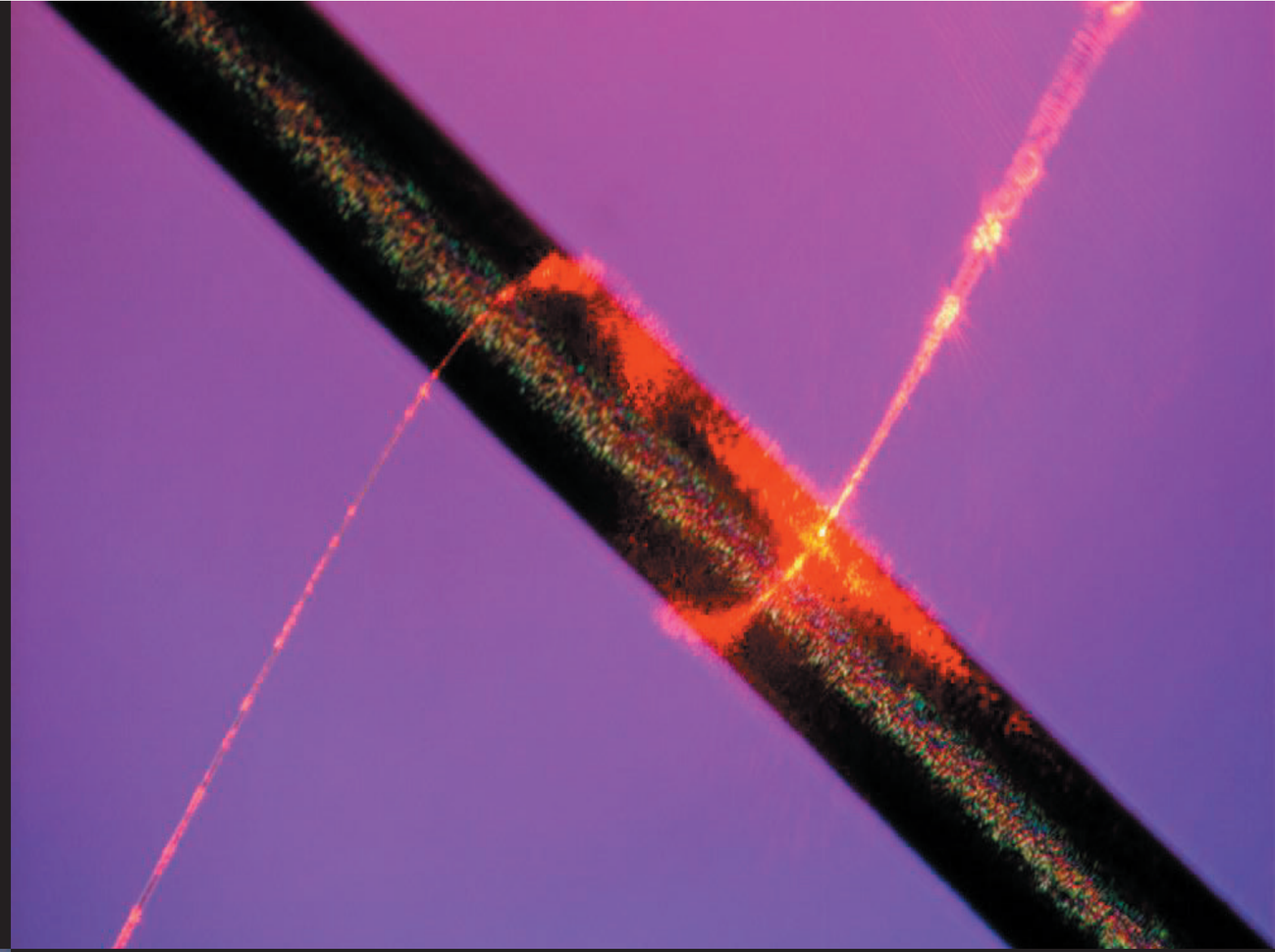


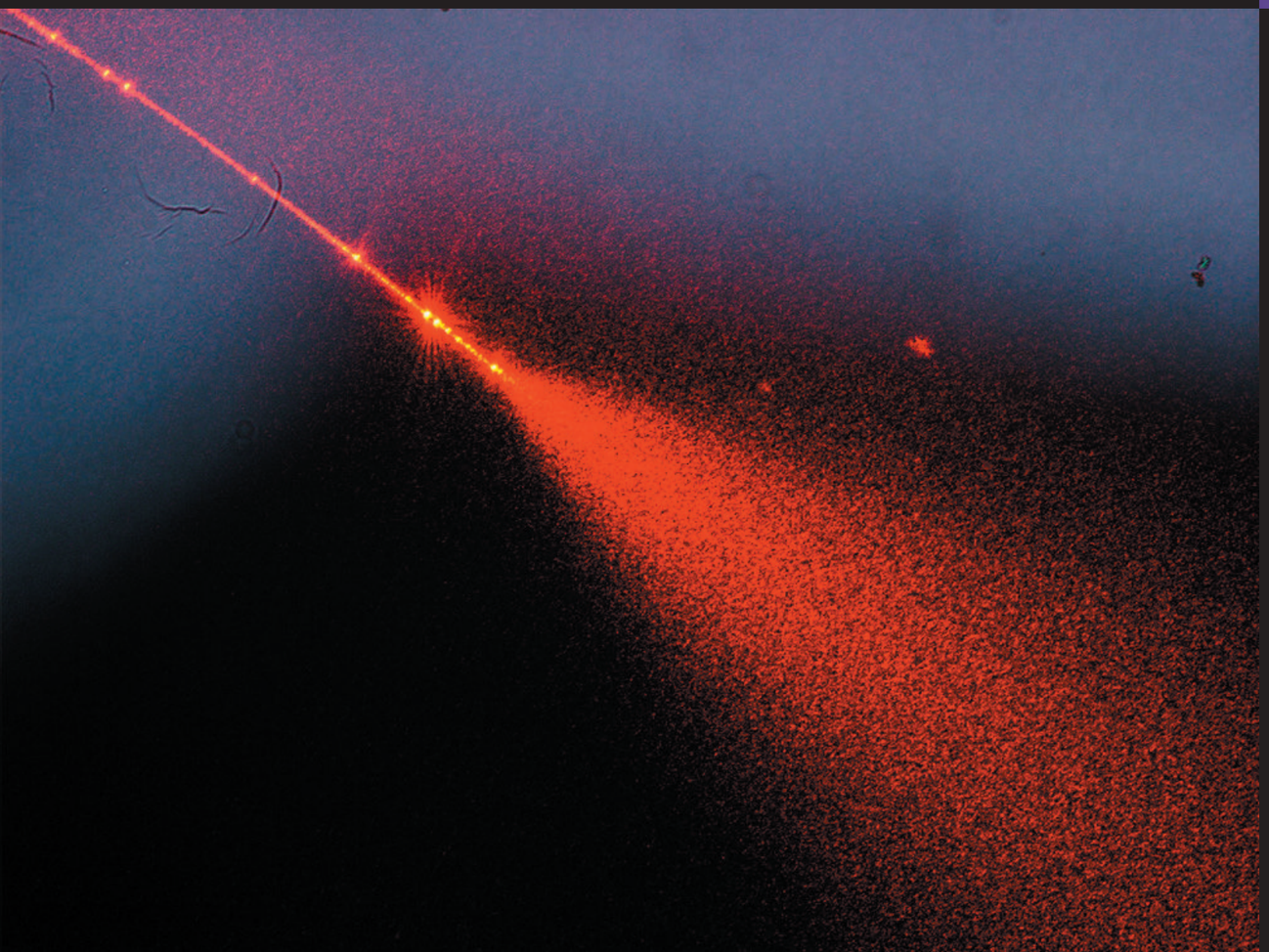
Eric Mazur
Harvard University

Museum of Science
Current Science & Technology
29 May 2005, 3:30 pm

This talk is about:

- guiding light
- nanotechnology





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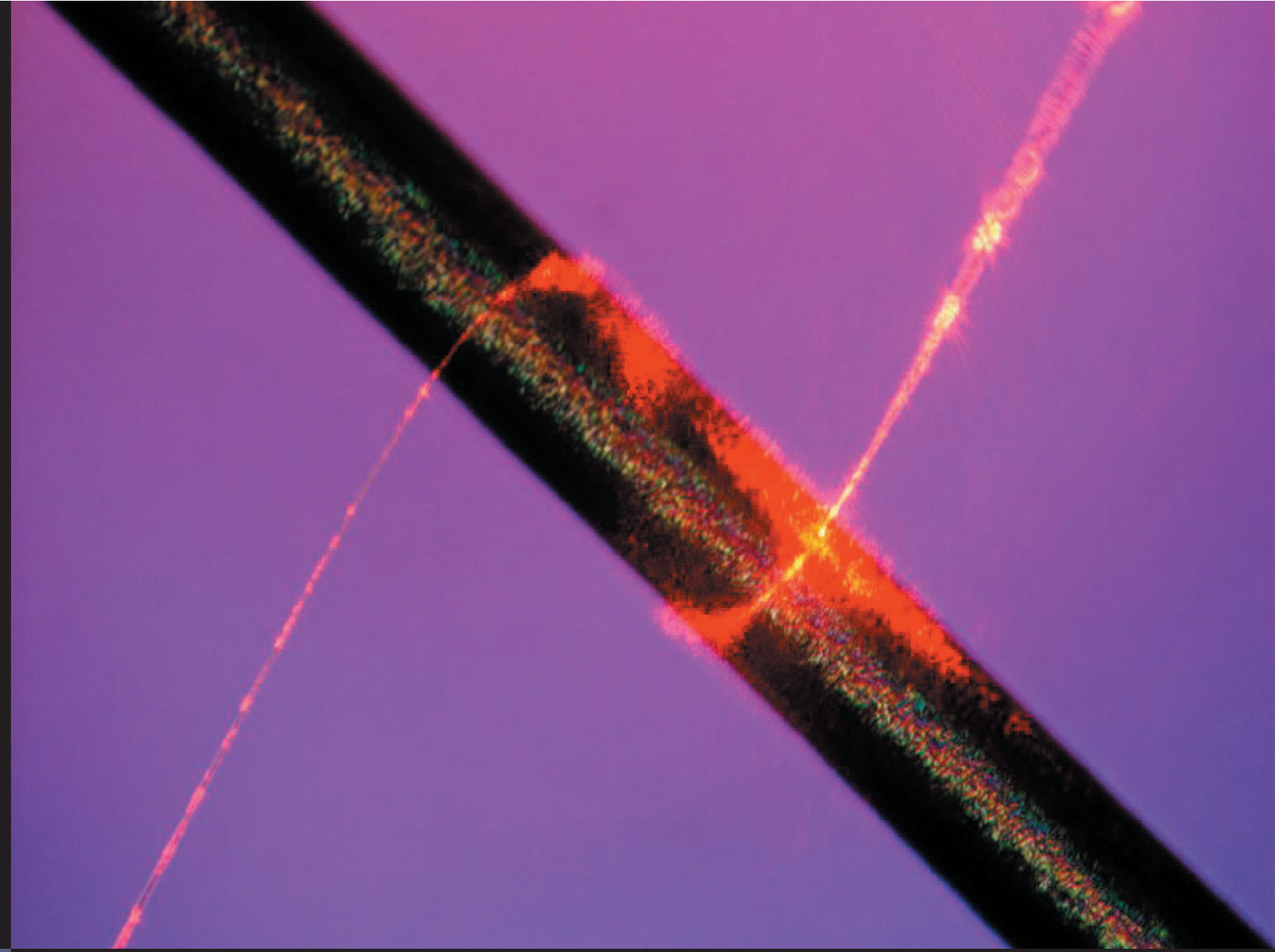
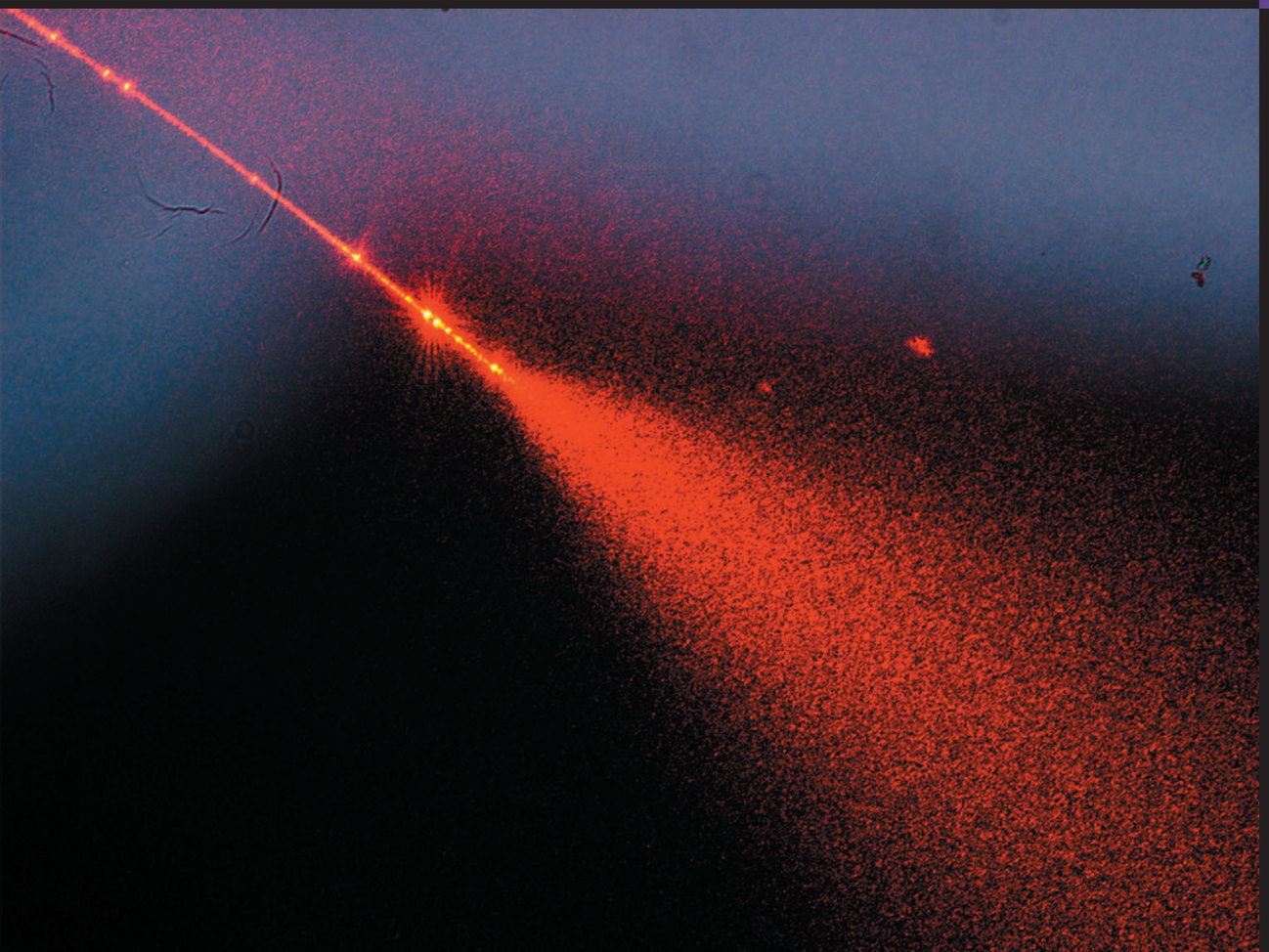
What is ‘nanotechnology’?

The fabrication of devices of nanometer size





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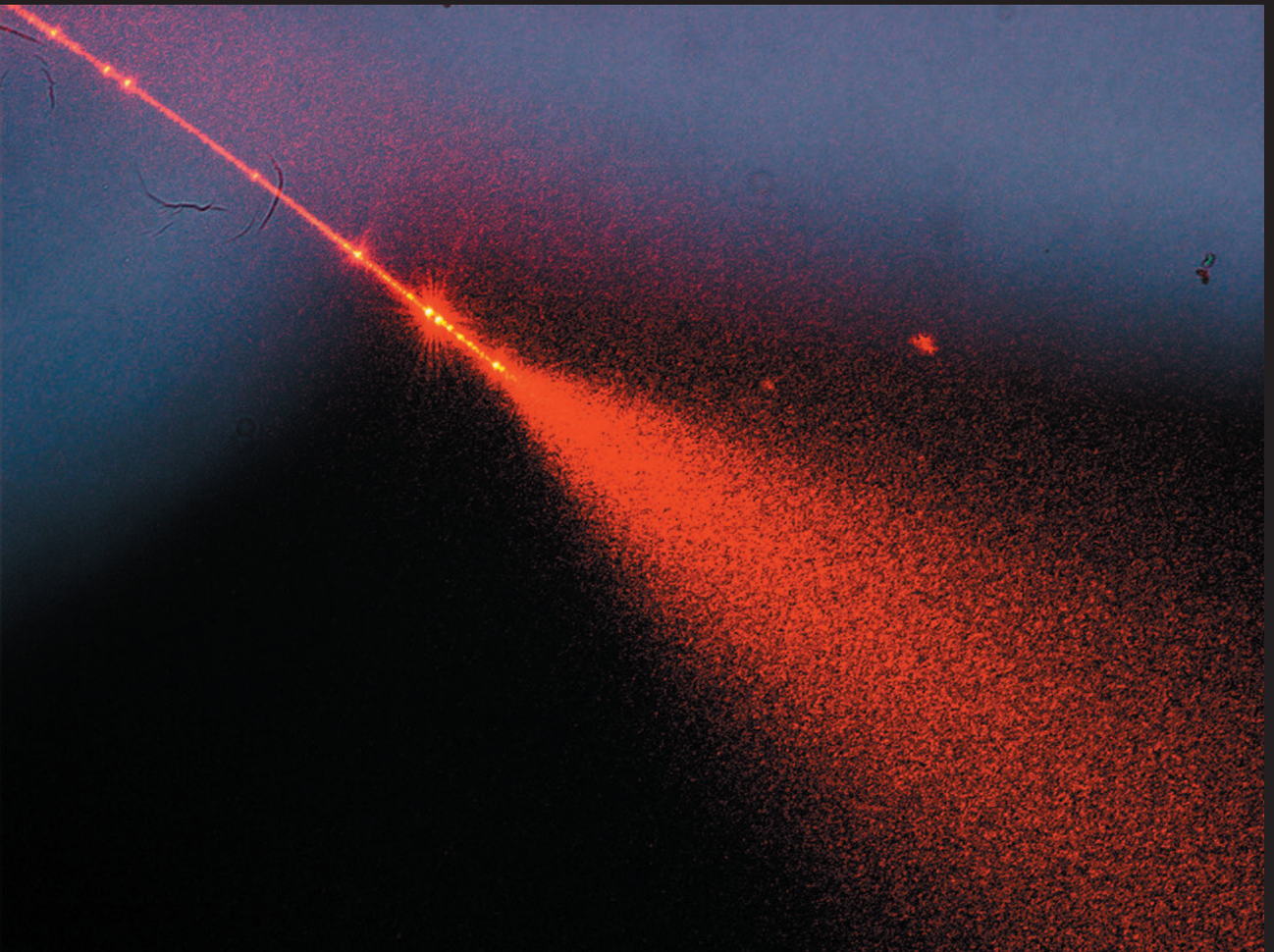
29 May 2005, 3:30 pm

What is ‘nanotechnology’?

The fabrication of devices of nanometer size

1 m = one meter

one large step



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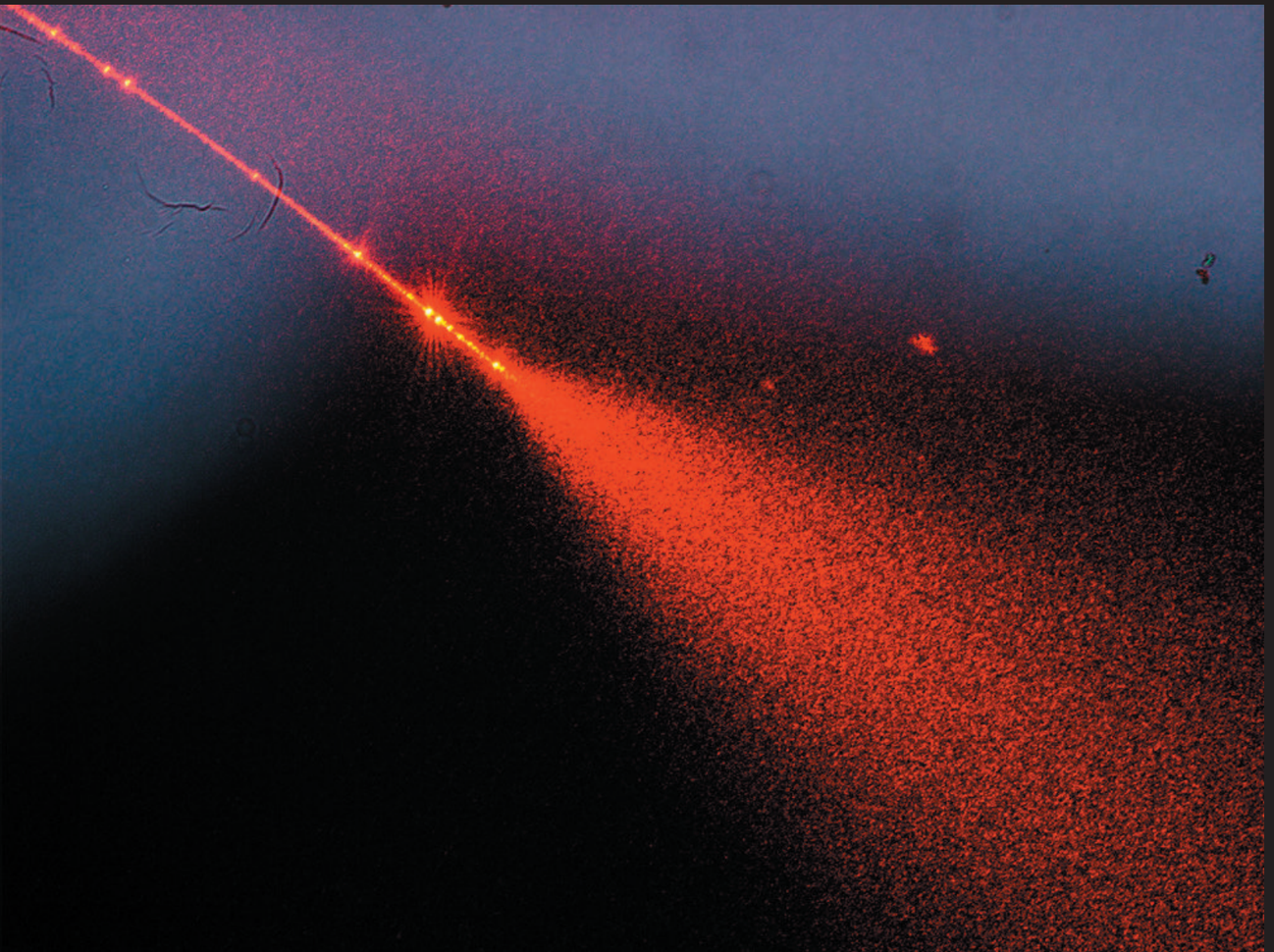
What is ‘nanotechnology’?

The fabrication of devices of nanometer size

1 mm = one millimeter
(one thousandth of a meter)

pin head



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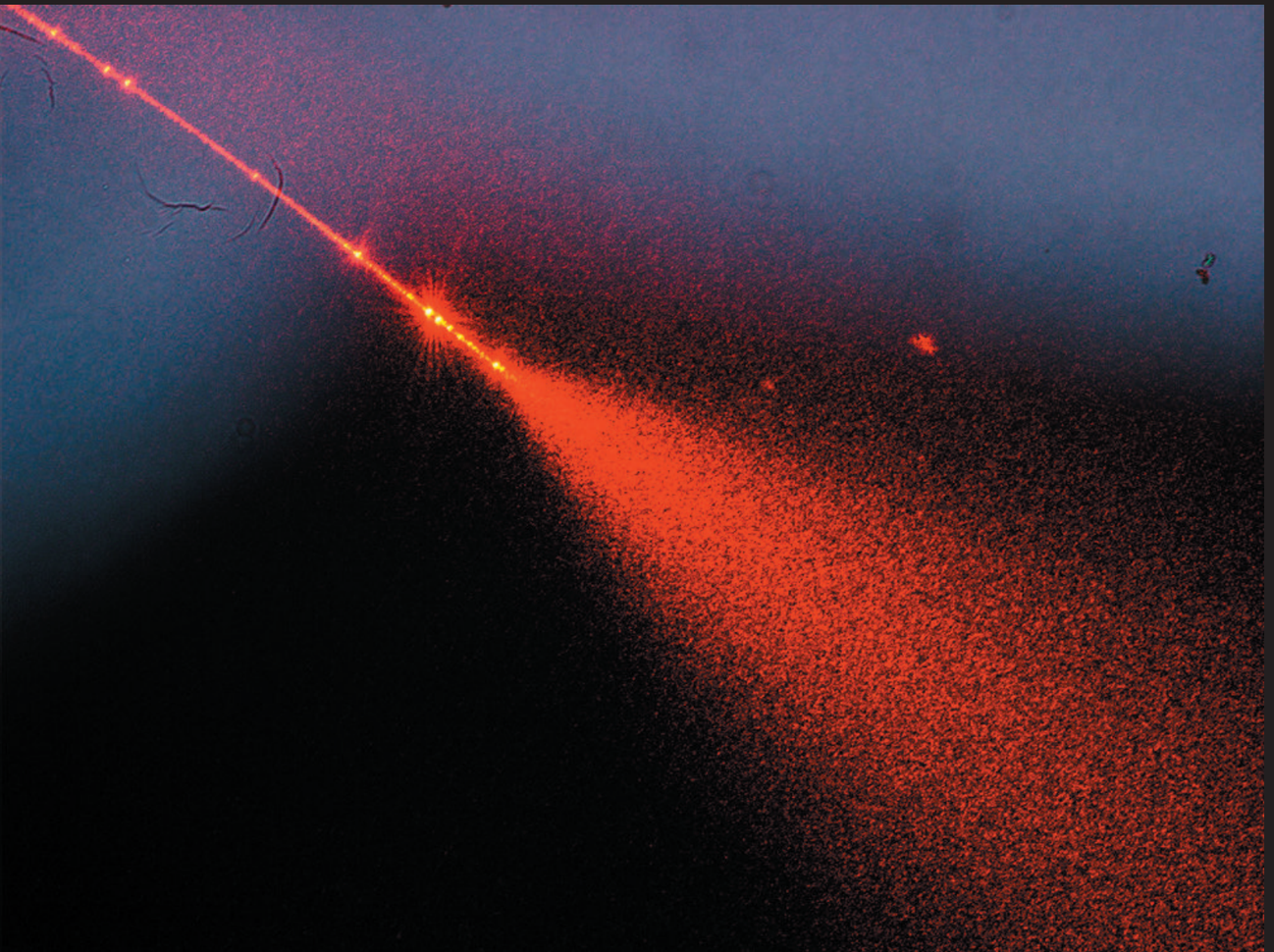
What is ‘nanotechnology’?

The fabrication of devices of nanometer size

1 µm = one micrometer
(one millionth of a meter)

red blood cell



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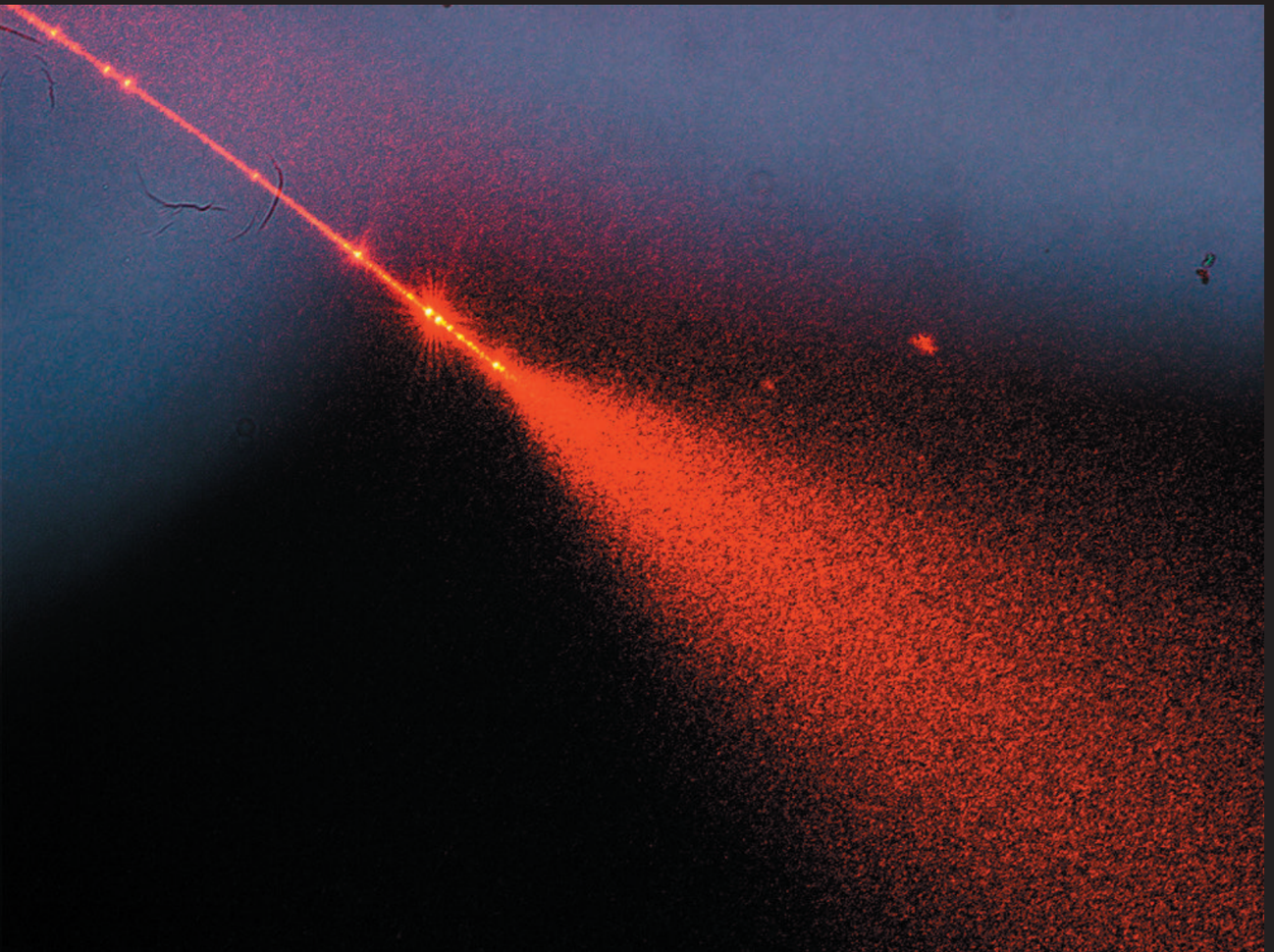
What is ‘nanotechnology’?

The fabrication of devices of nanometer size

1 nm = one nanometer

(one billionth of a meter)

a virus



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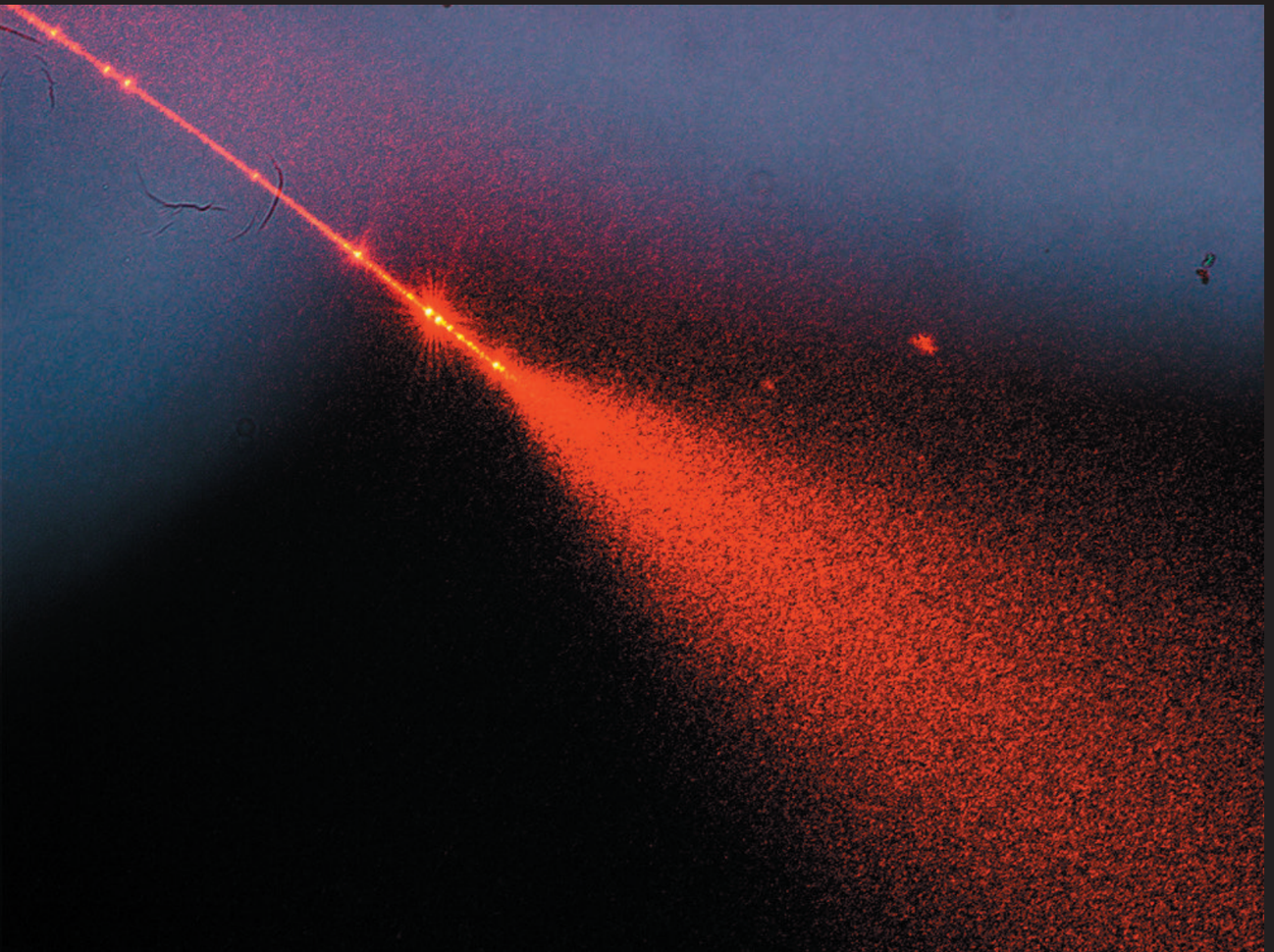
Nanotechnology:

The fabrication of devices on the 1–100 nm scale

1 nm = one nanometer

(one billionth of a meter)

a virus



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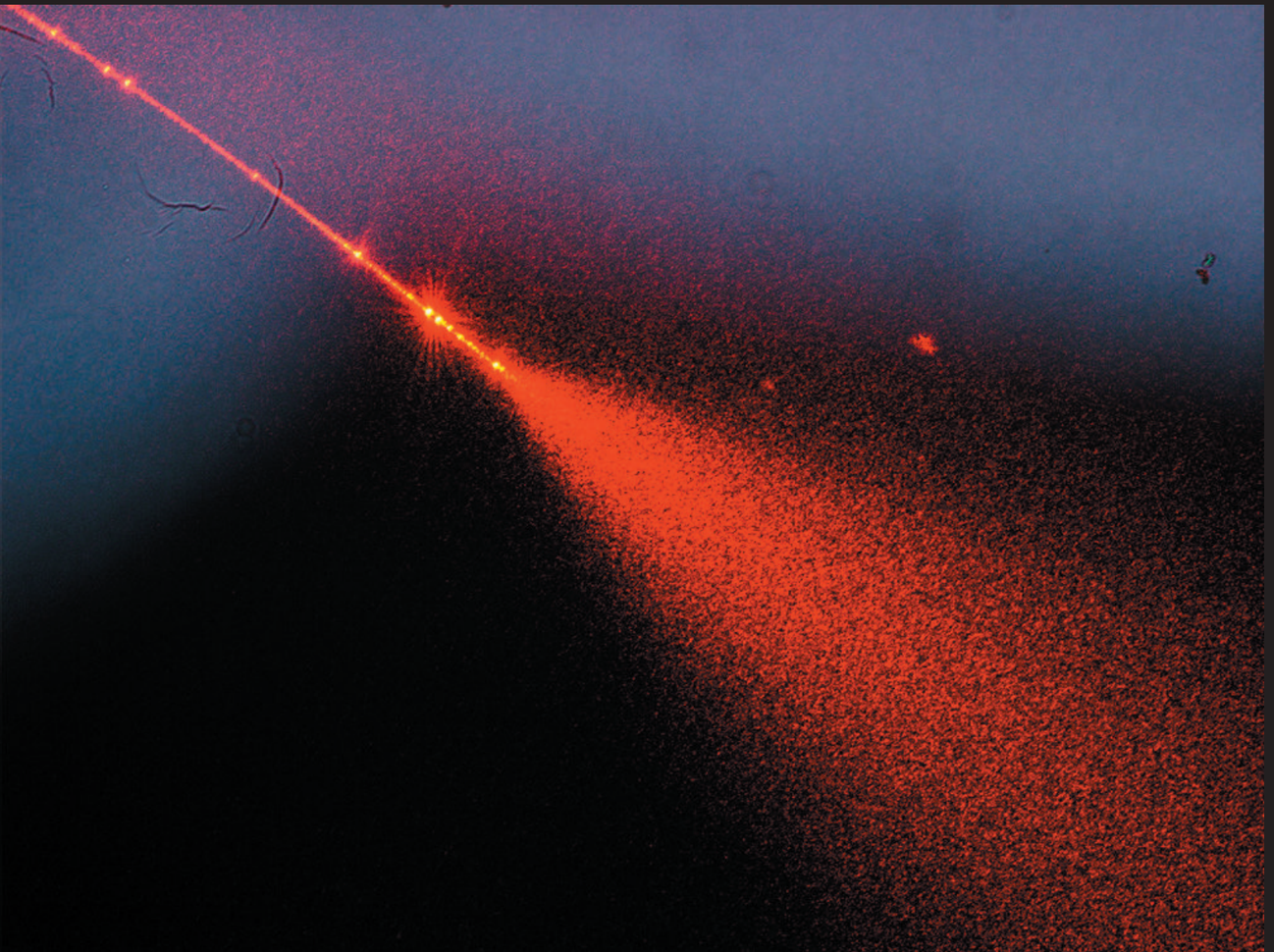
Nanotechnology:

The fabrication of devices on the 1–100 nm scale

Guiding light:

Transporting a light signal through a structure that confines the light



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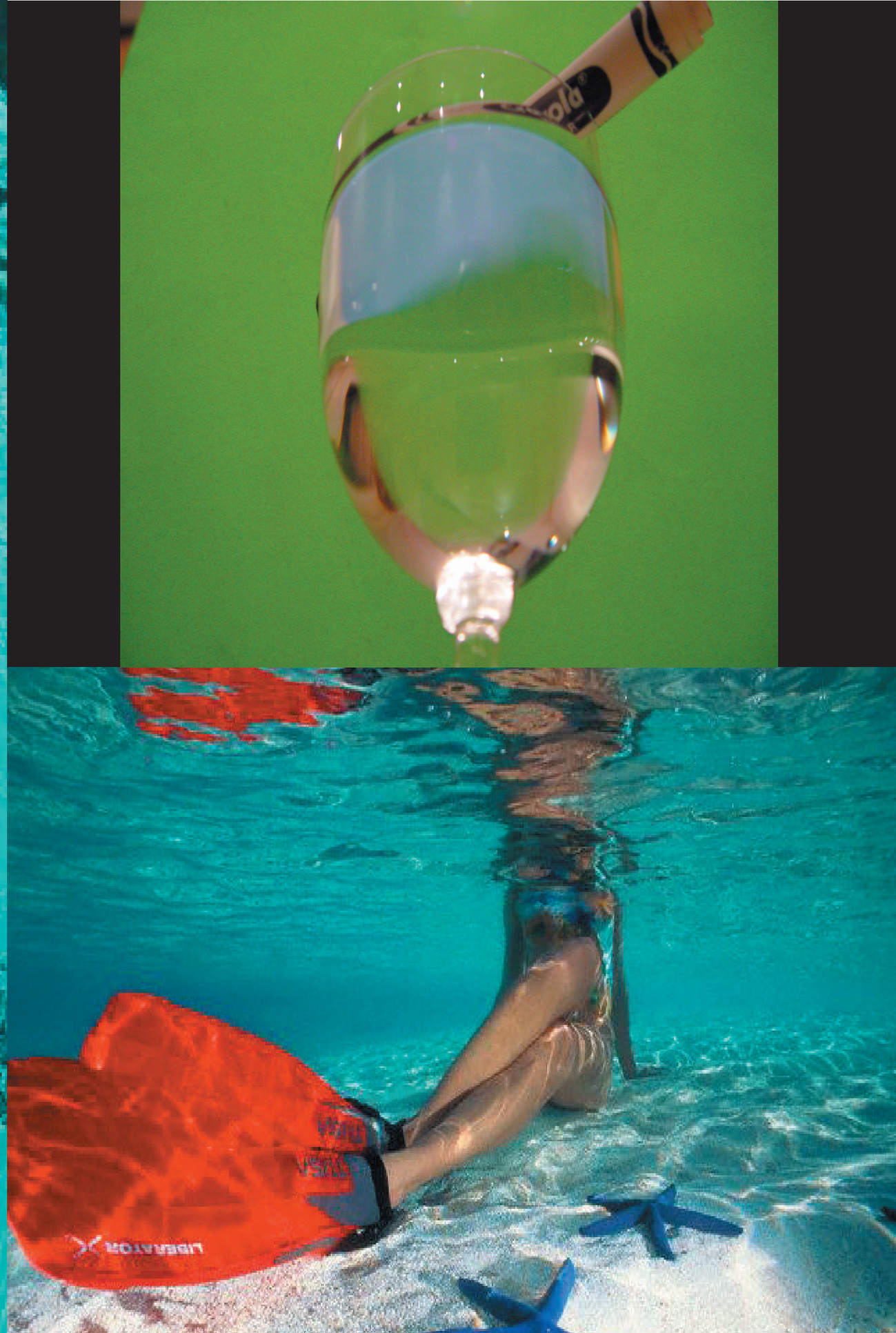
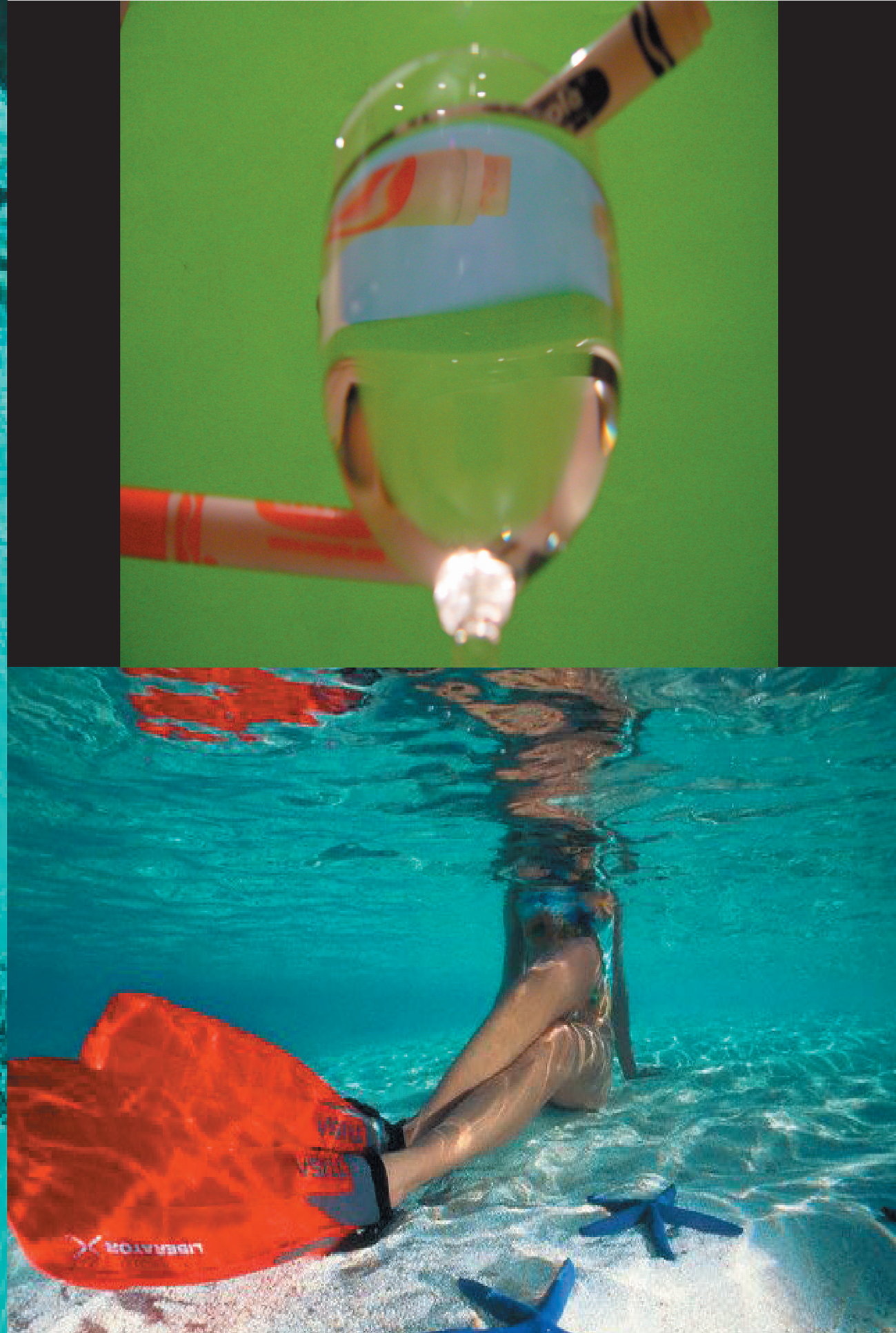
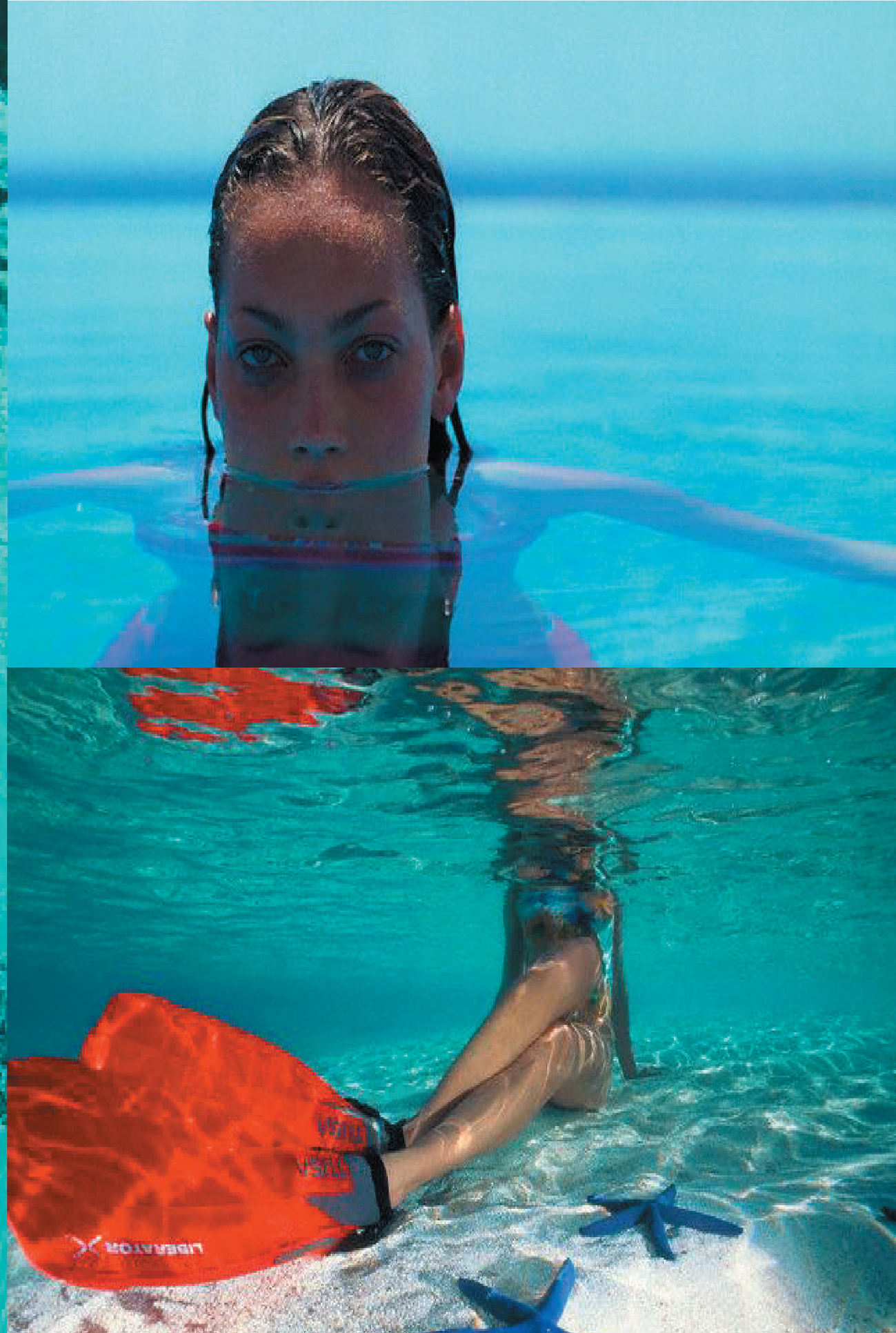






Interface between water and air is a perfect one-way mirror!

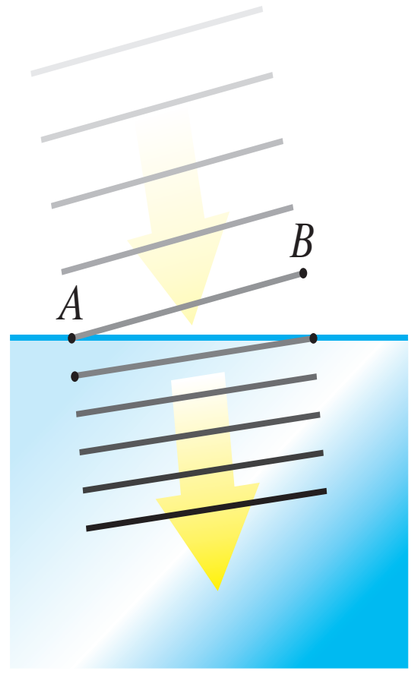
Why?

Why?

Because light travels more slowly in water (or plastic, or glass) than in air

Why?

Because light travels more slowly in water (or plastic, or glass) than in air



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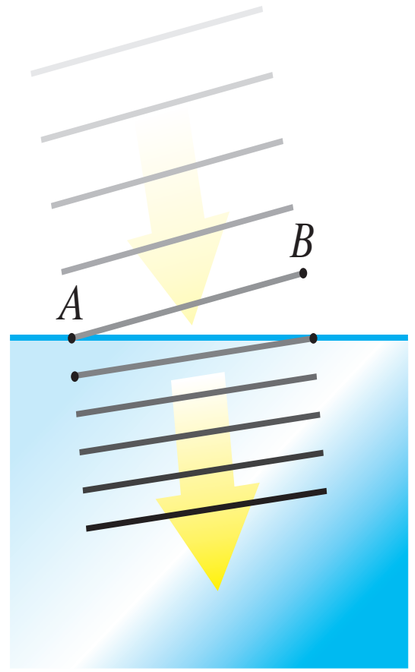
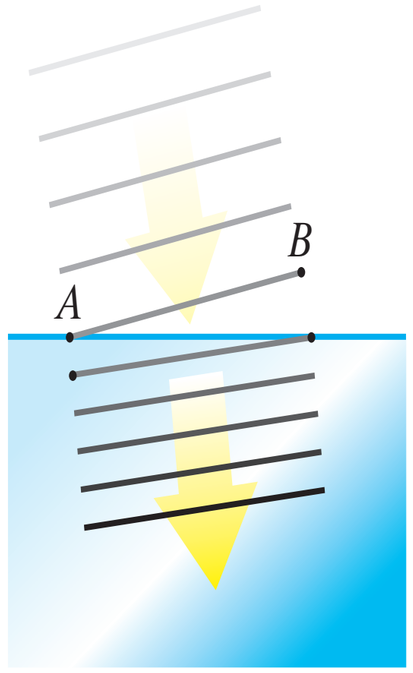
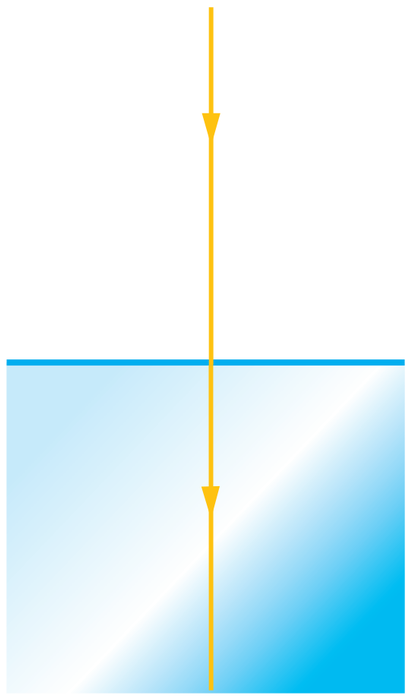


The more angled the incident ray, the stronger the bending





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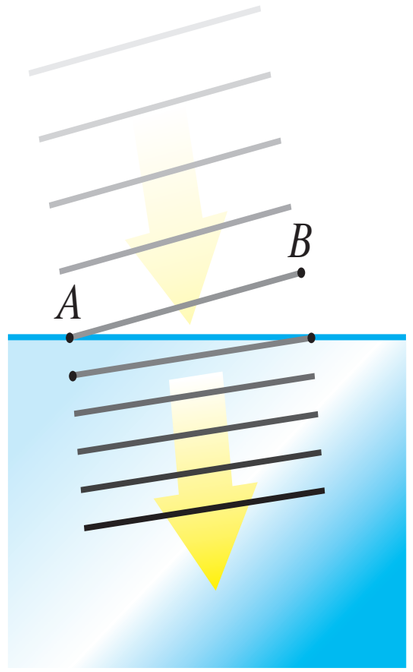
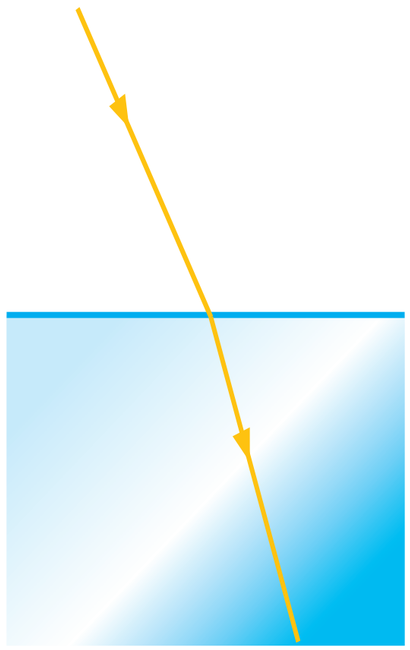
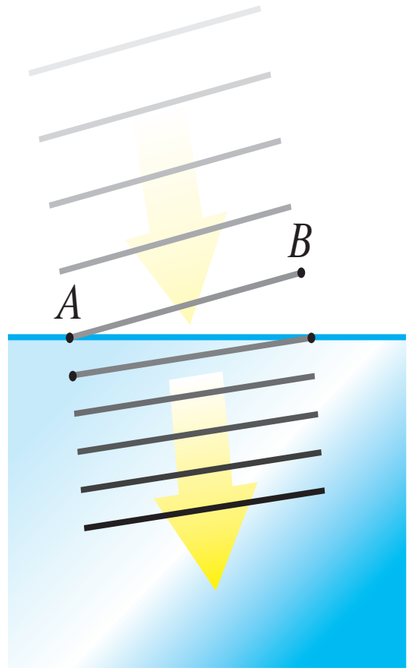
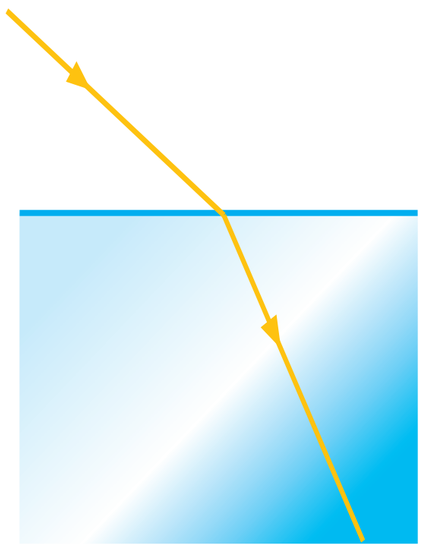




The shallower the incident ray, the stronger the bending





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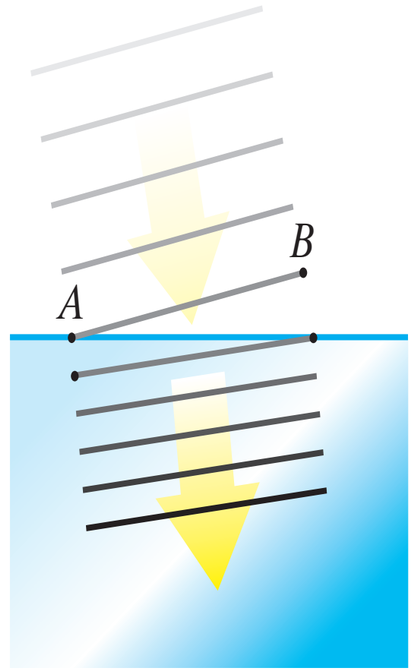
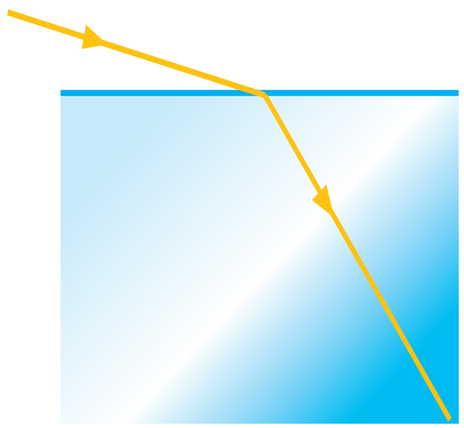
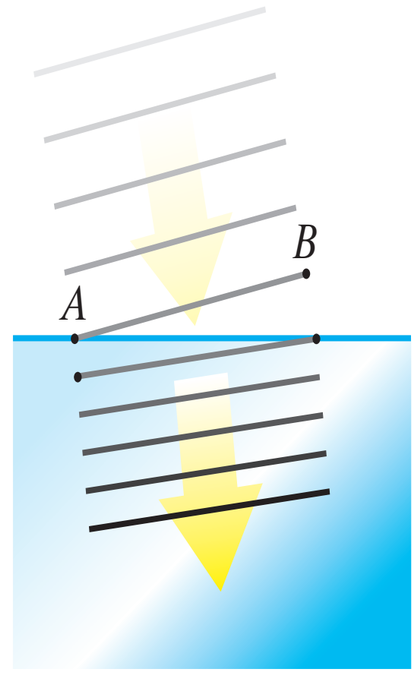
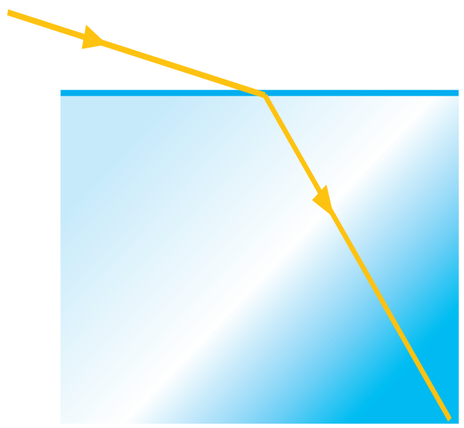




The shallower the incident ray, the stronger the bending

The amount of bending is the same in reverse





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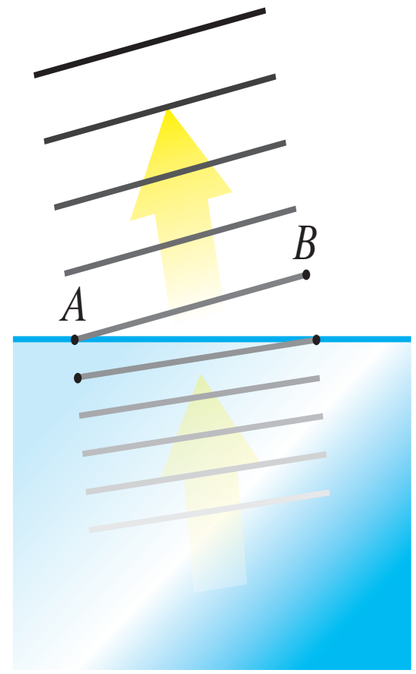

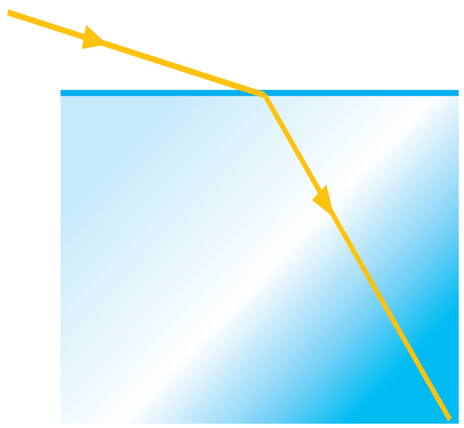

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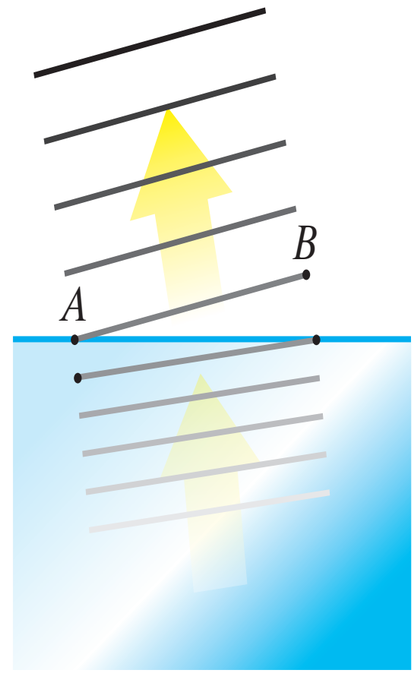

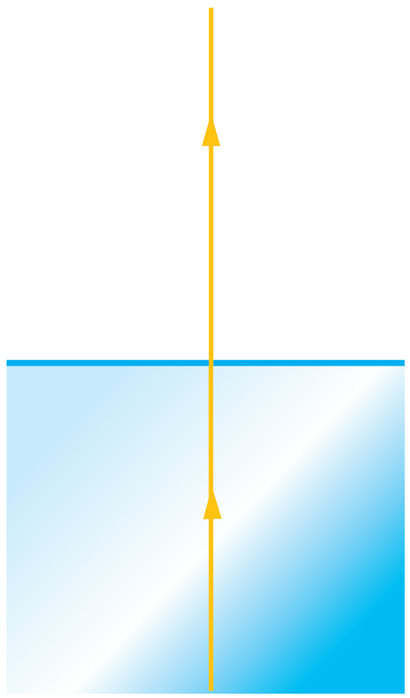

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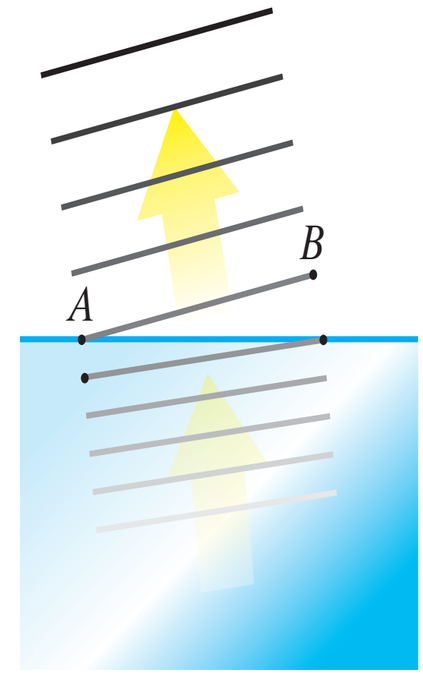

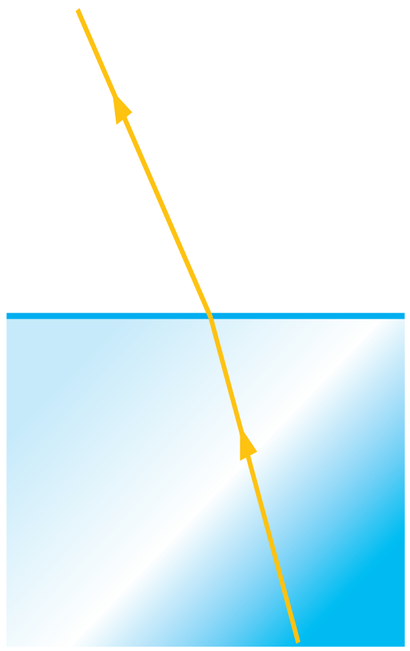

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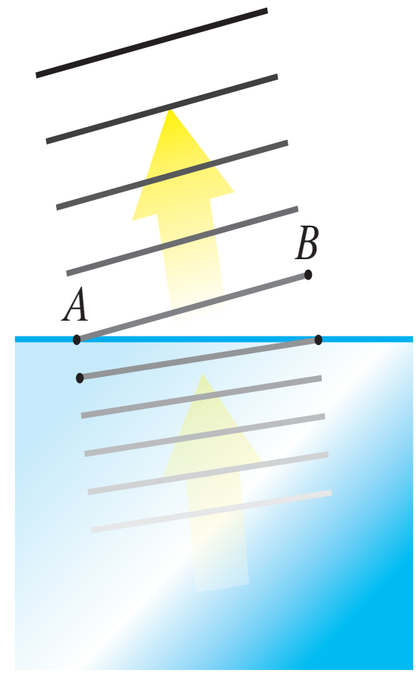

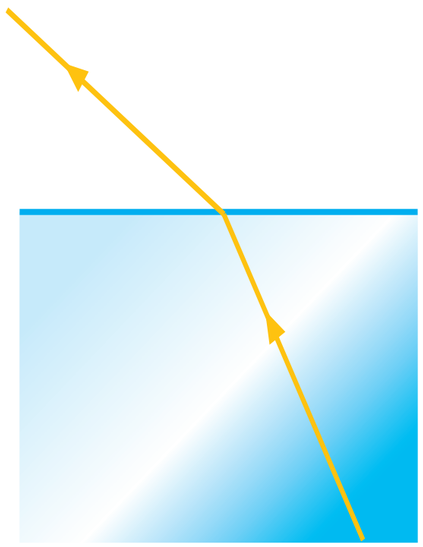

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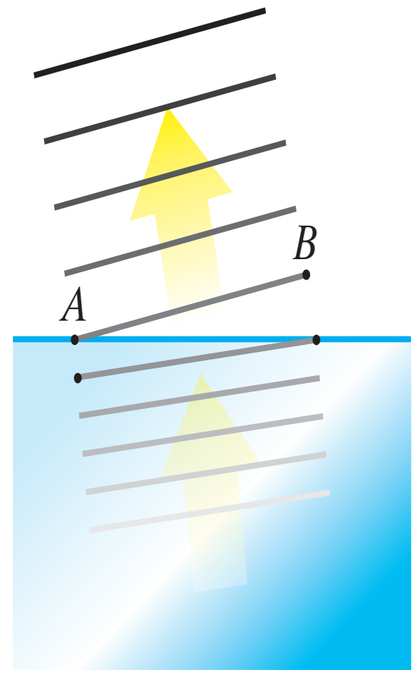

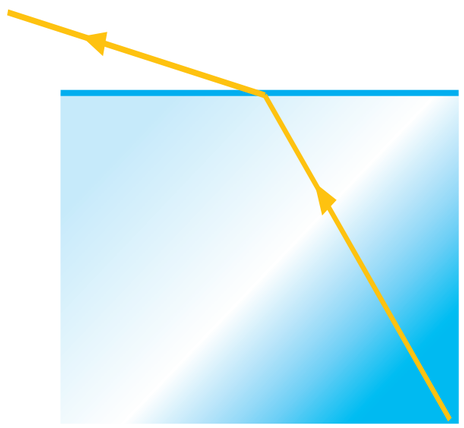

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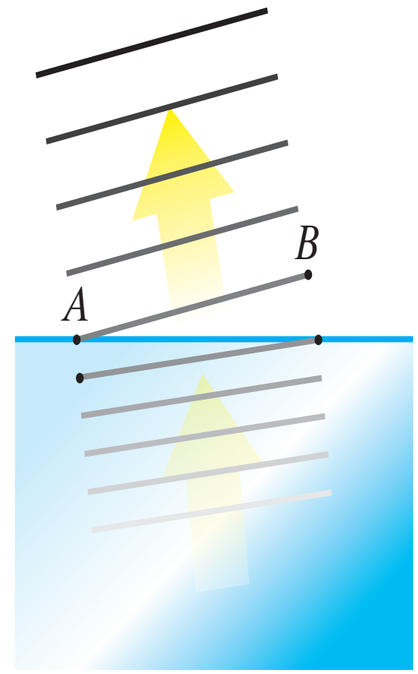
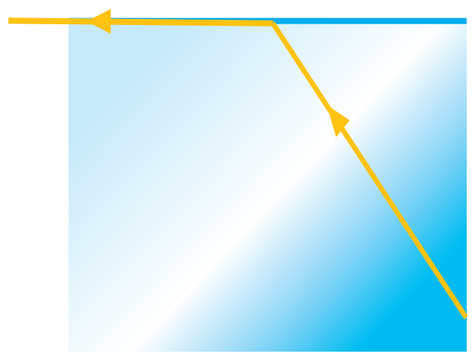
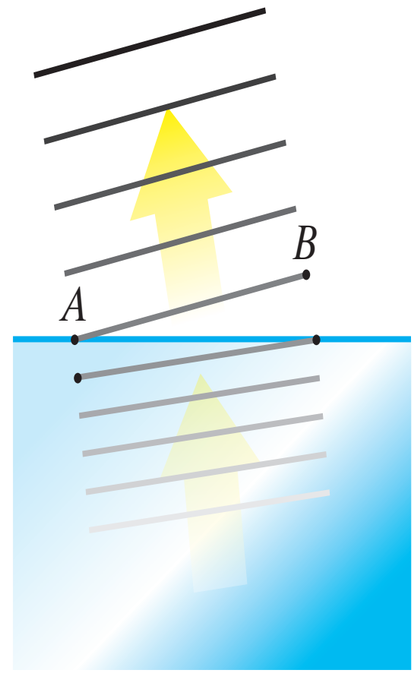
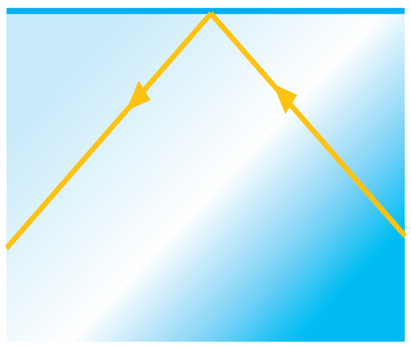




At the ‘critical angle’, the bent ray travels along the surface

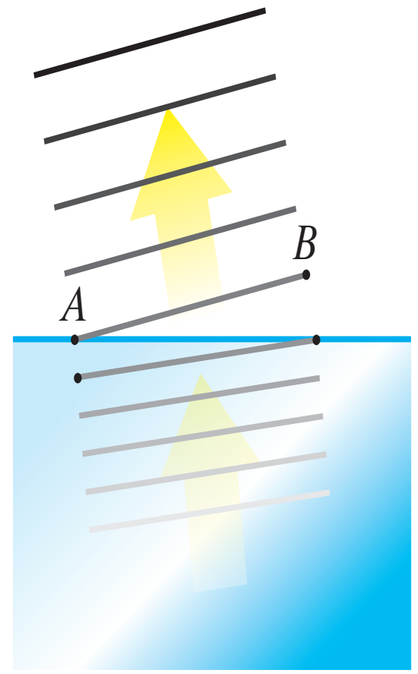
The amount of bending is the same in reverse

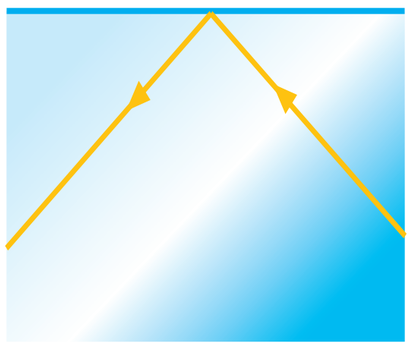




Beyond critical angle: total internal reflection!

Seeing underwater





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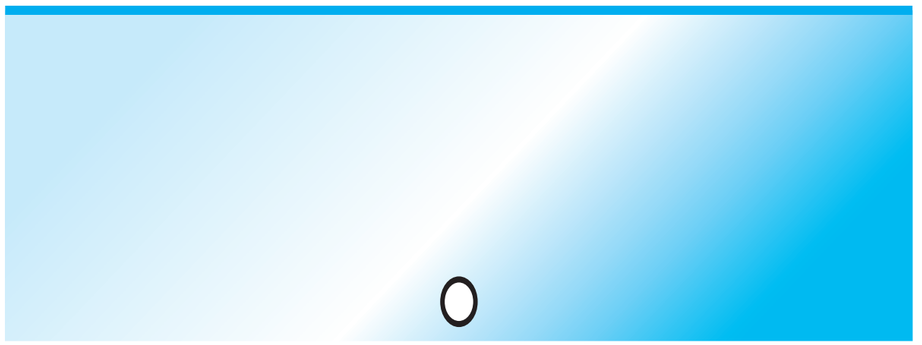

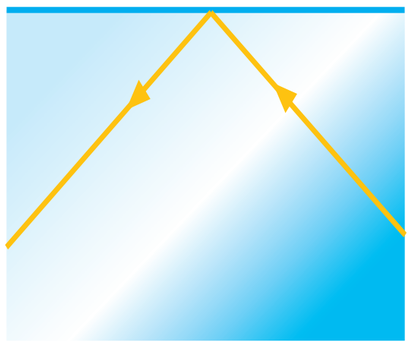

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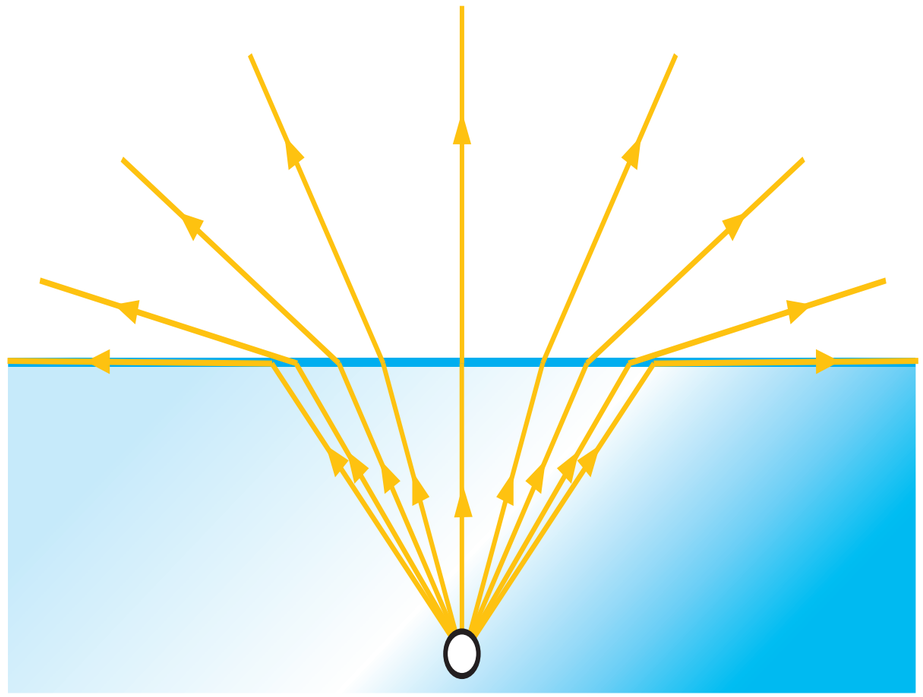

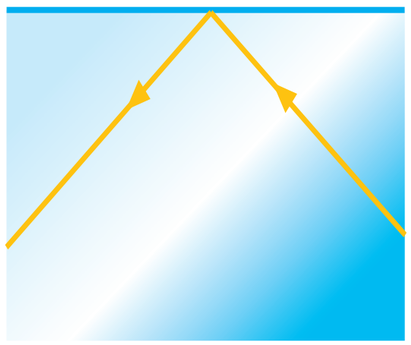

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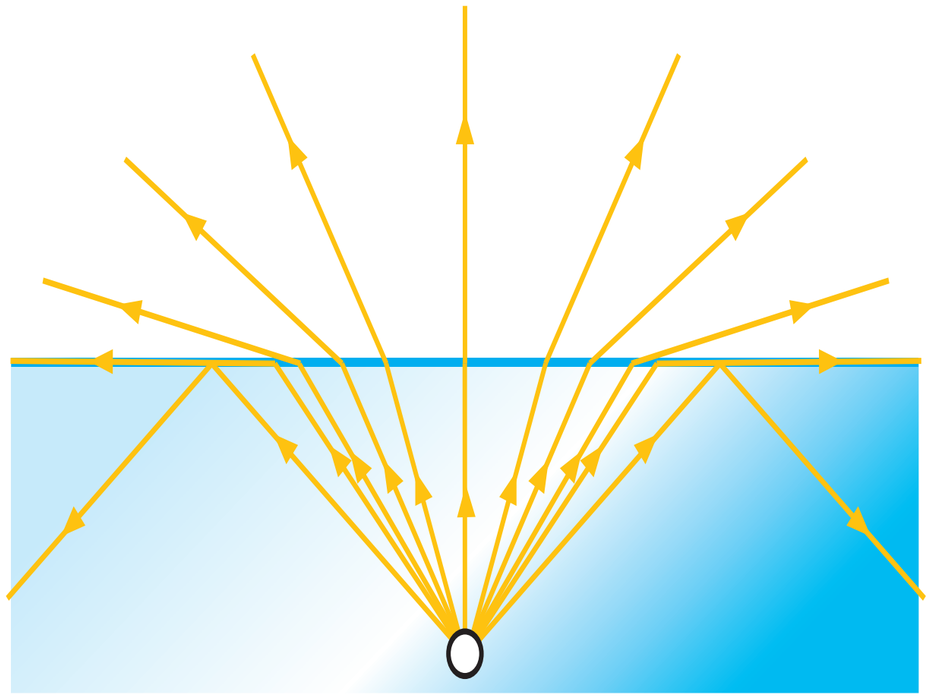

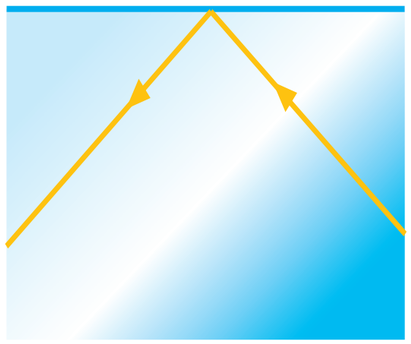

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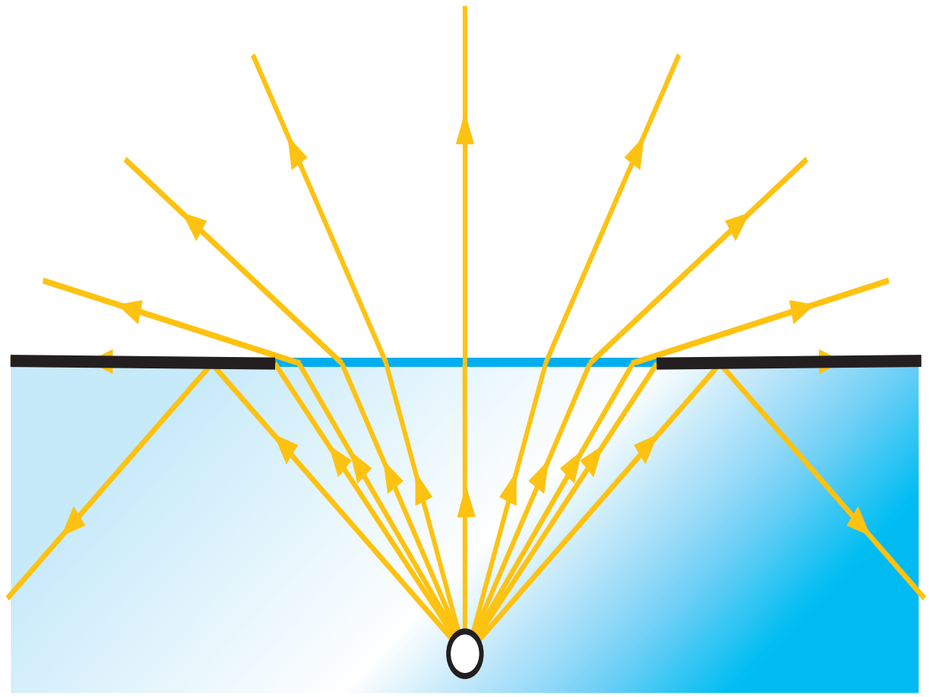

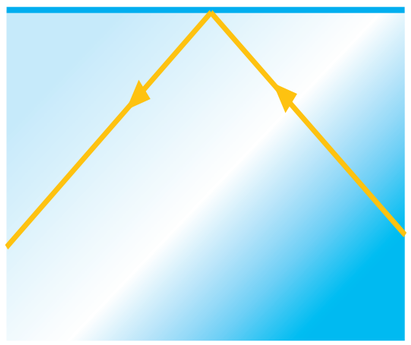

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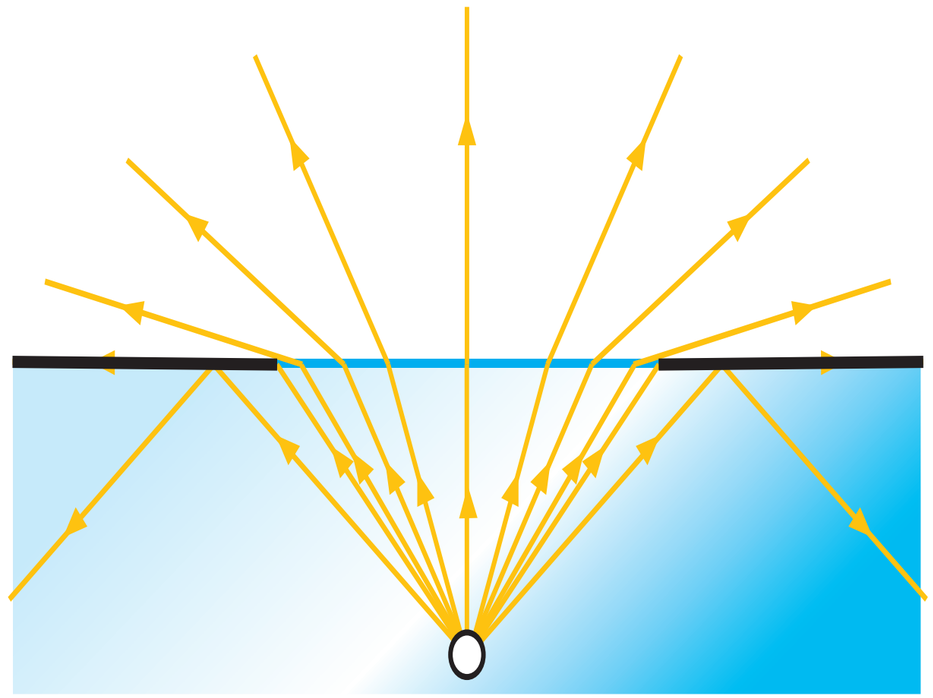

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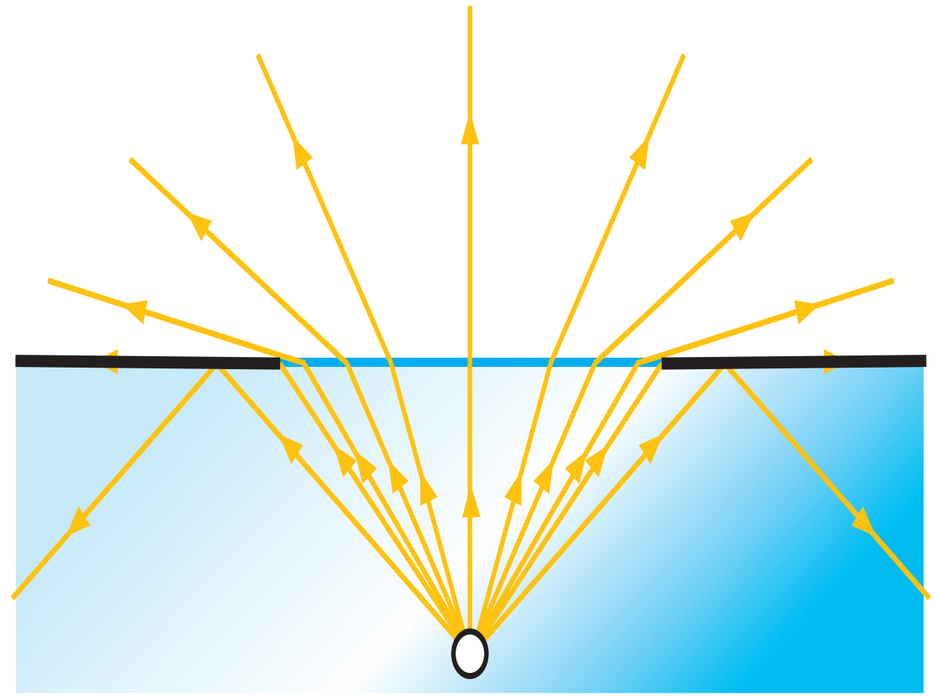
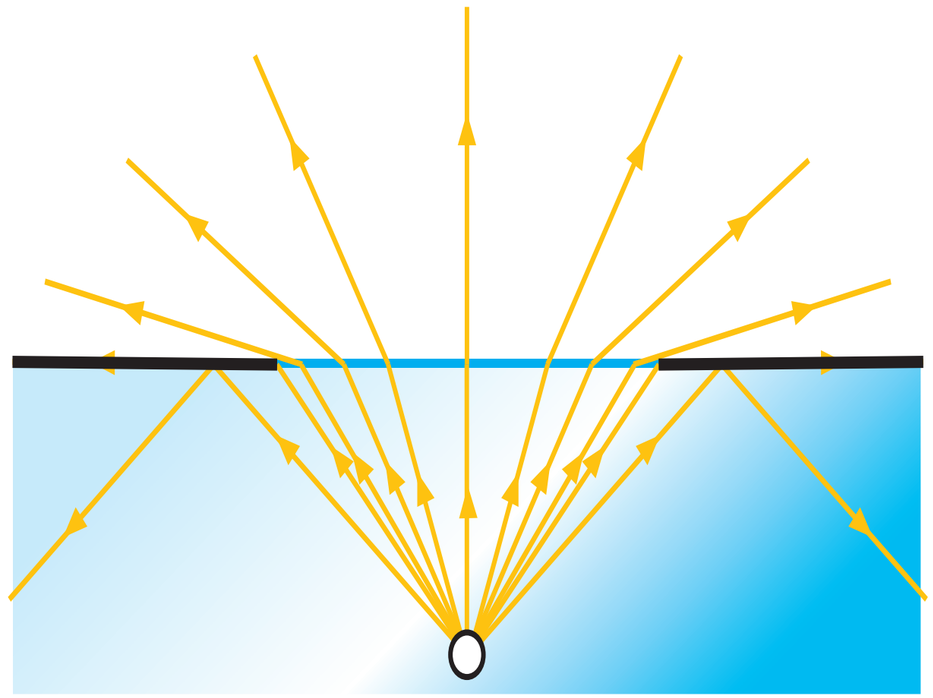
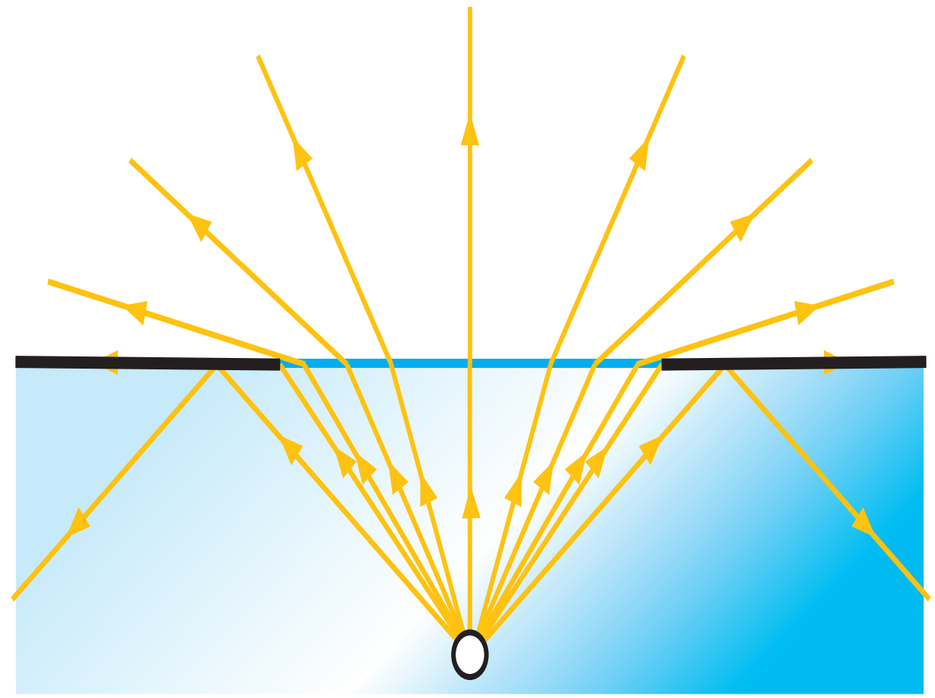
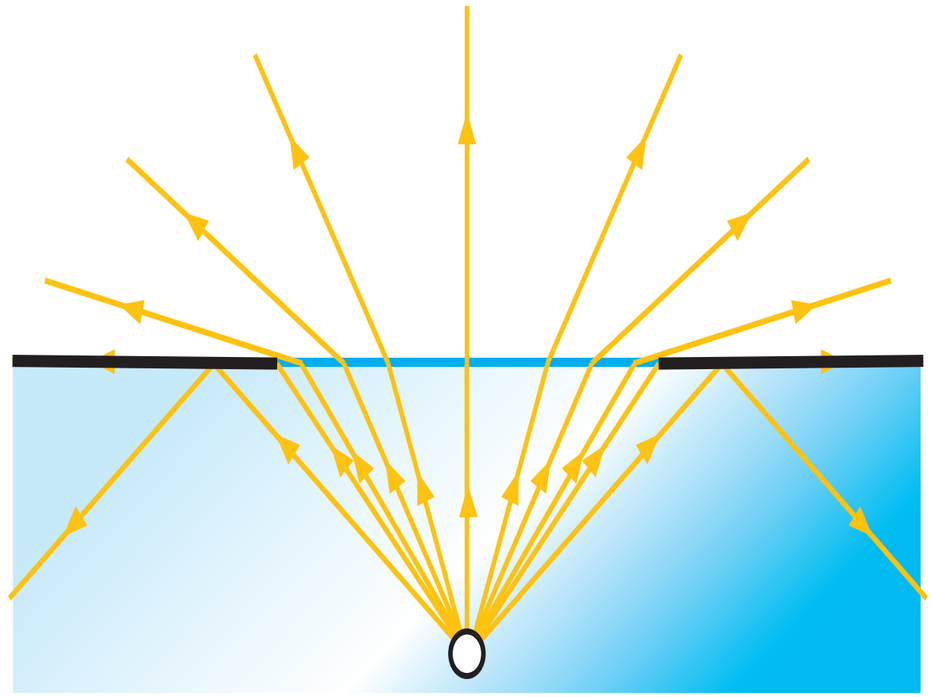




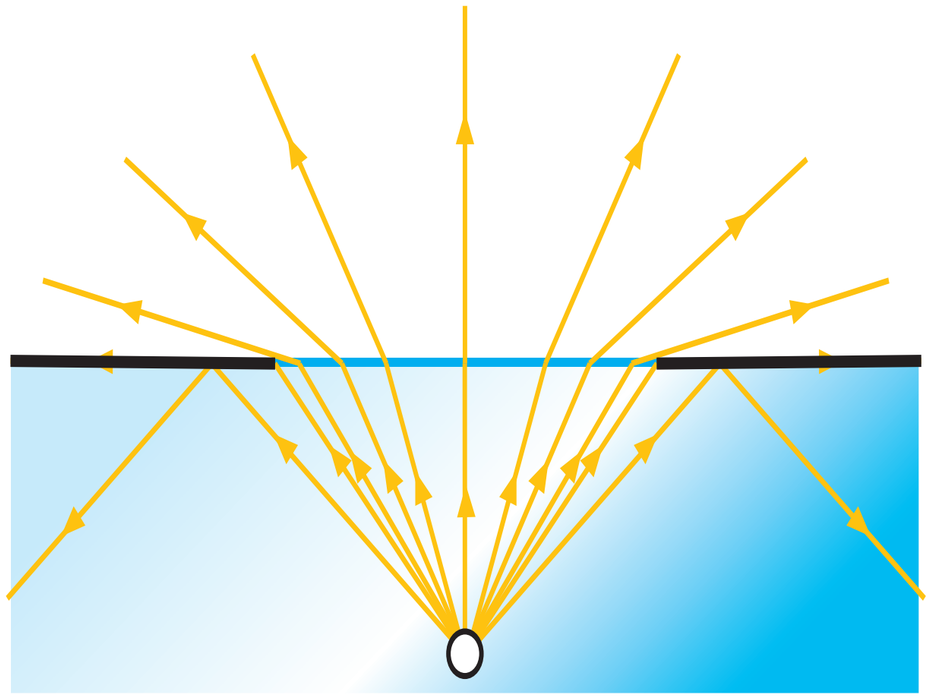
Use total internal reflection to guide light

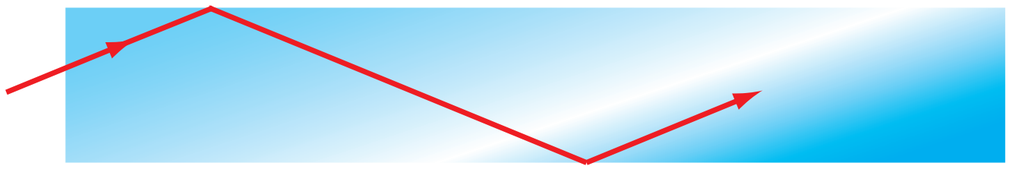


Use total internal reflection to guide light

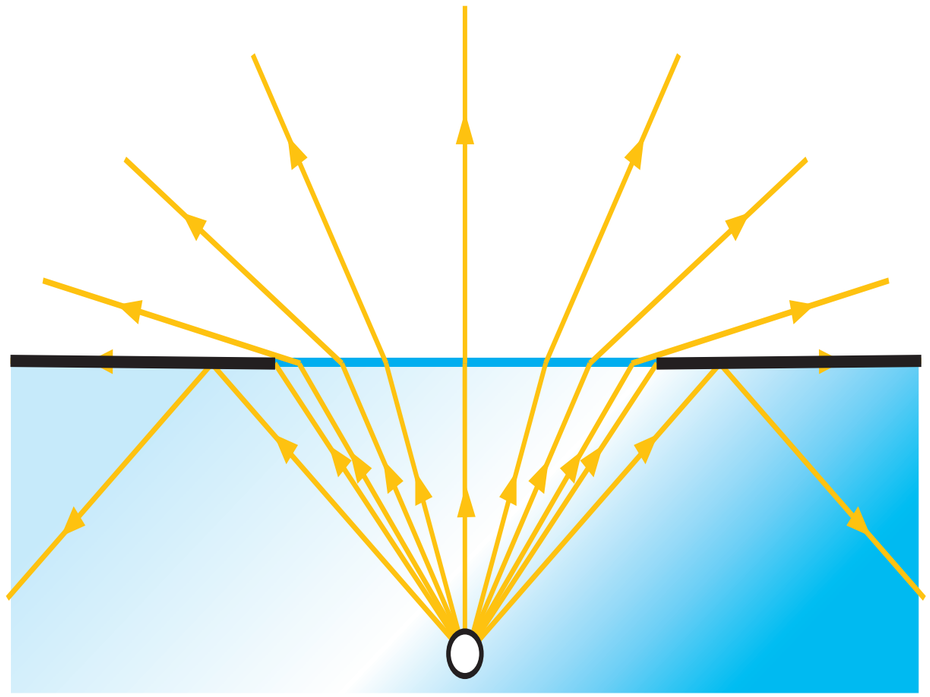


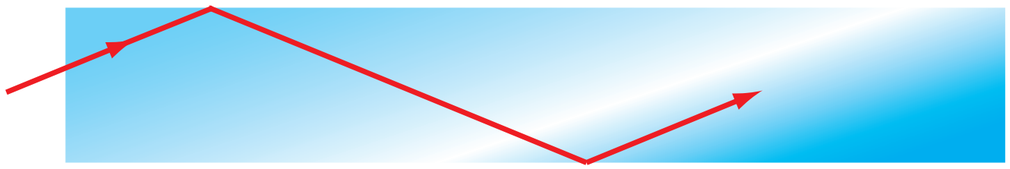
Use total internal reflection to guide light





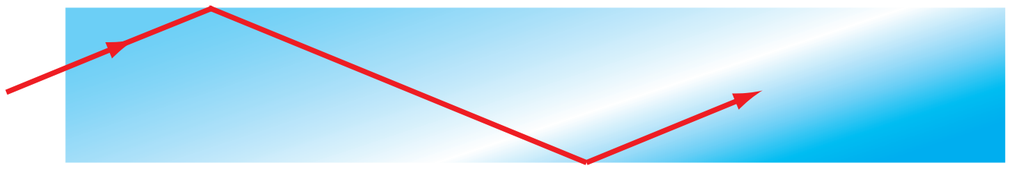
Use total internal reflection to guide light





Optical fiber:

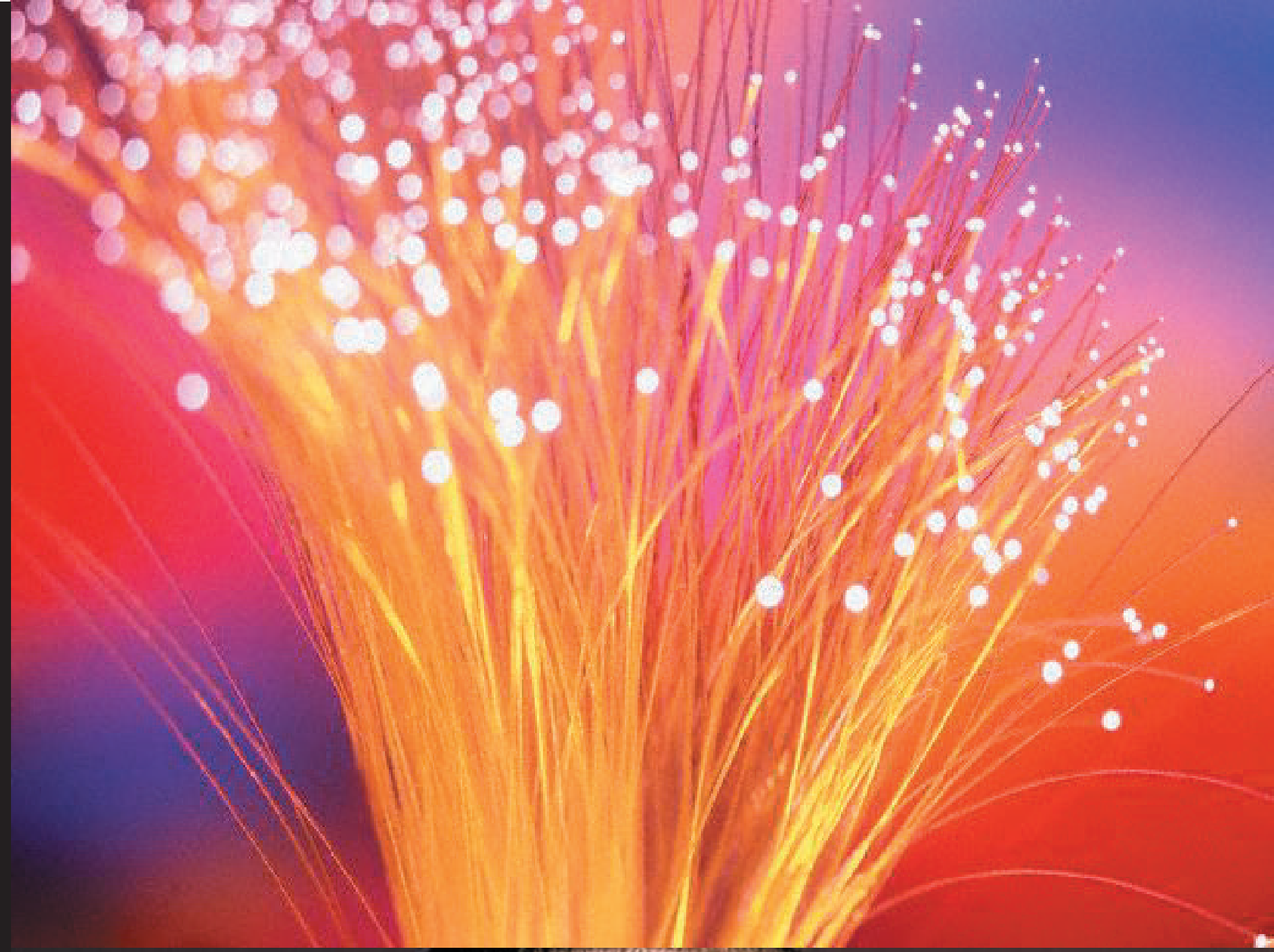
a ‘hose’ for light



Optical fiber:

a ‘hose’ for light

thickness: about 100 µm



Optical fiber:

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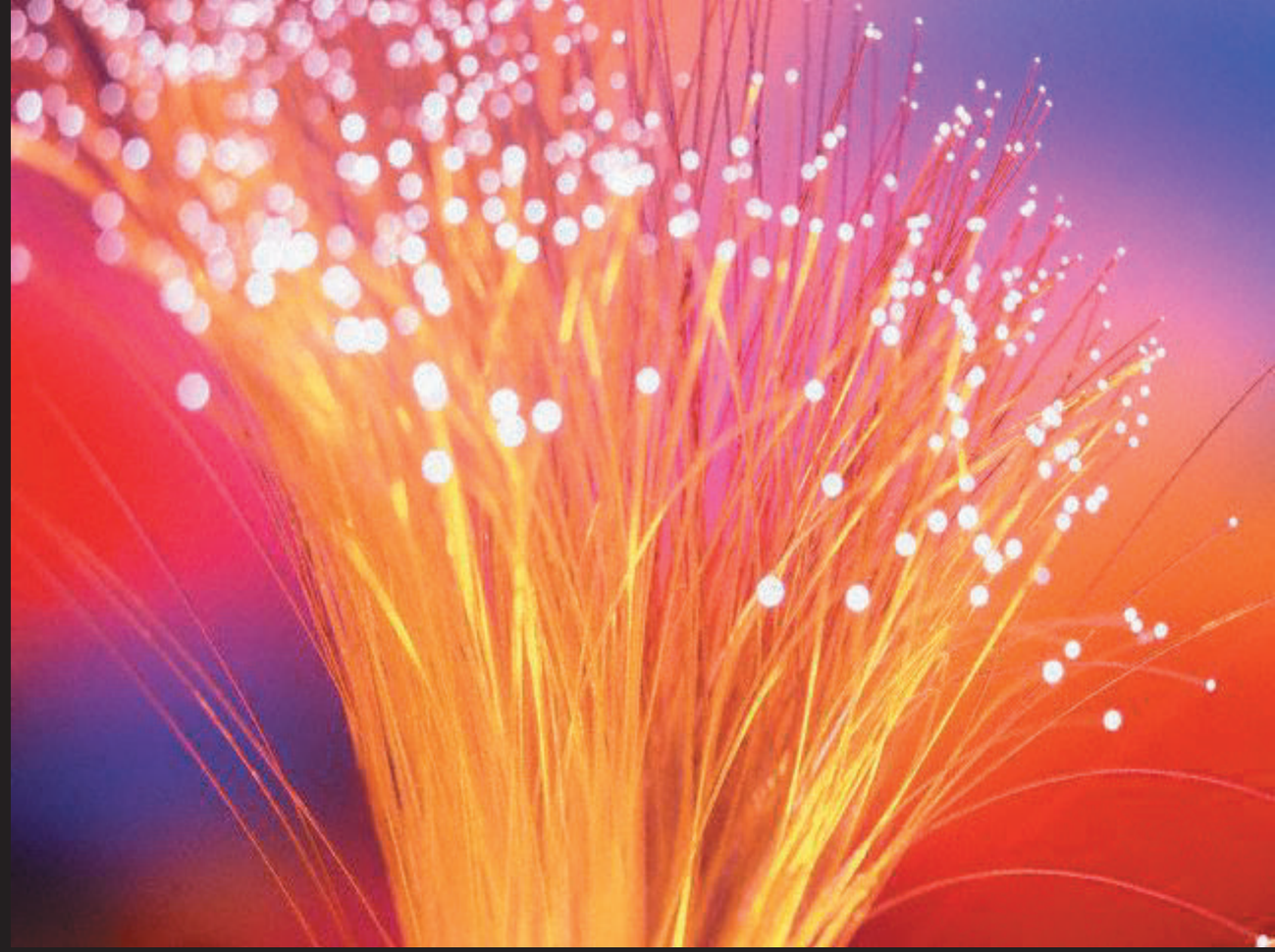
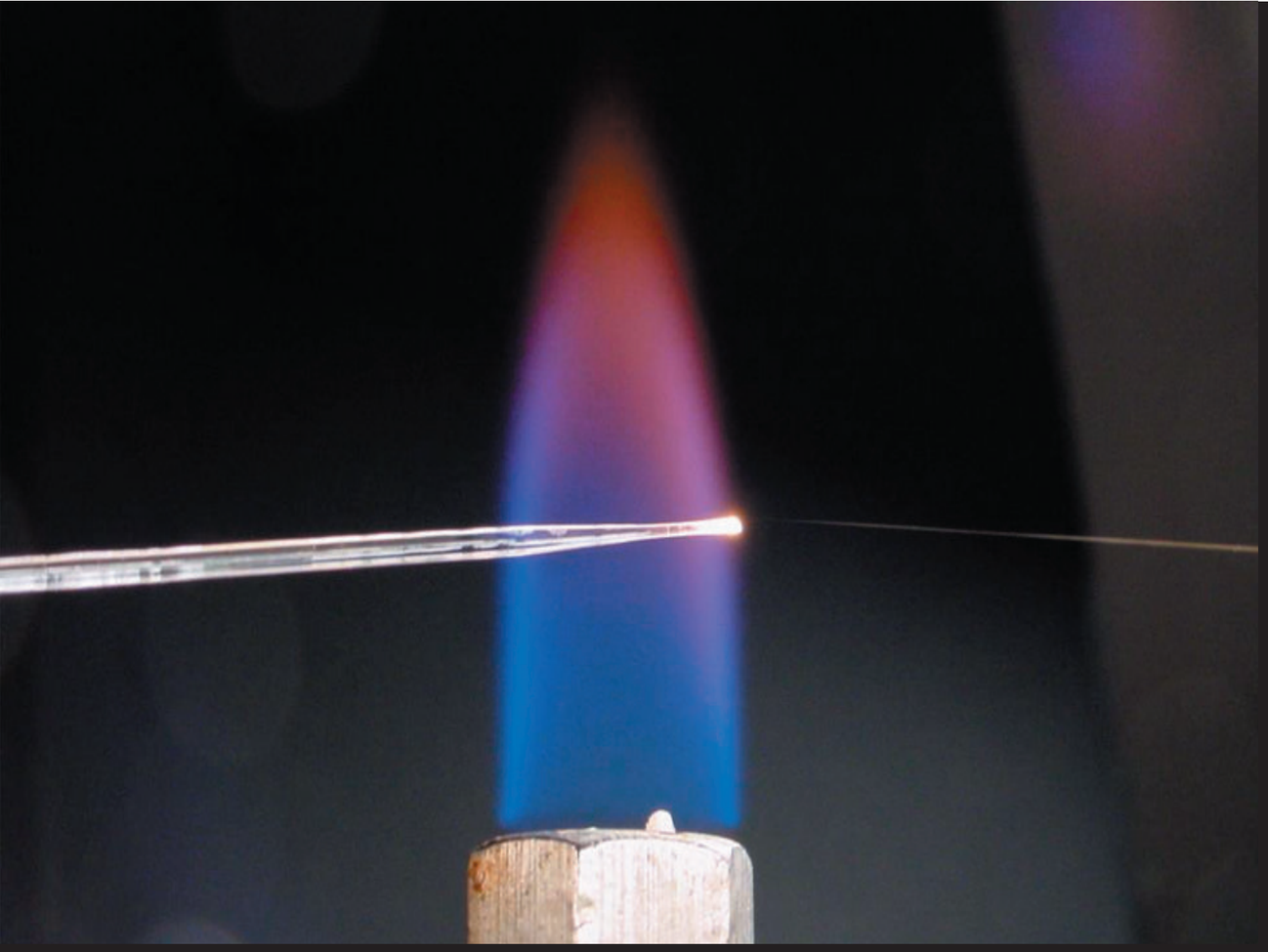
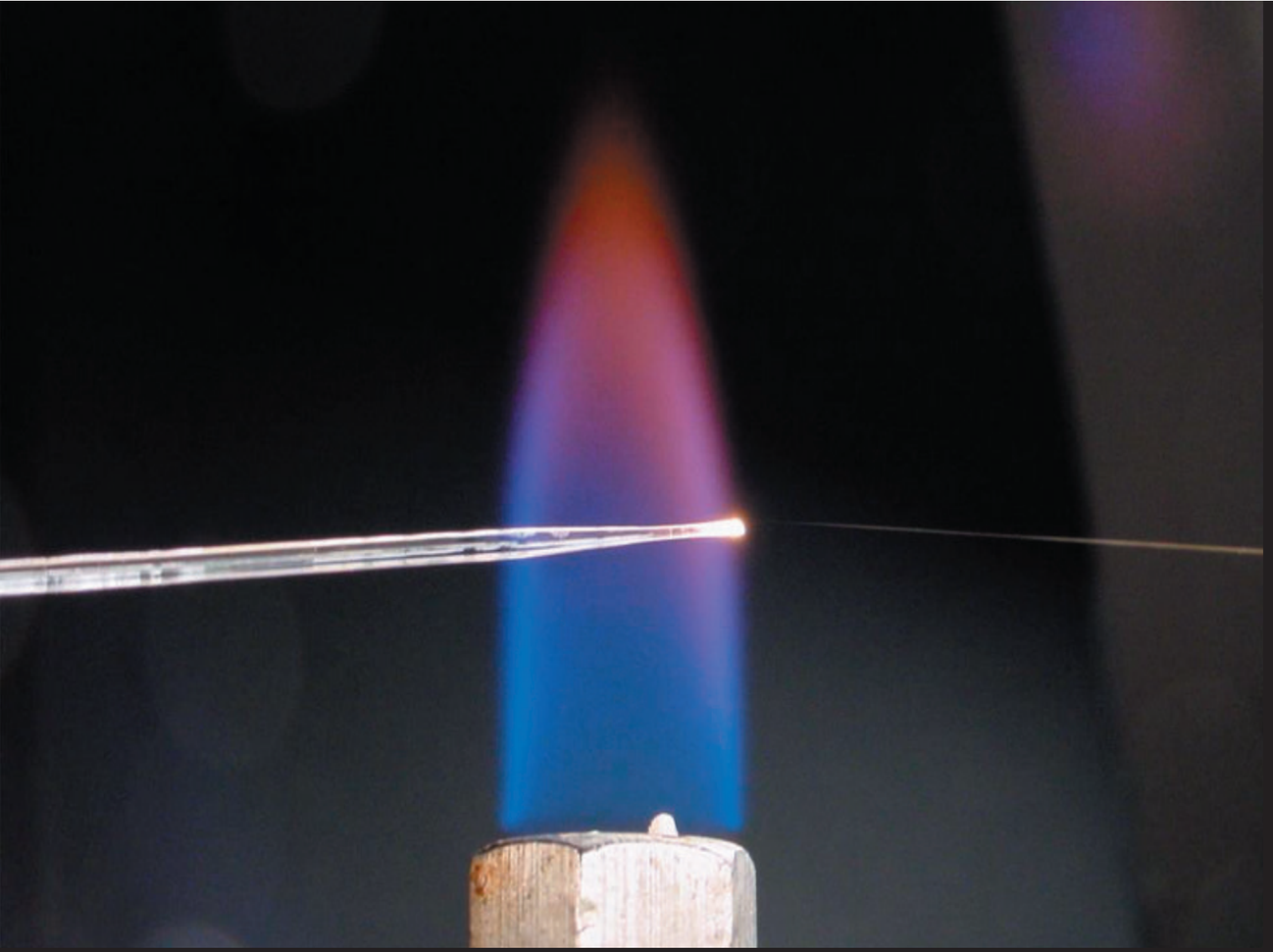


thickness: about 100 µm

too big for optical chips

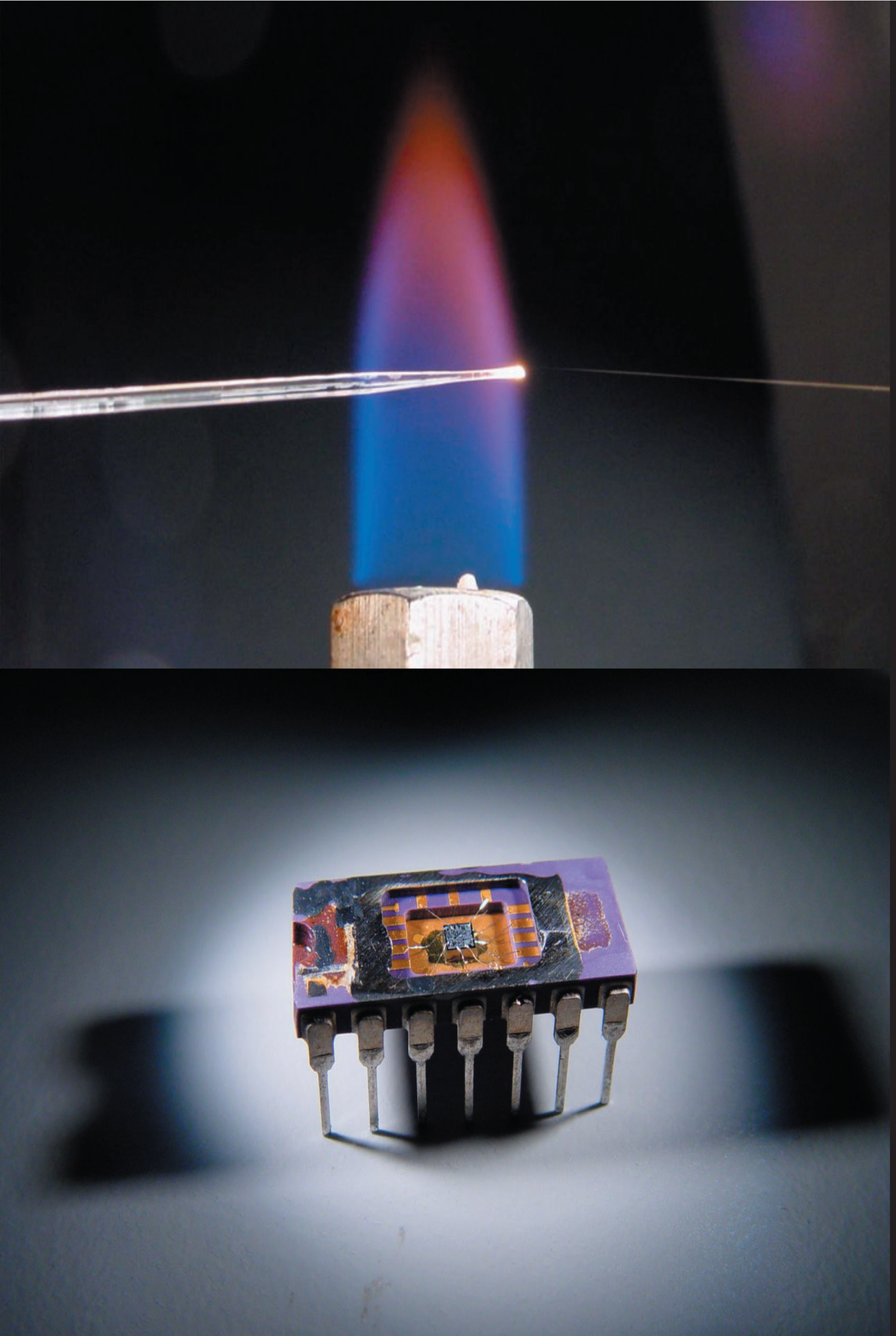
no tight bending of light





fabricating nanowires:

as thin as 20 nm!



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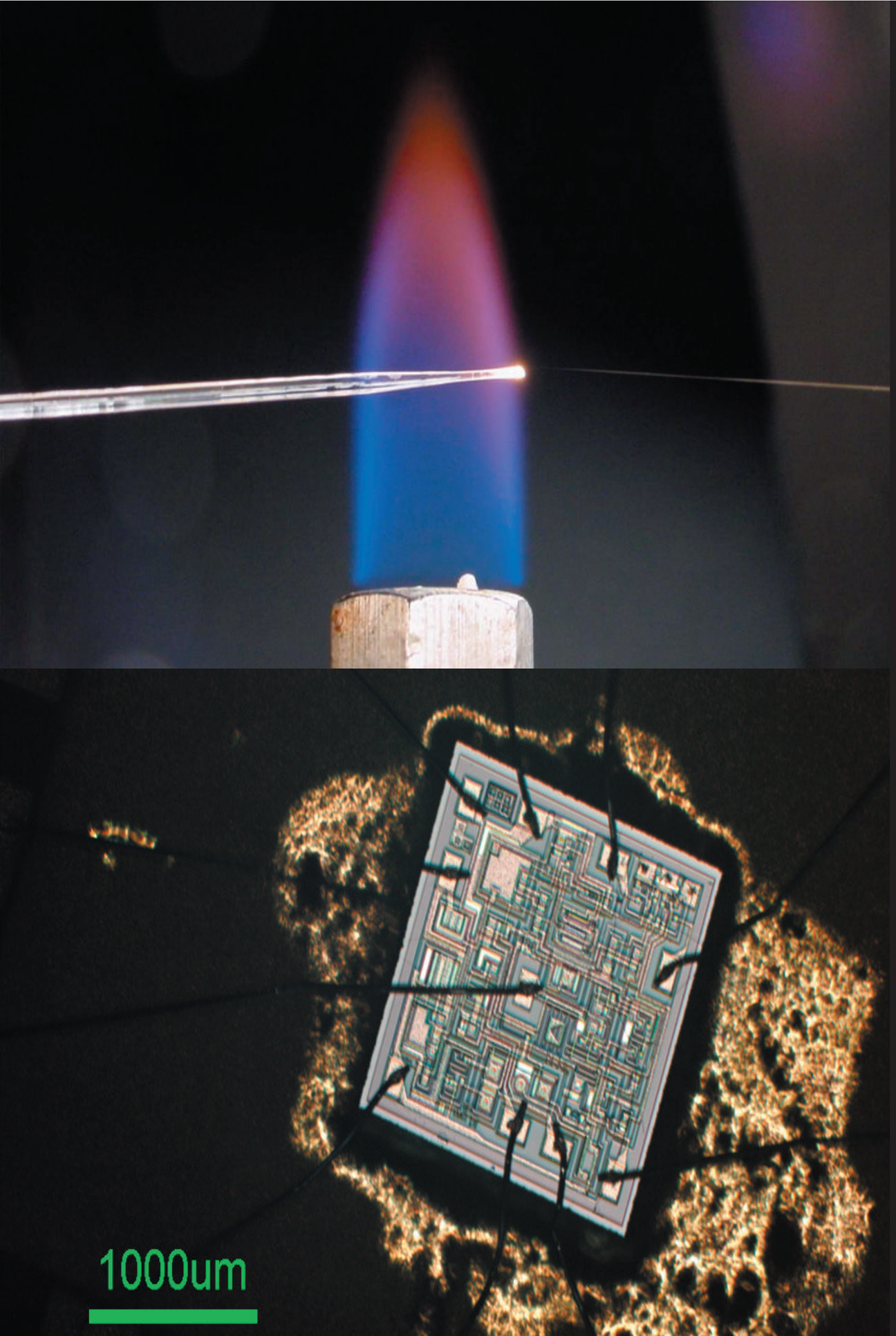

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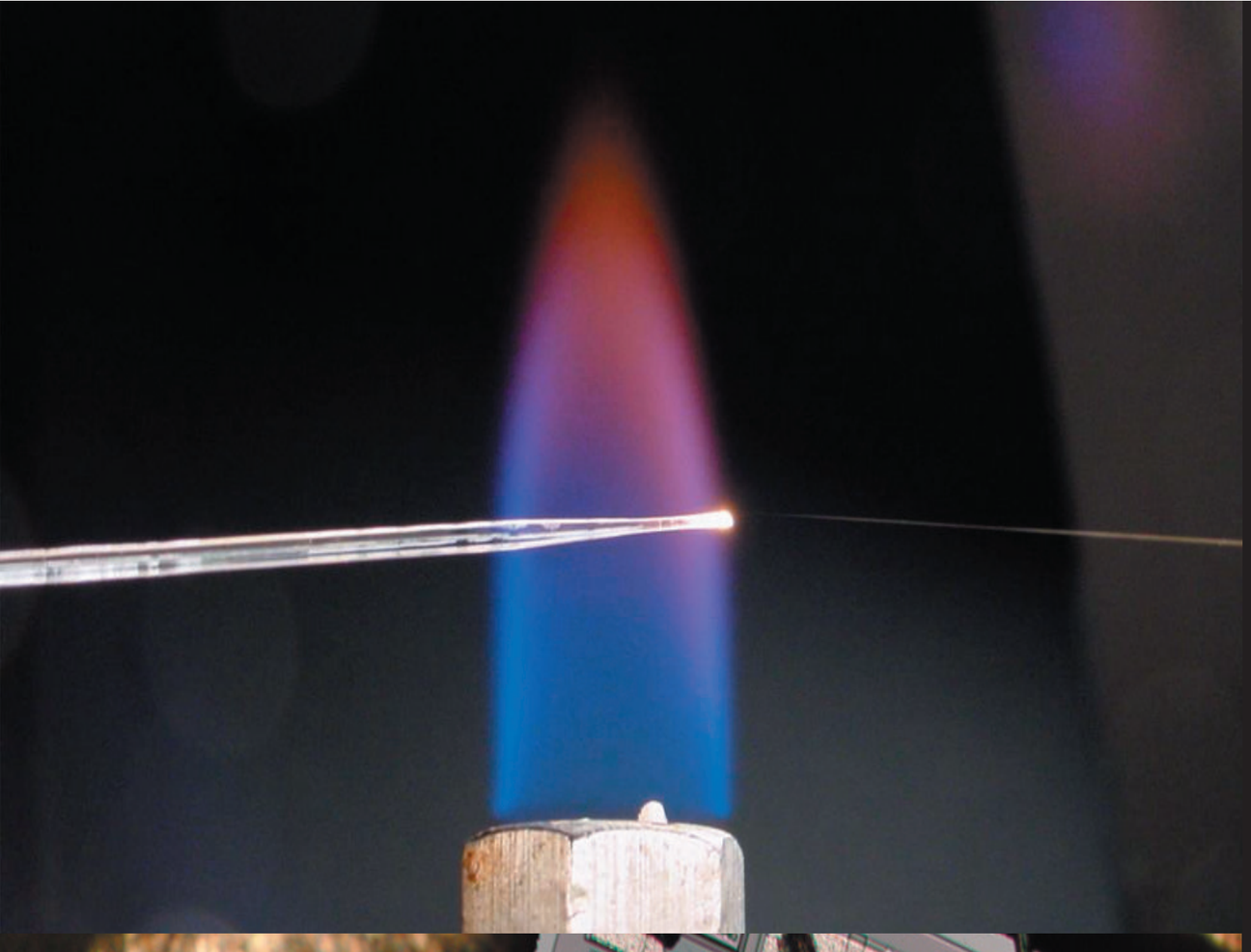

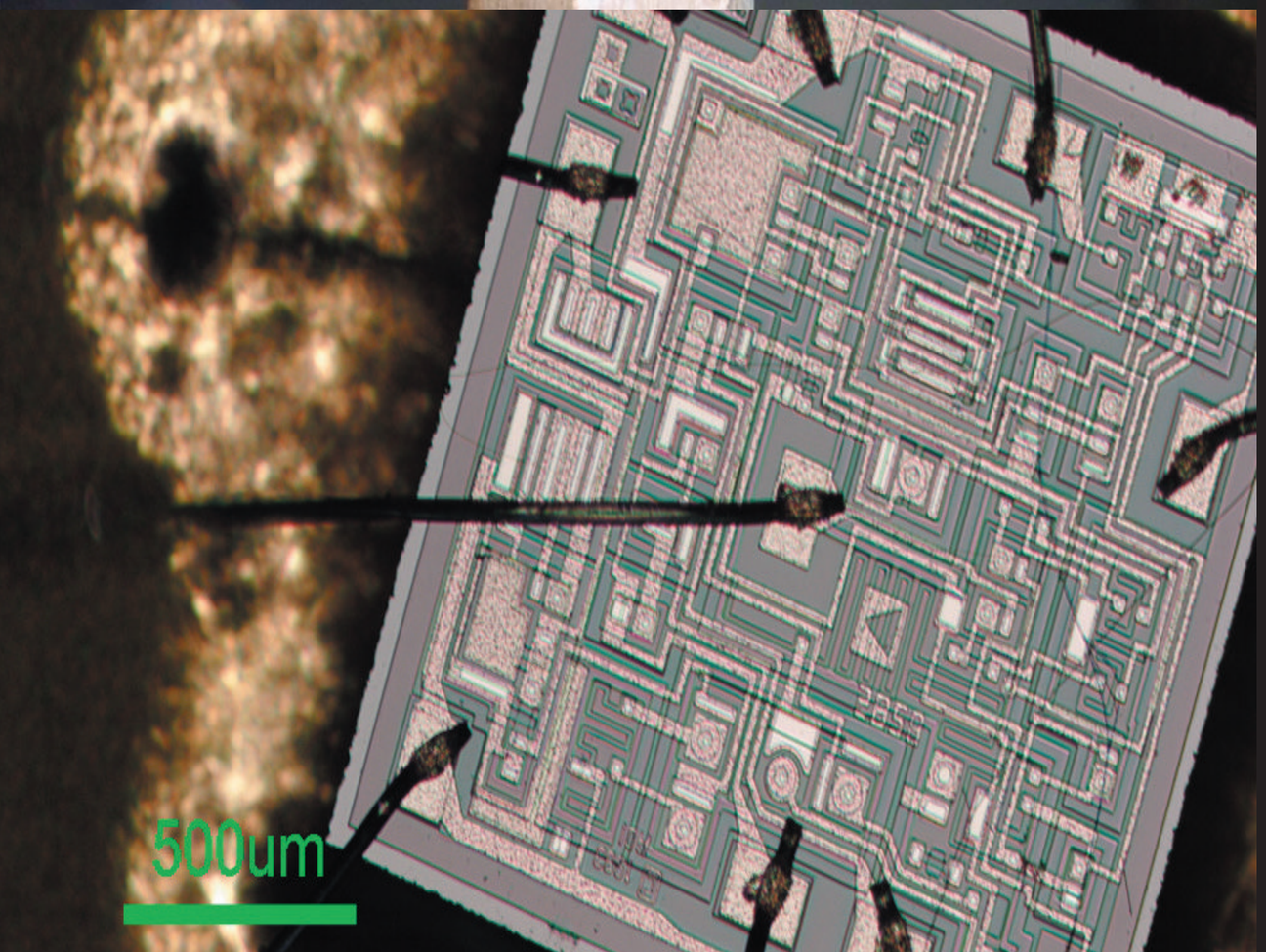

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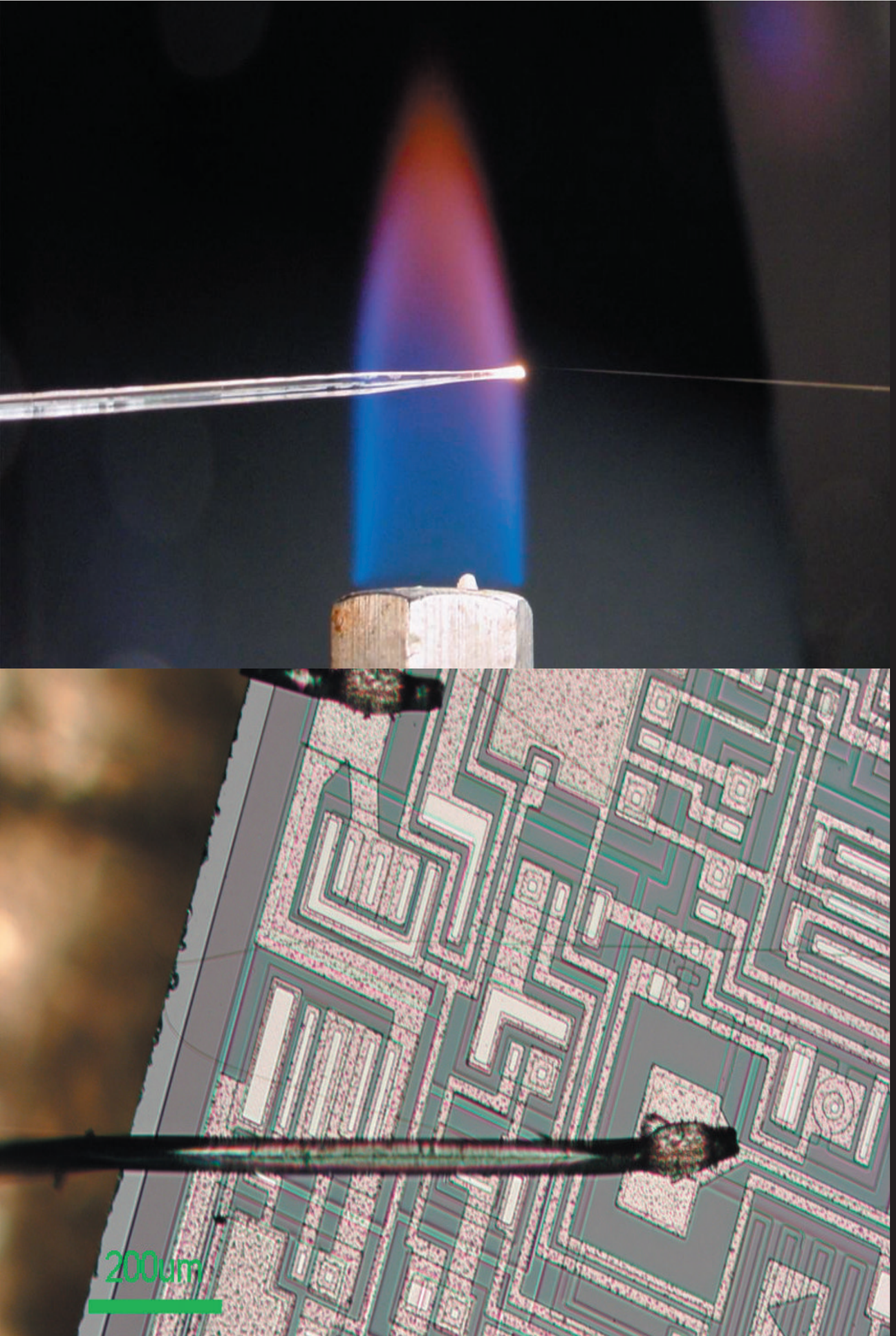

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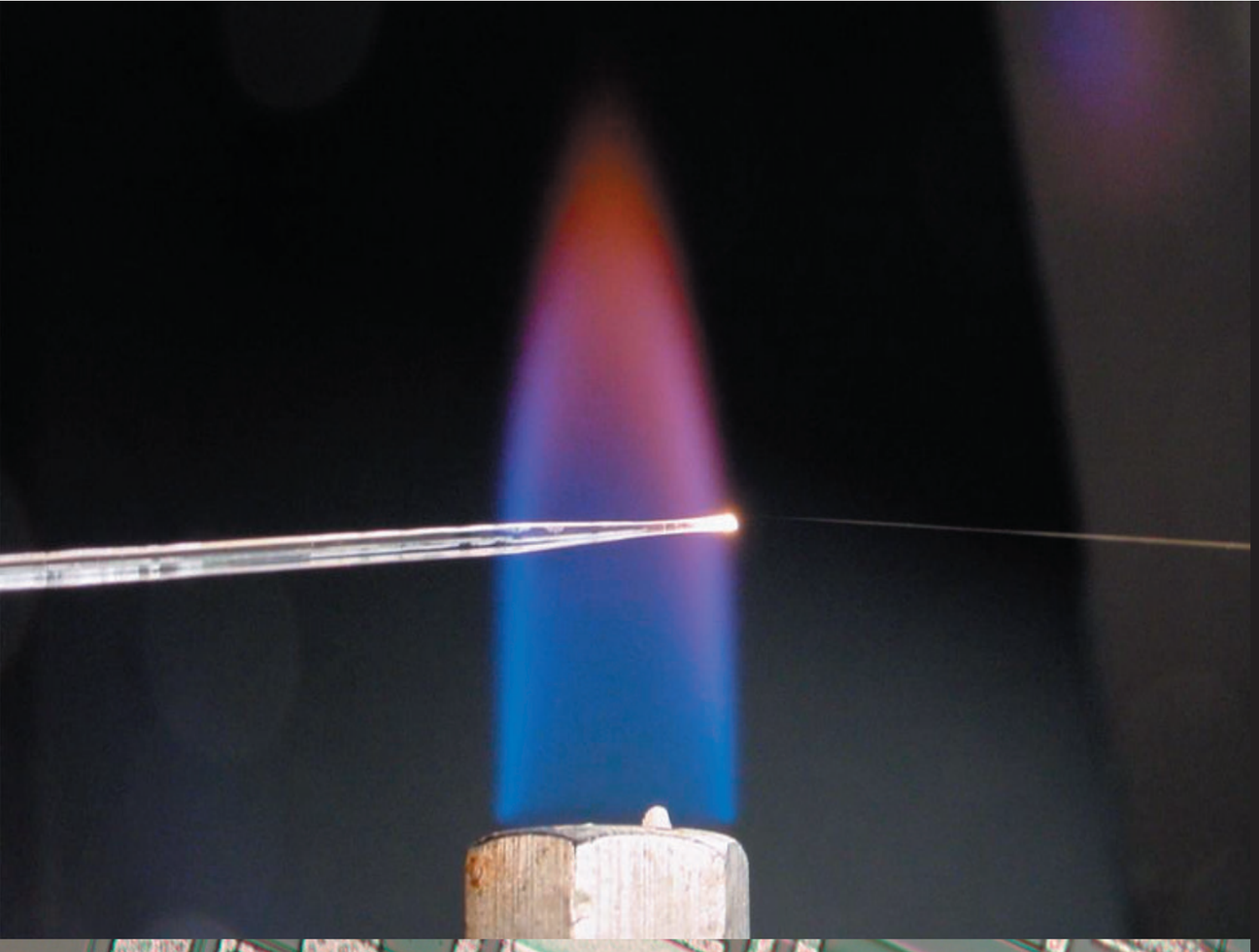

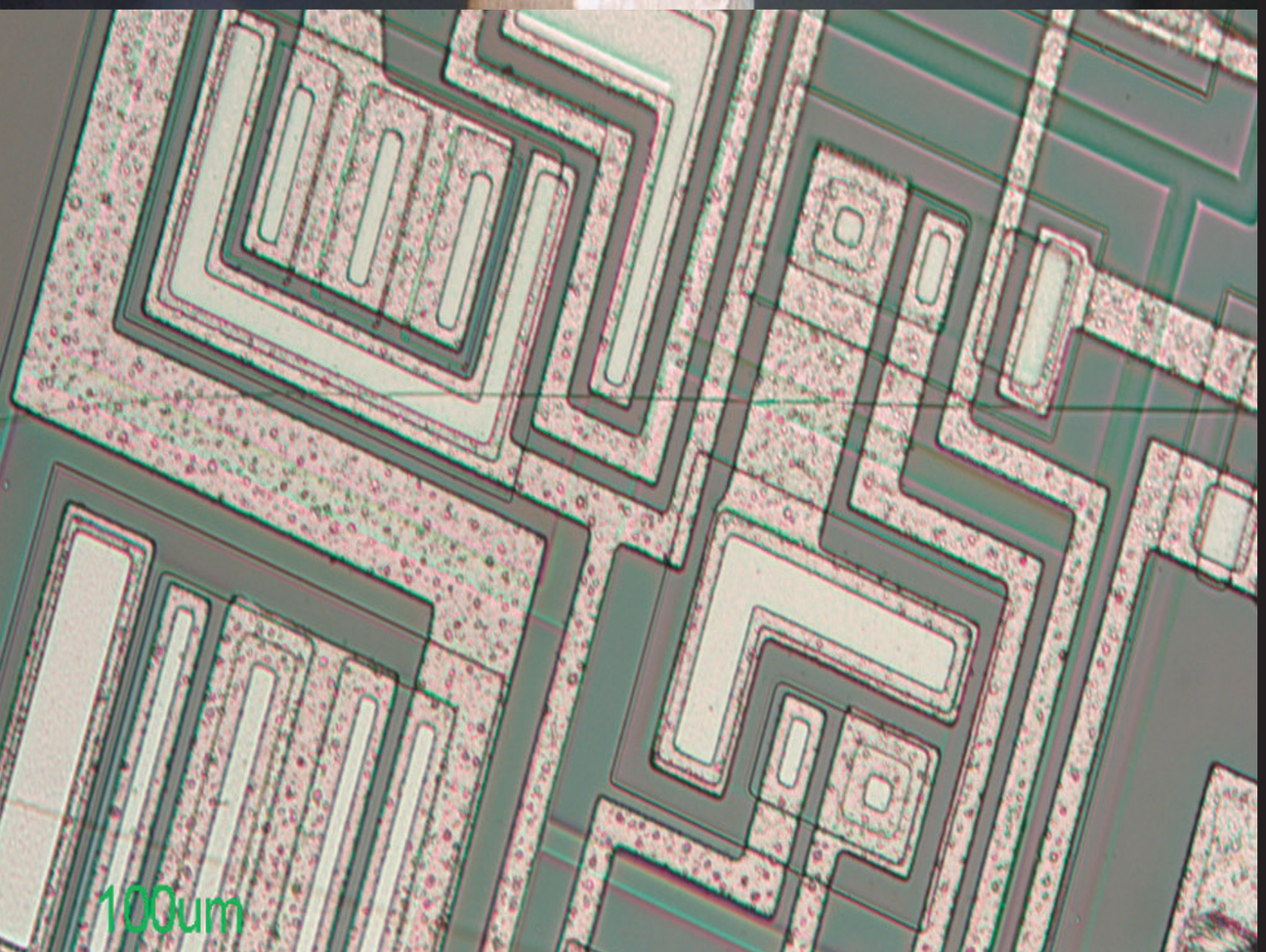

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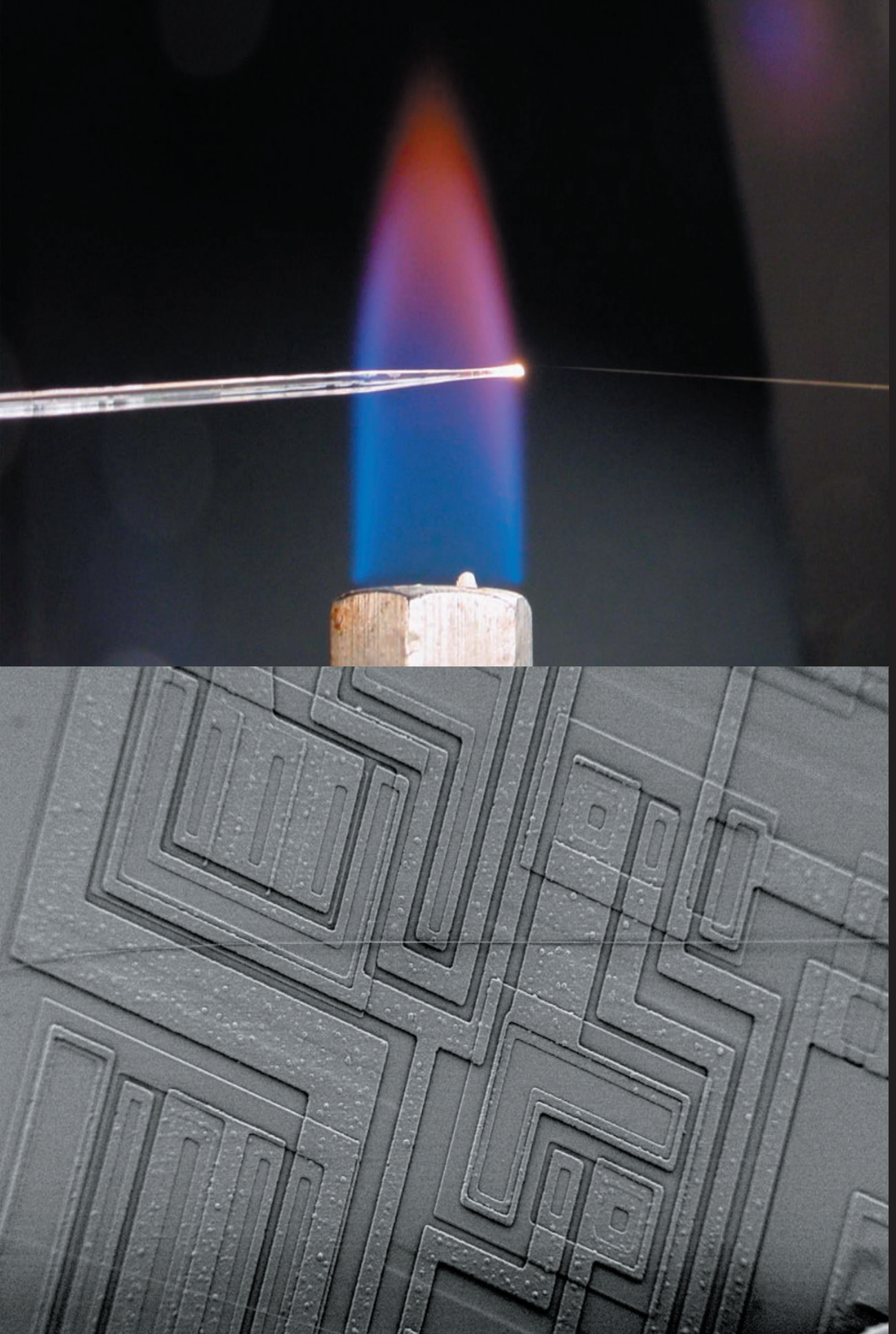

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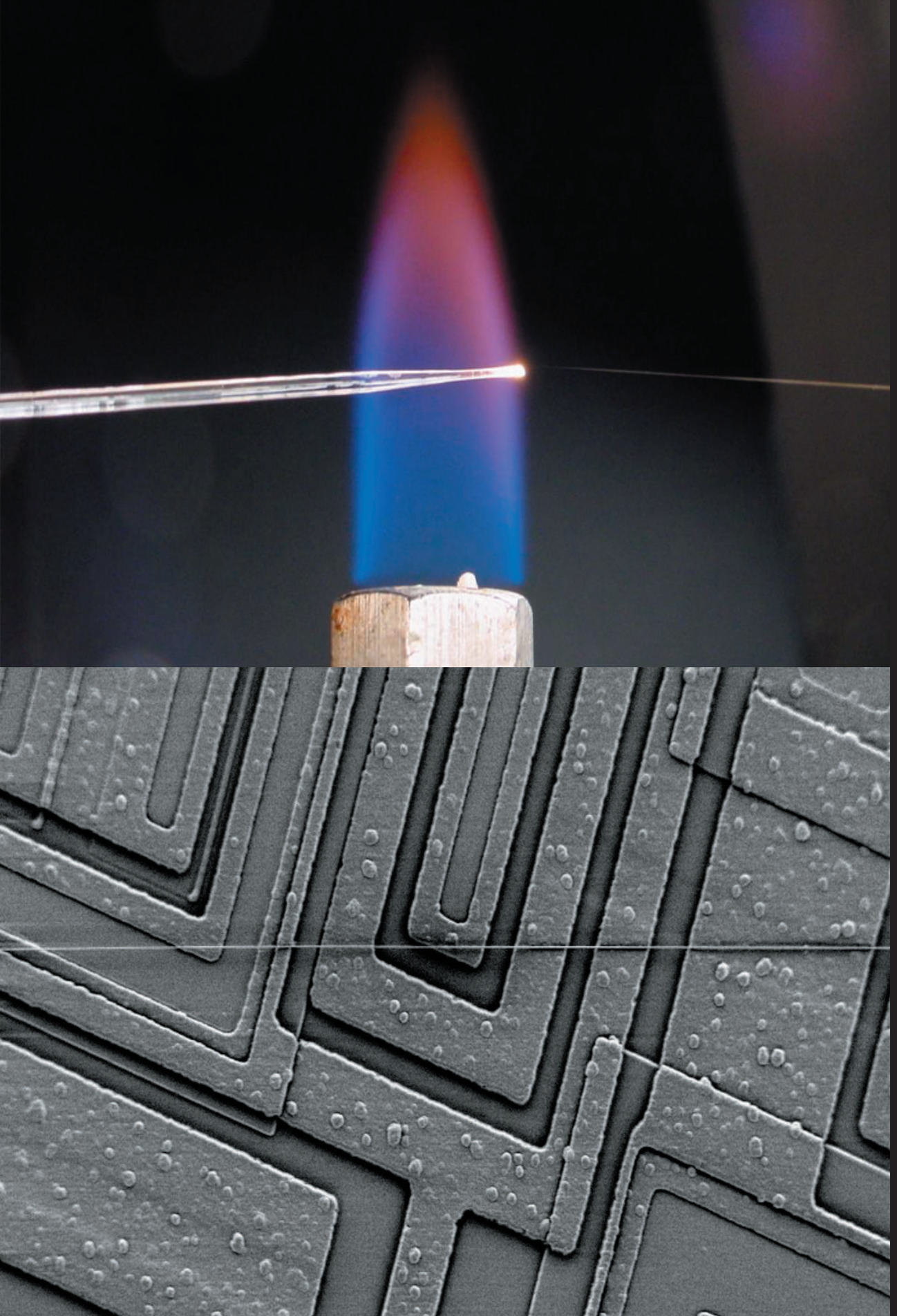

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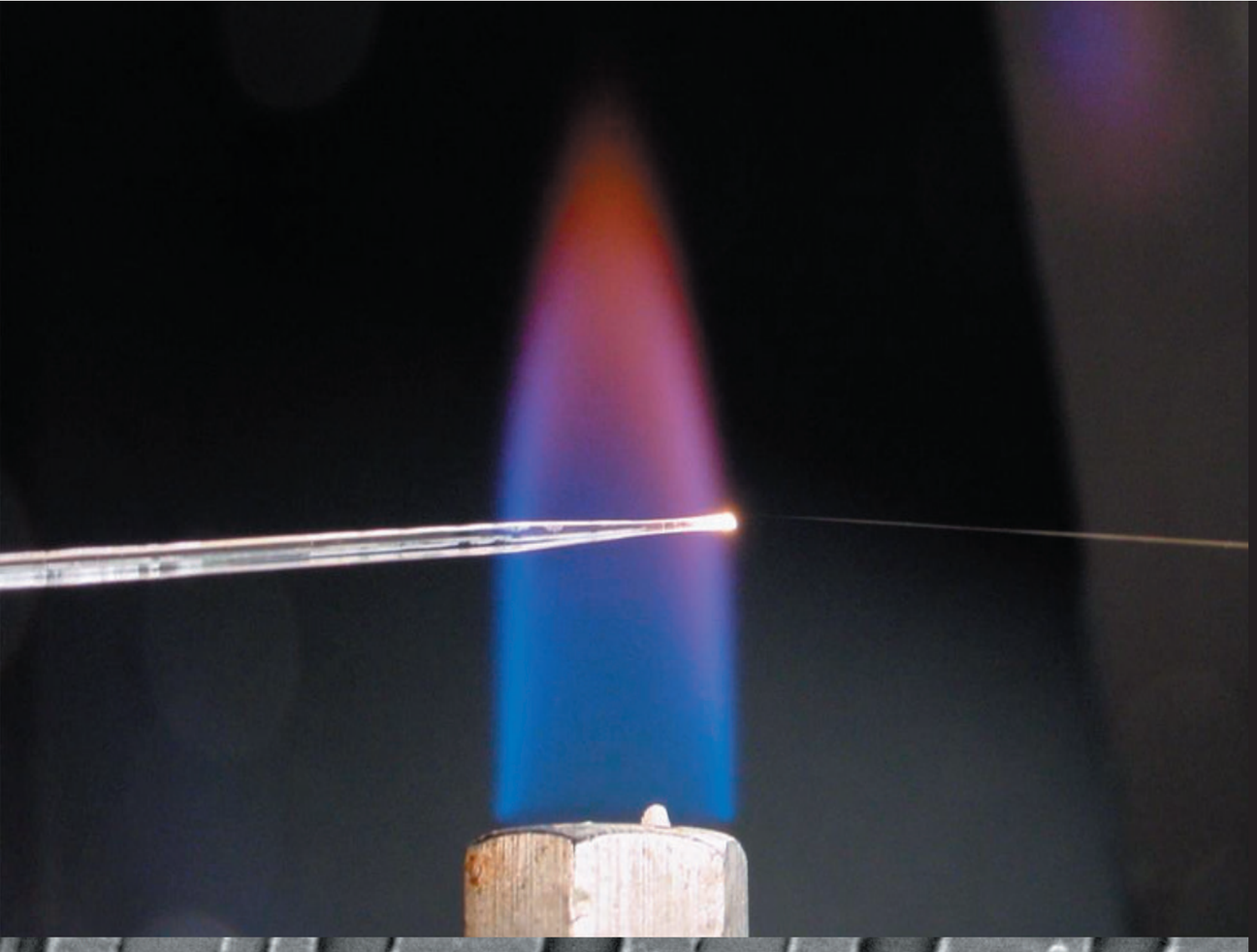

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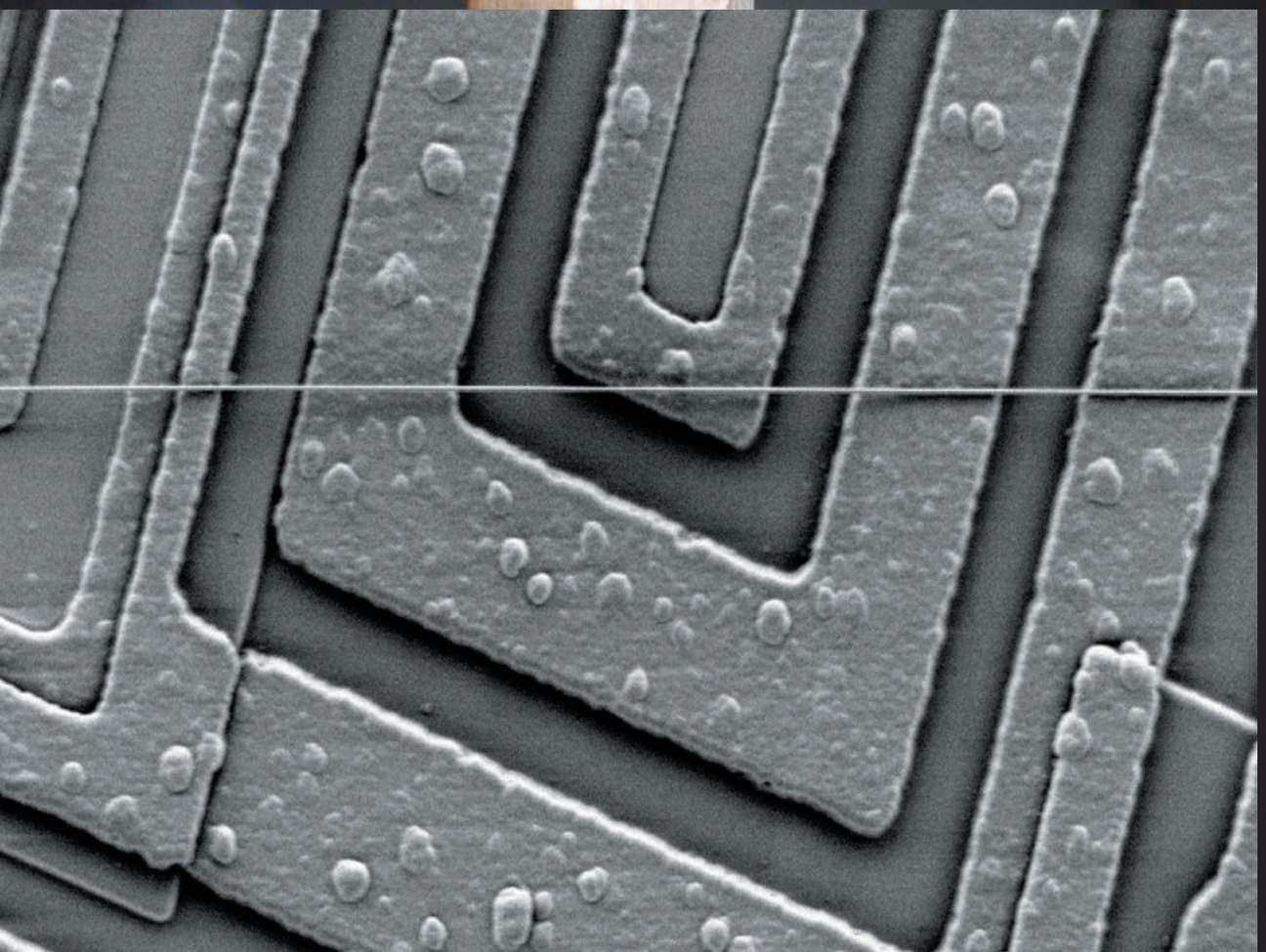

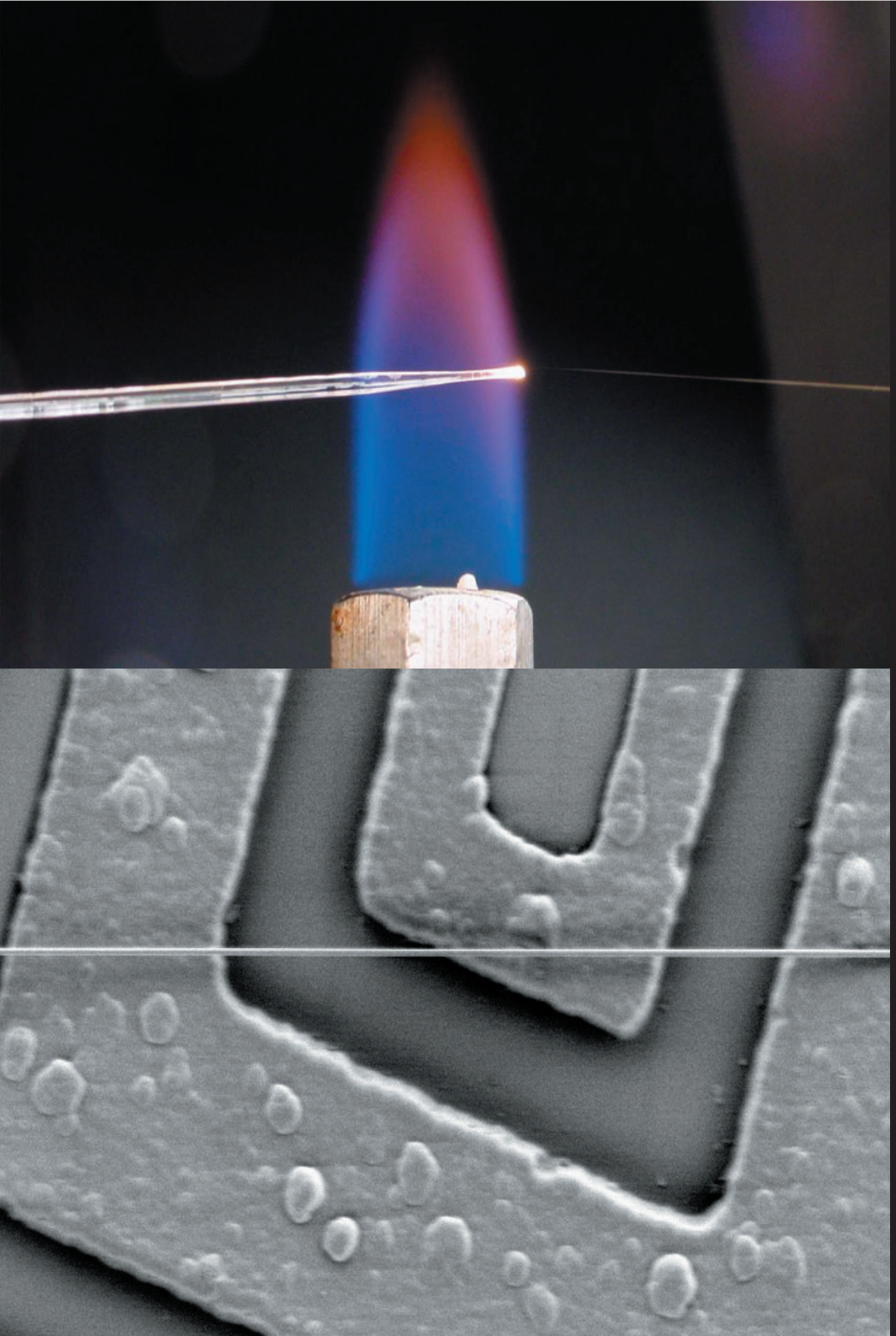

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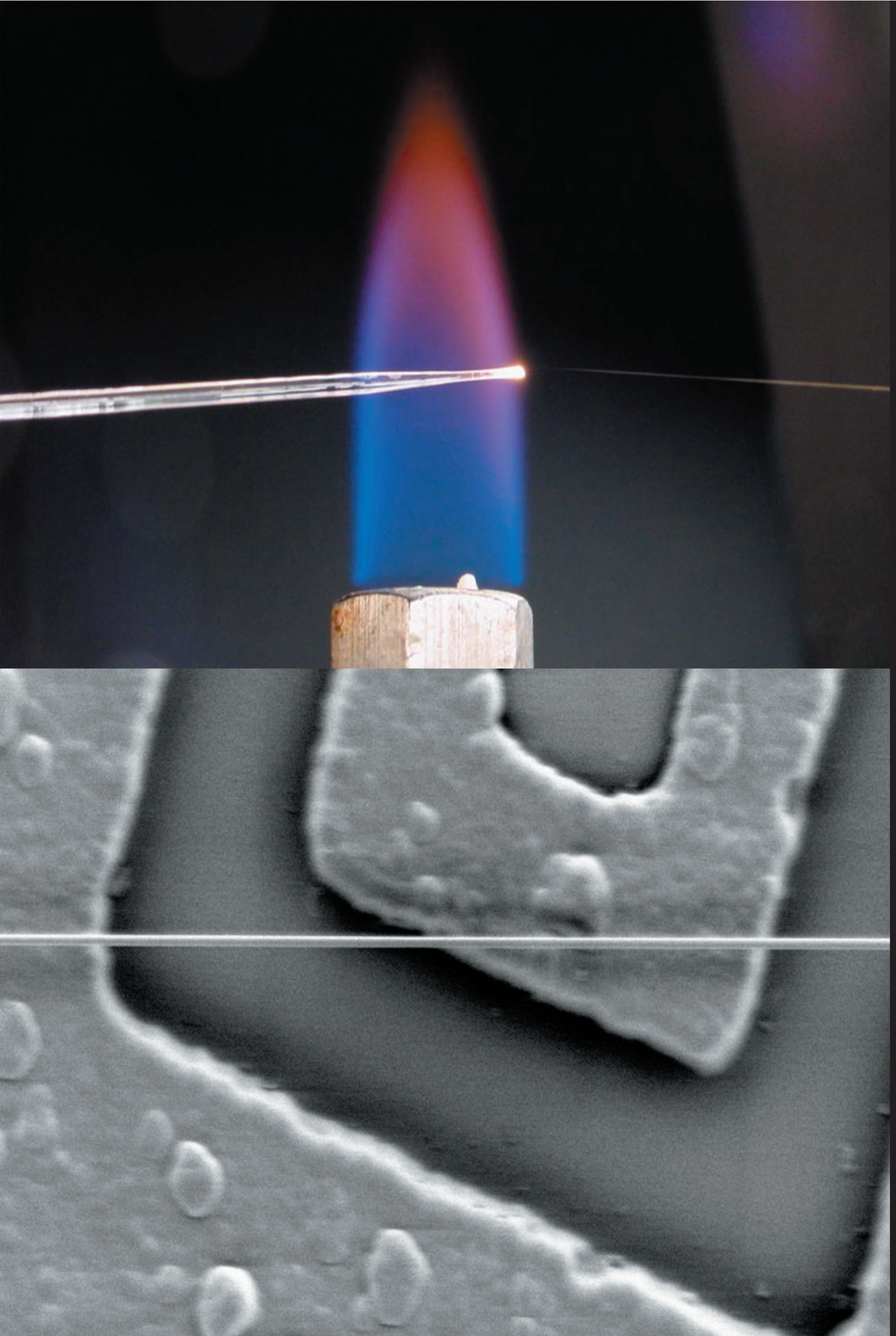

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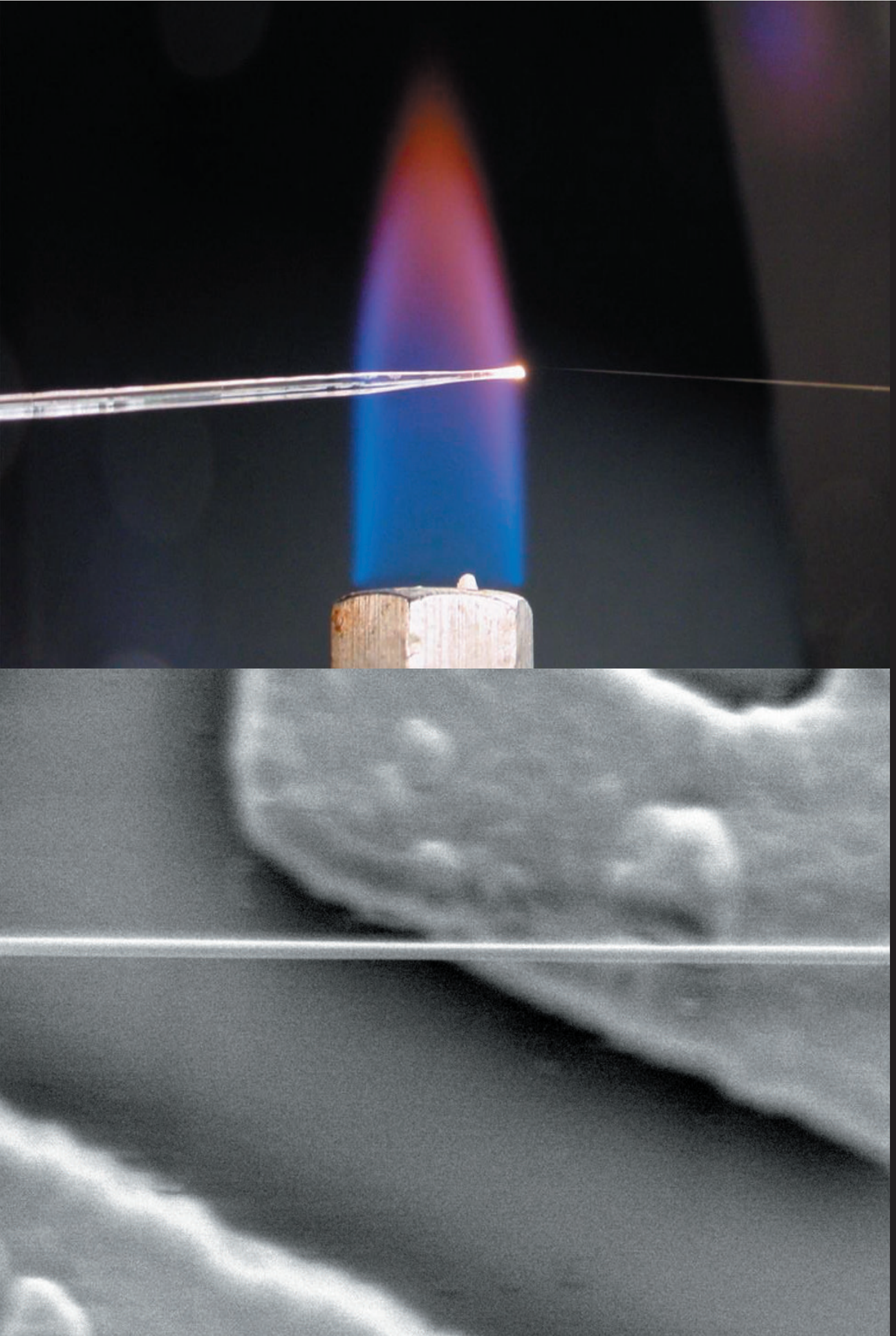

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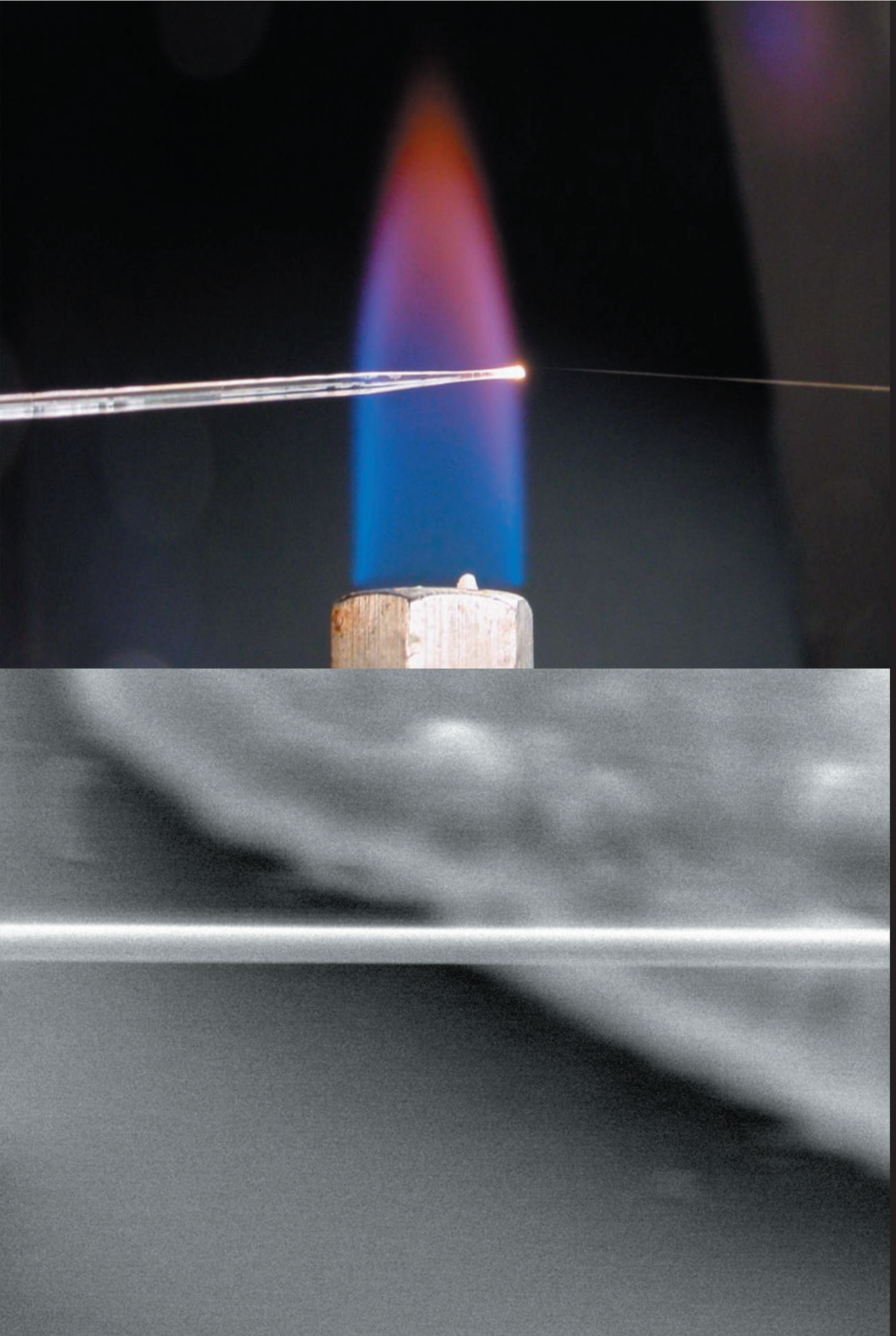

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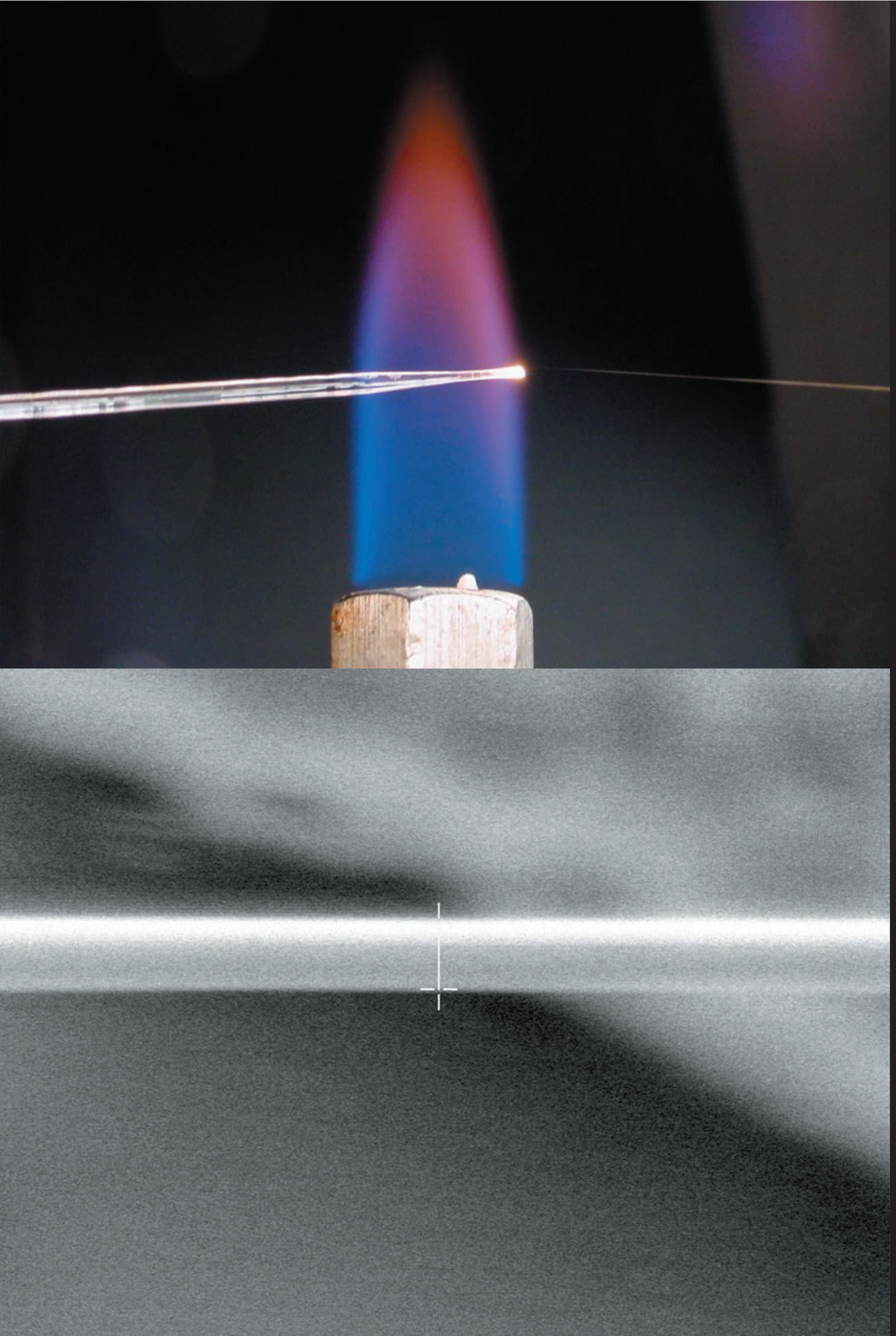

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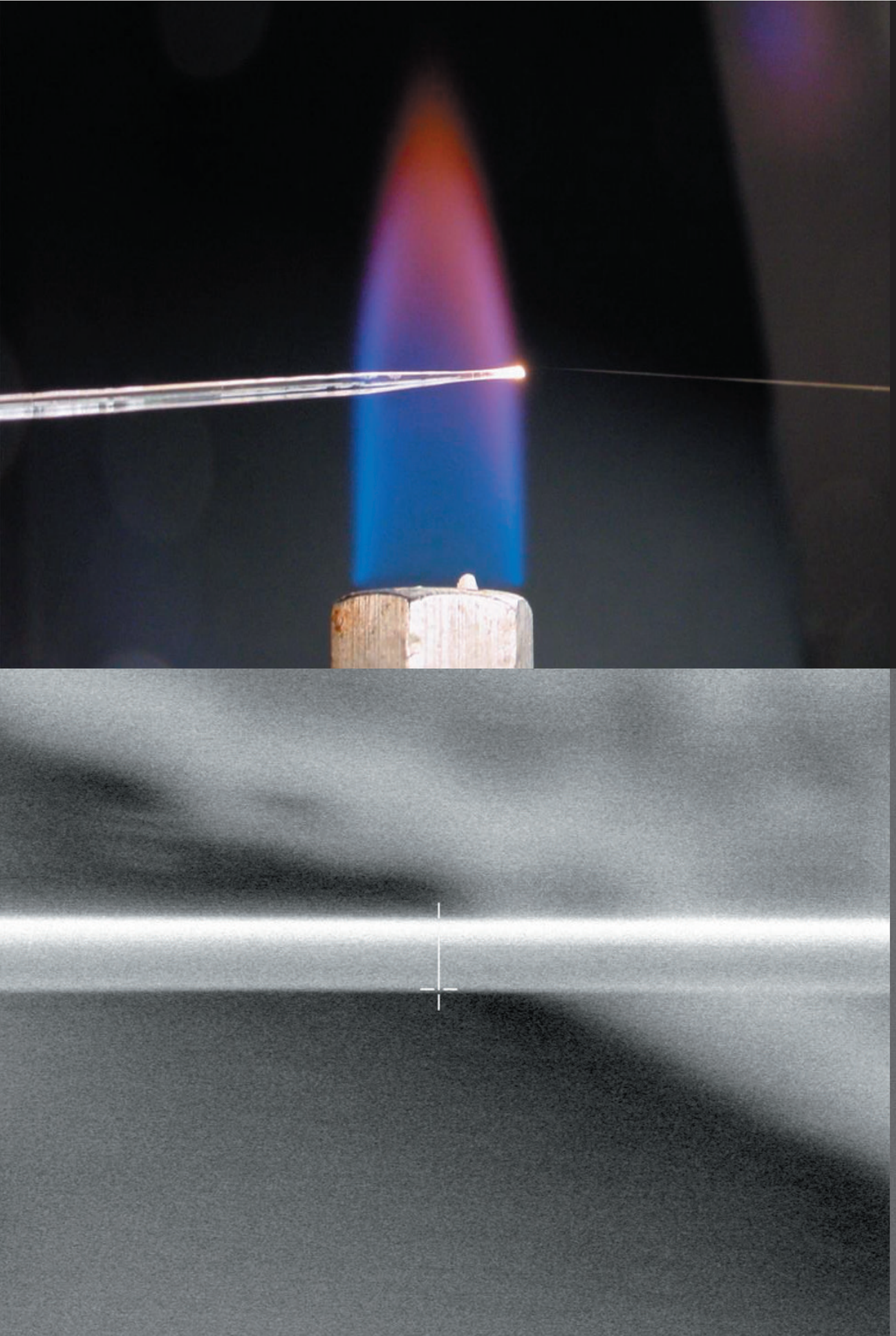
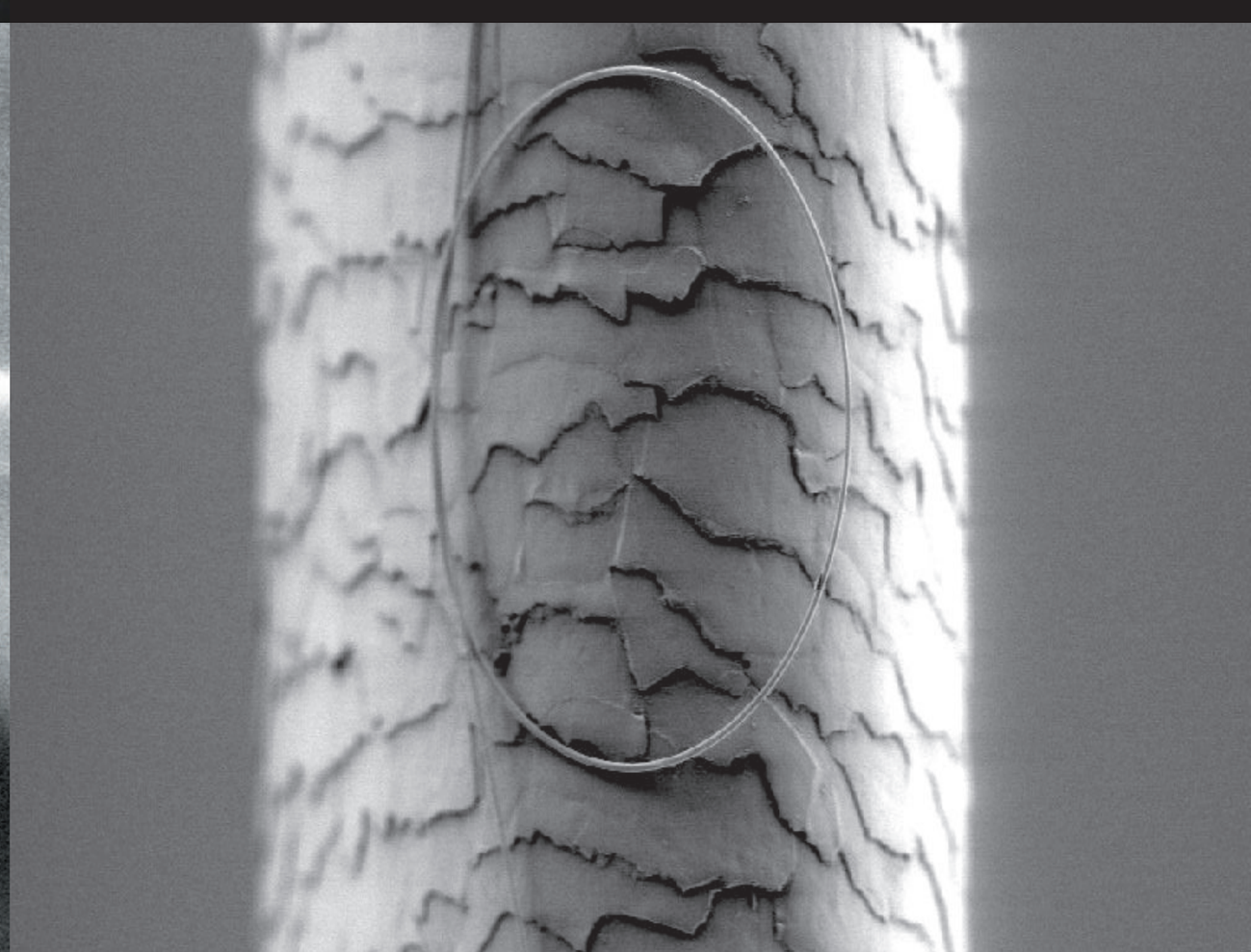
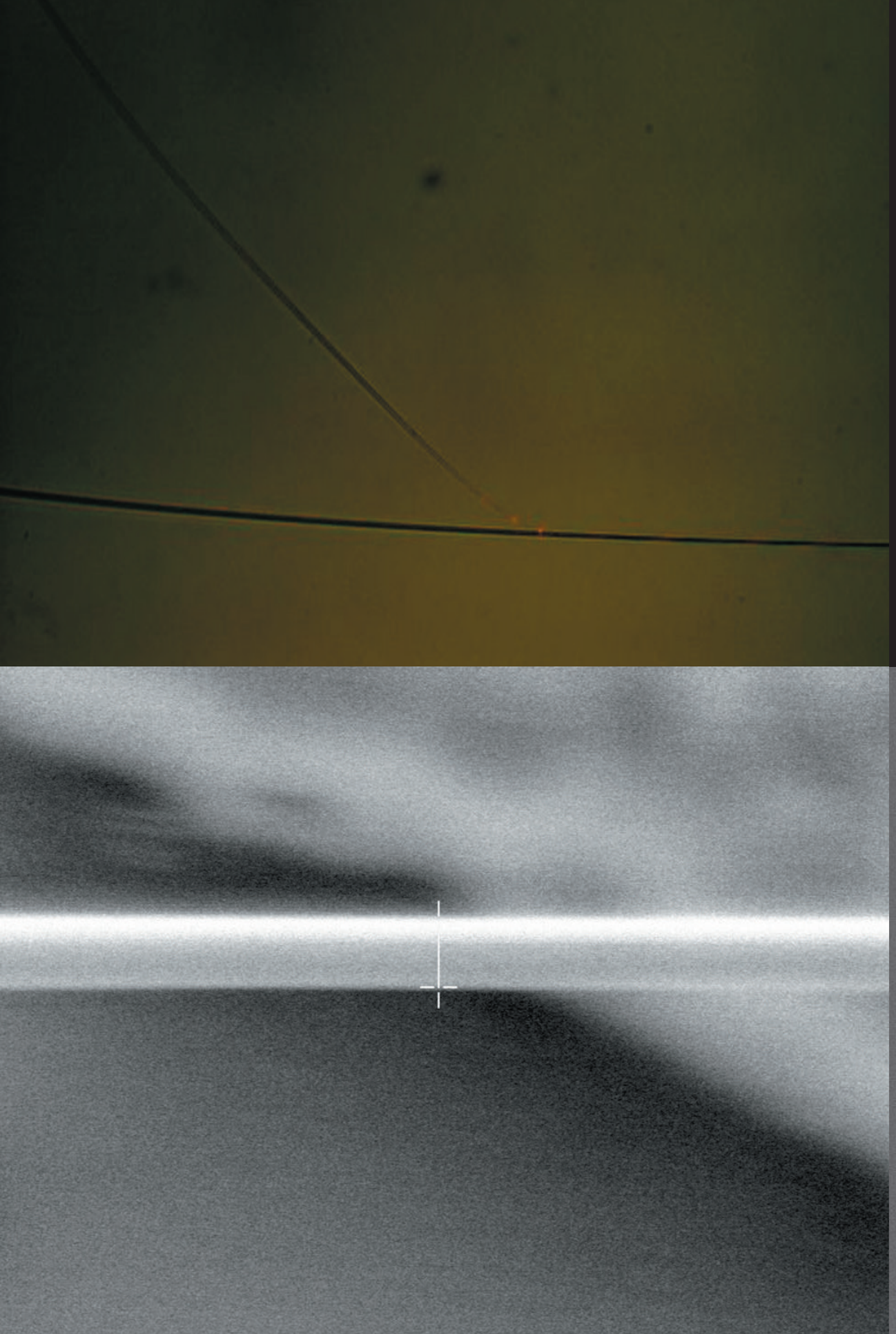
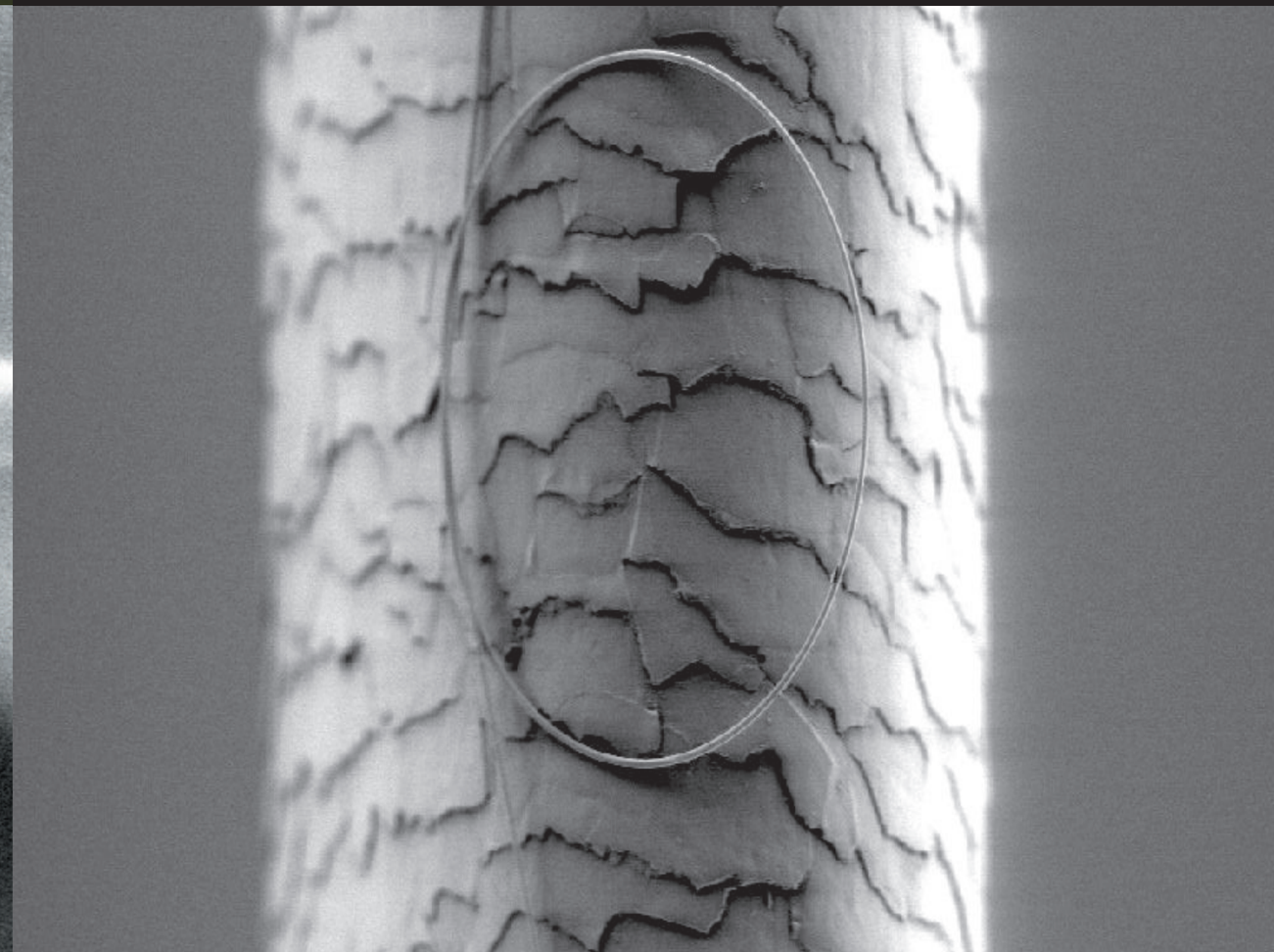
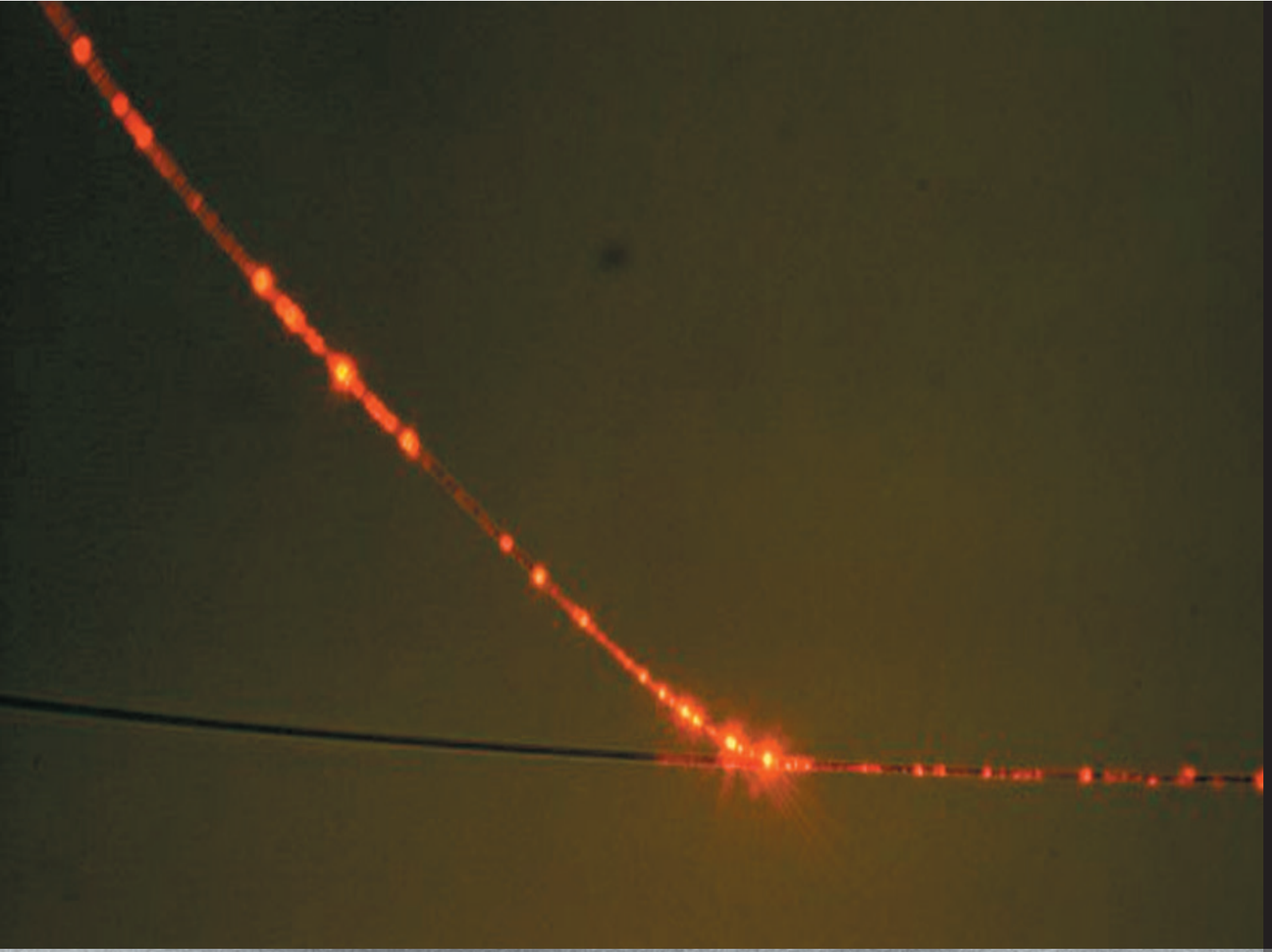






they guide light!





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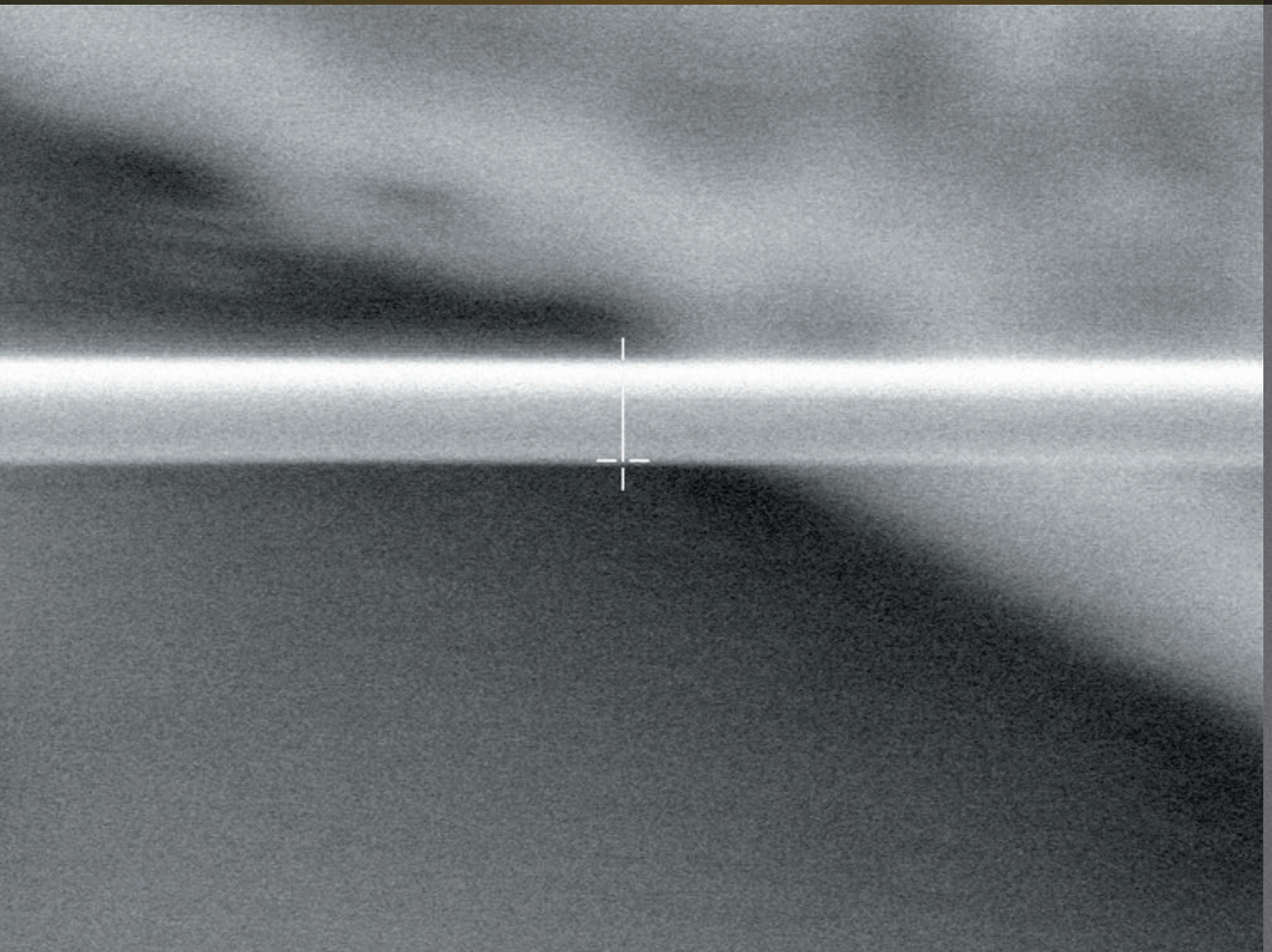
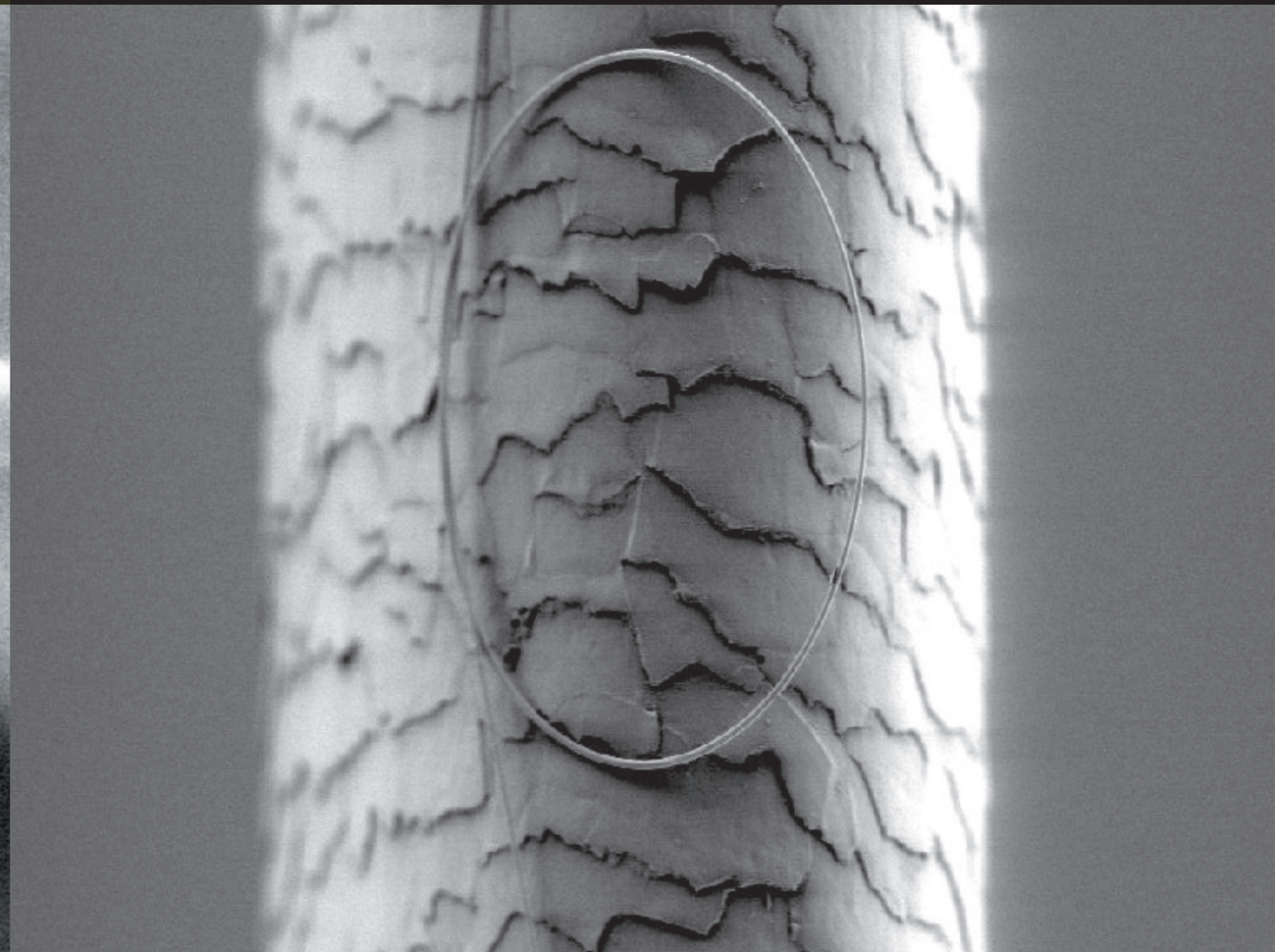
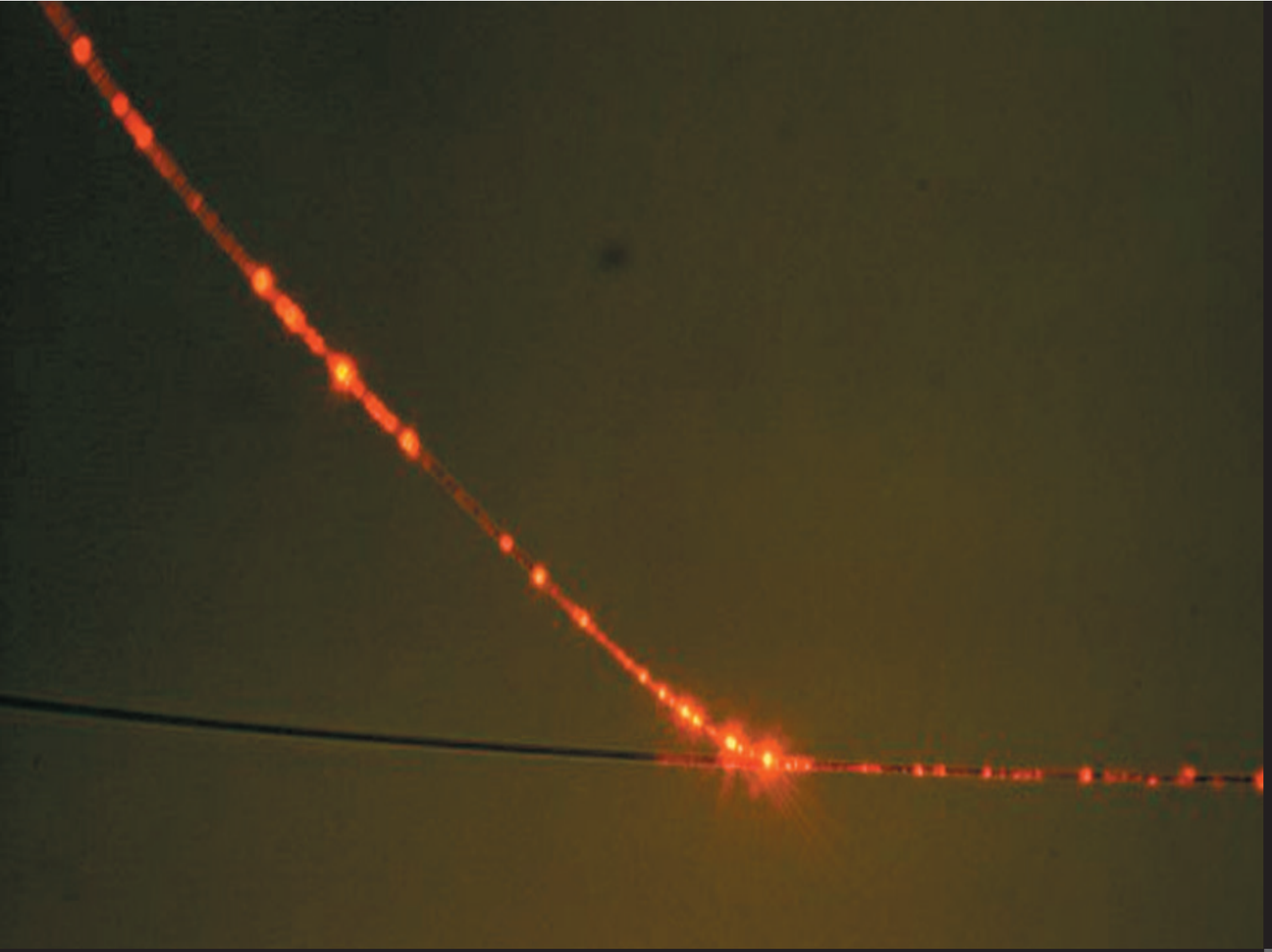
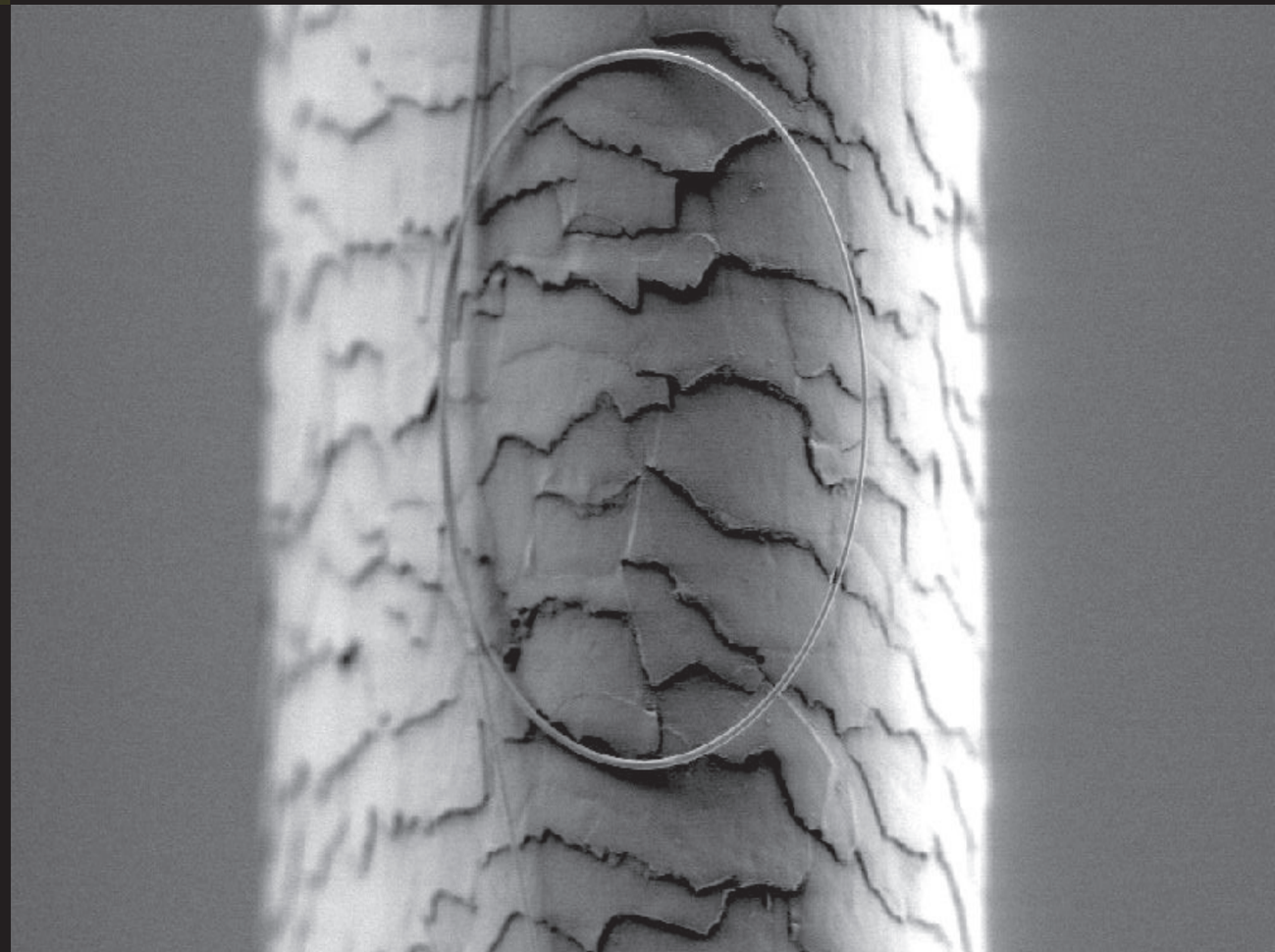


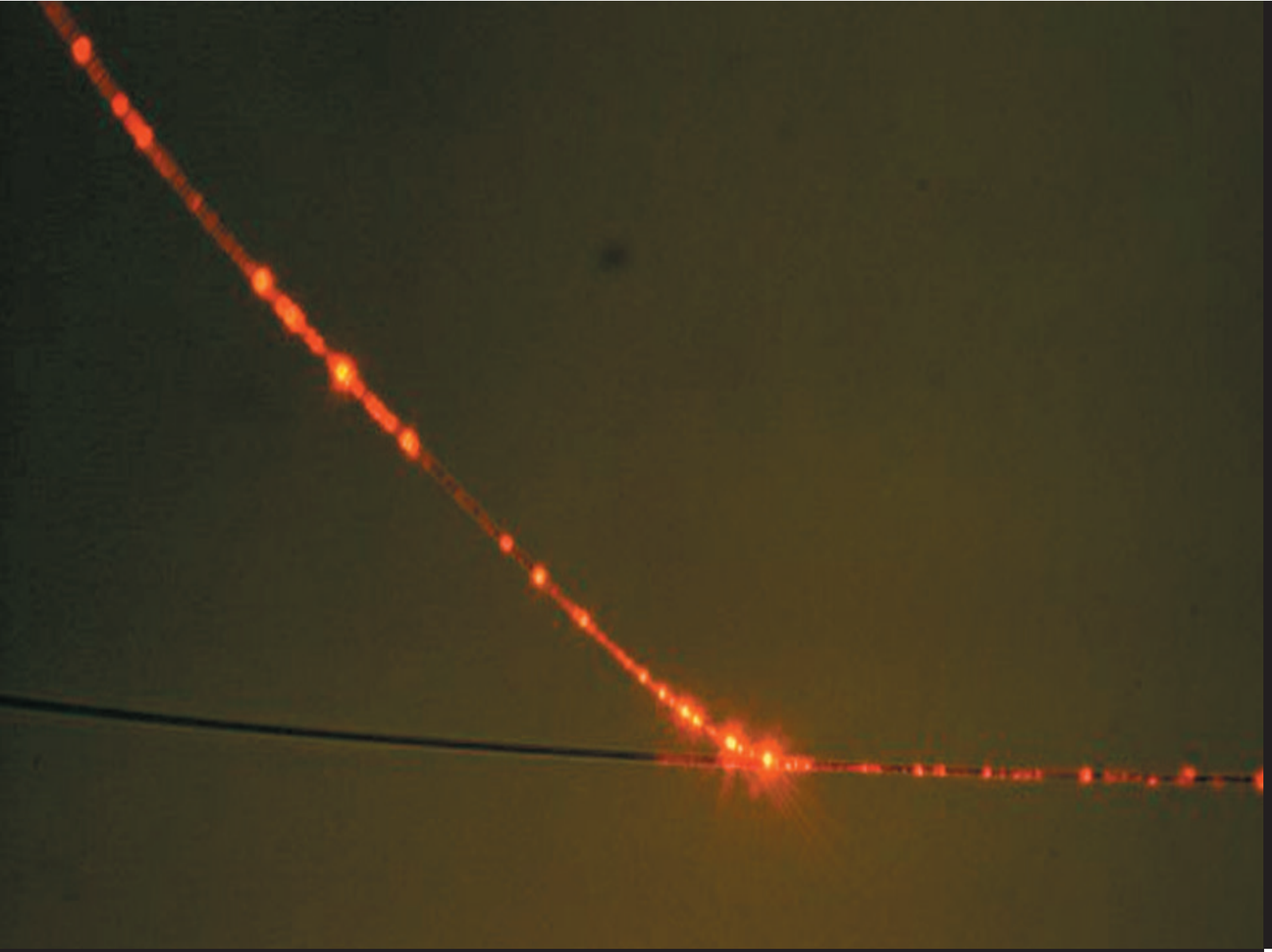




they guide light!

but very differently…





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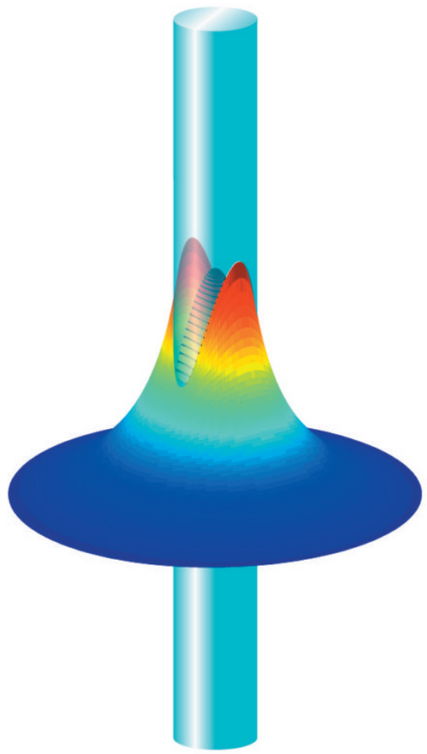
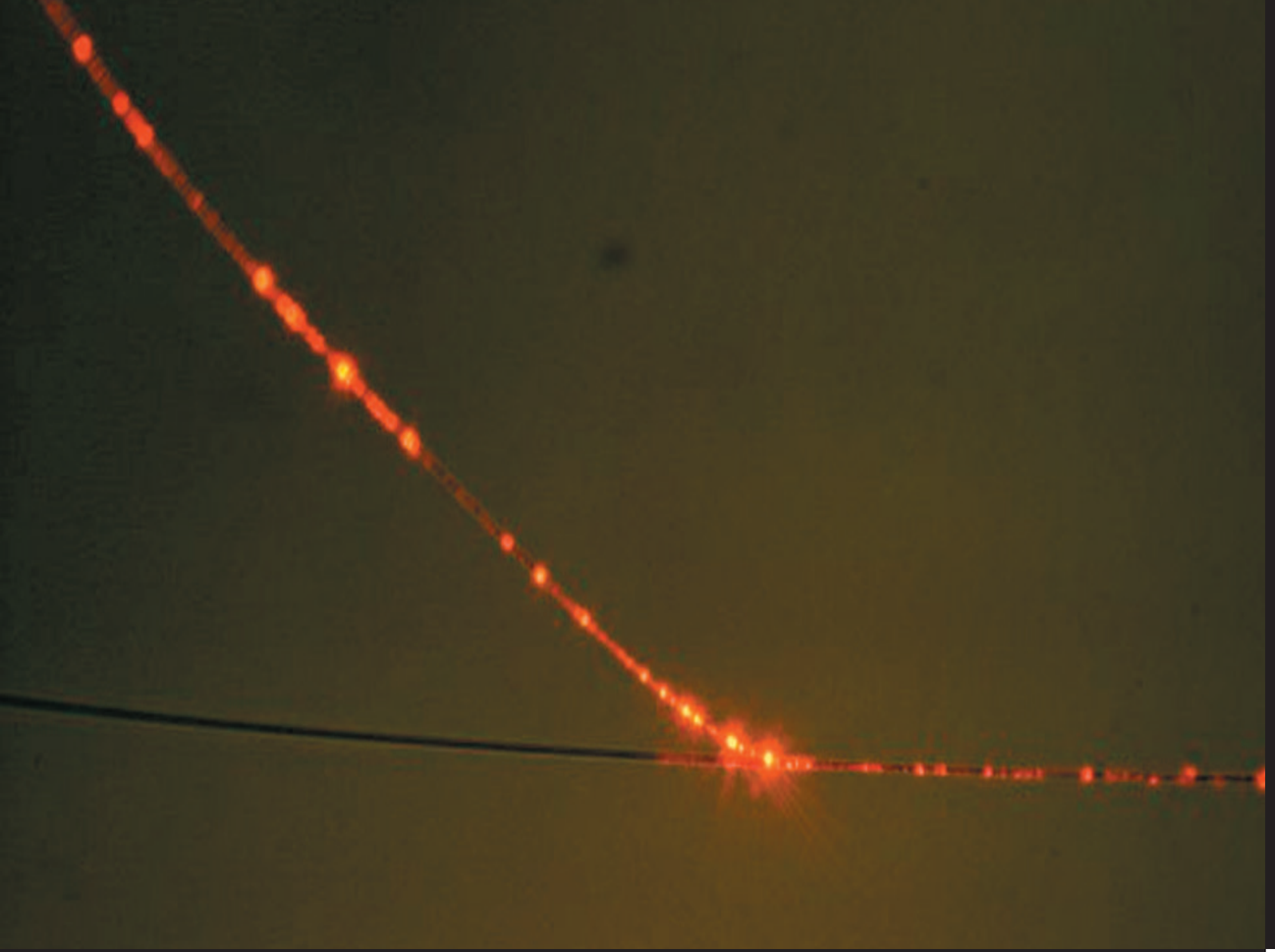
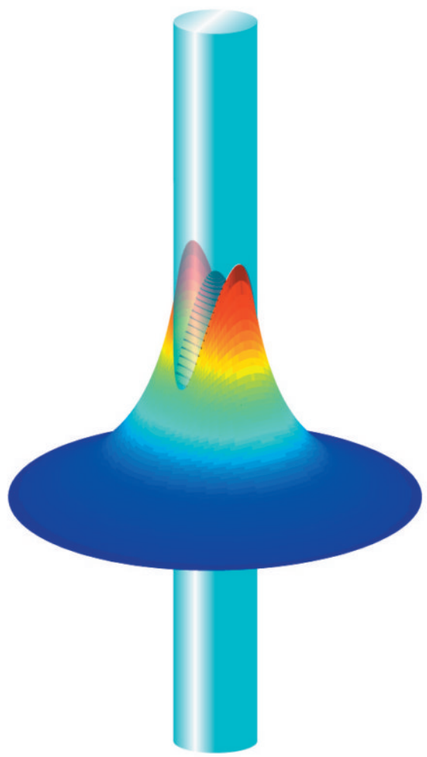




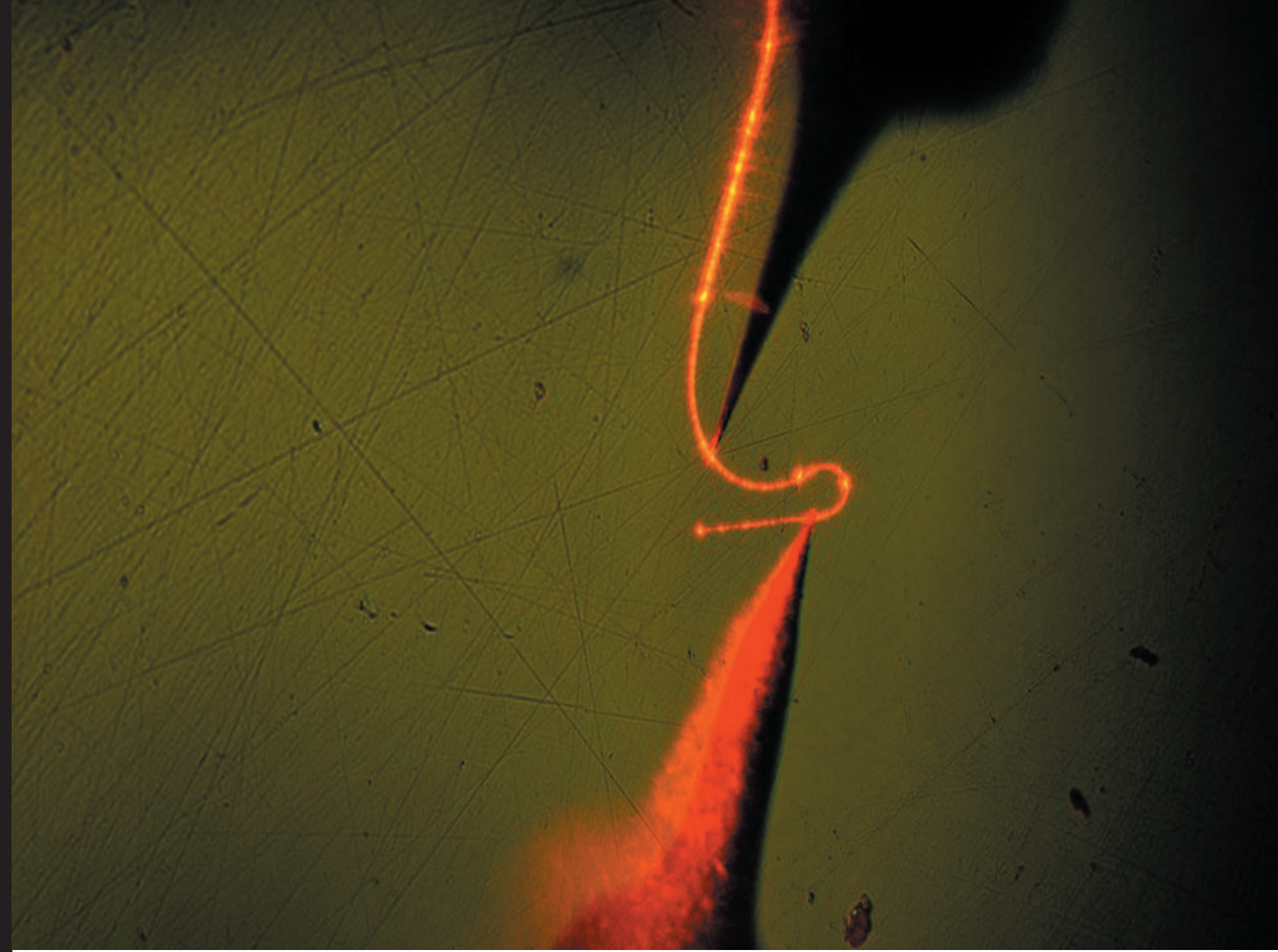
they guide light!

but very differently…

…as a ‘rail’ for light!

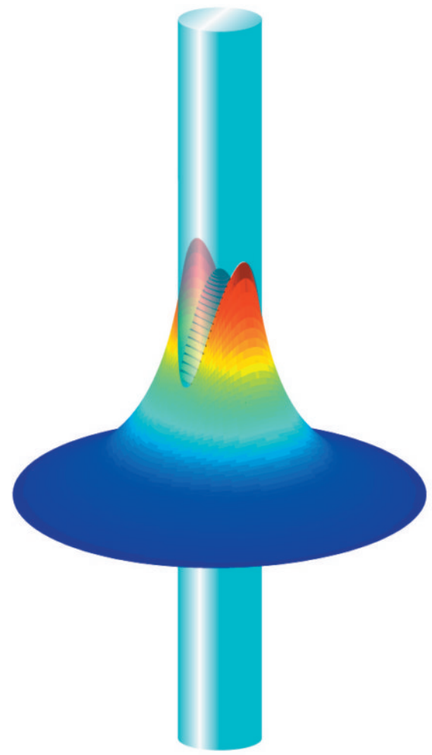


they can bend light tightly

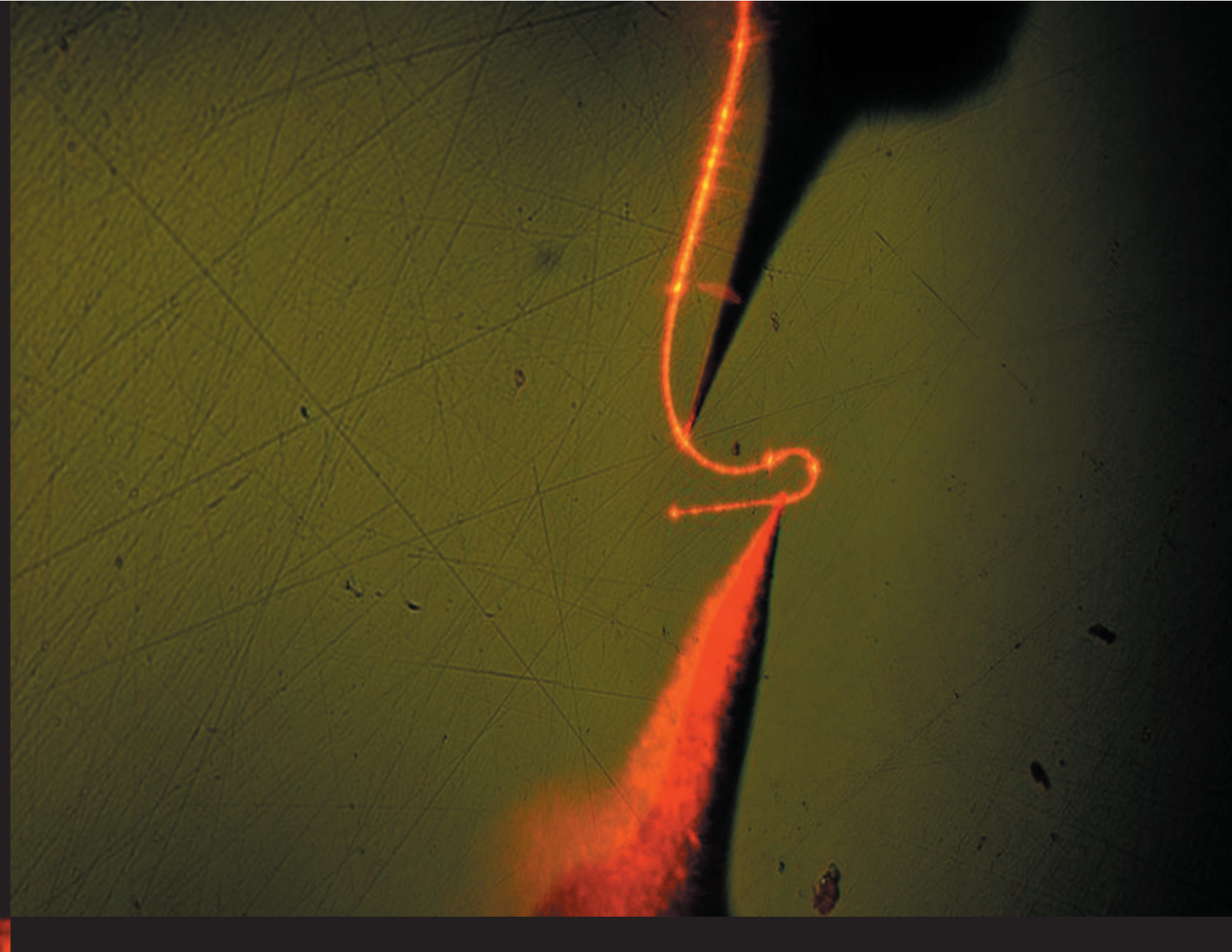


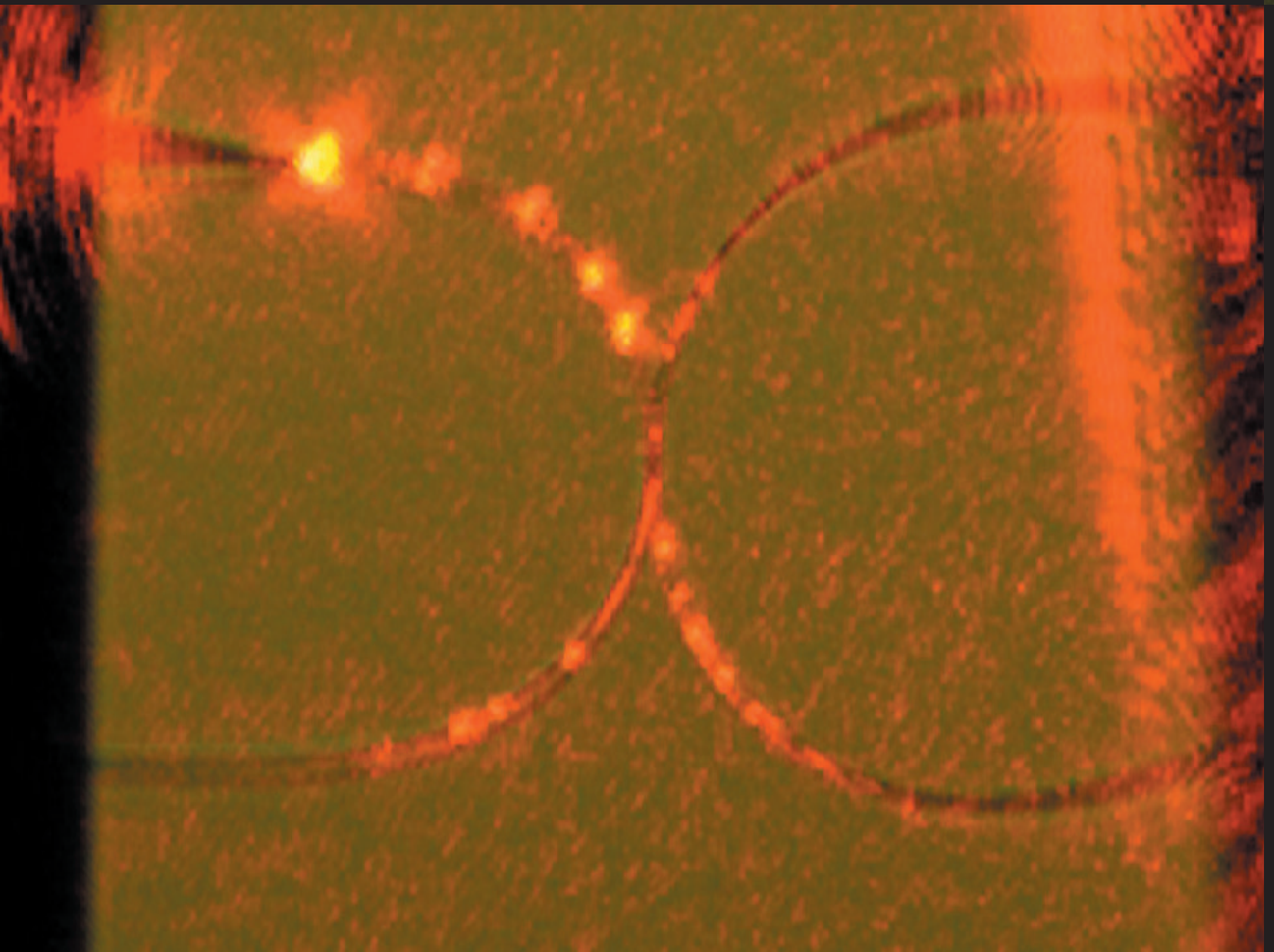
but very differently…

…as a ‘rail’ for light!



they can bend light tightly

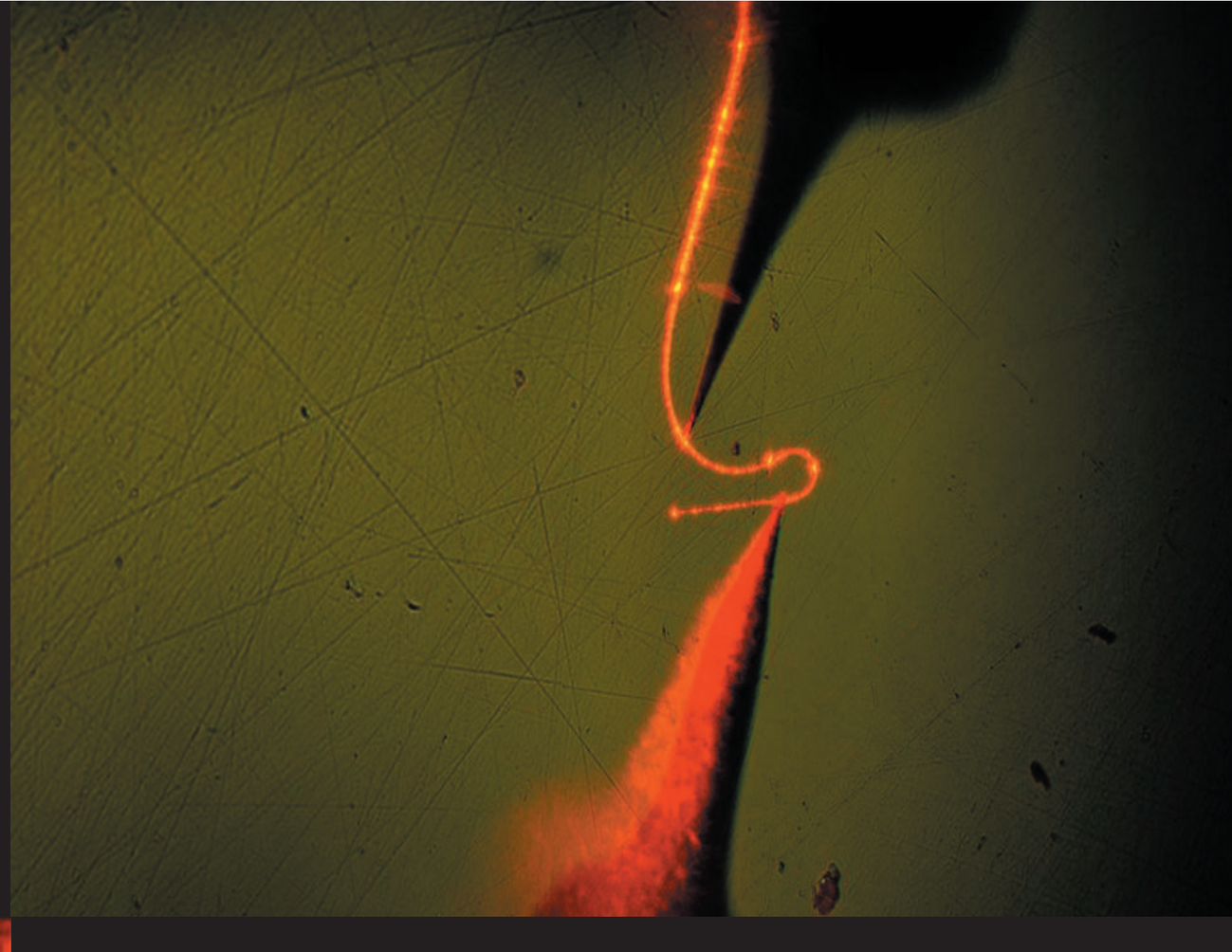


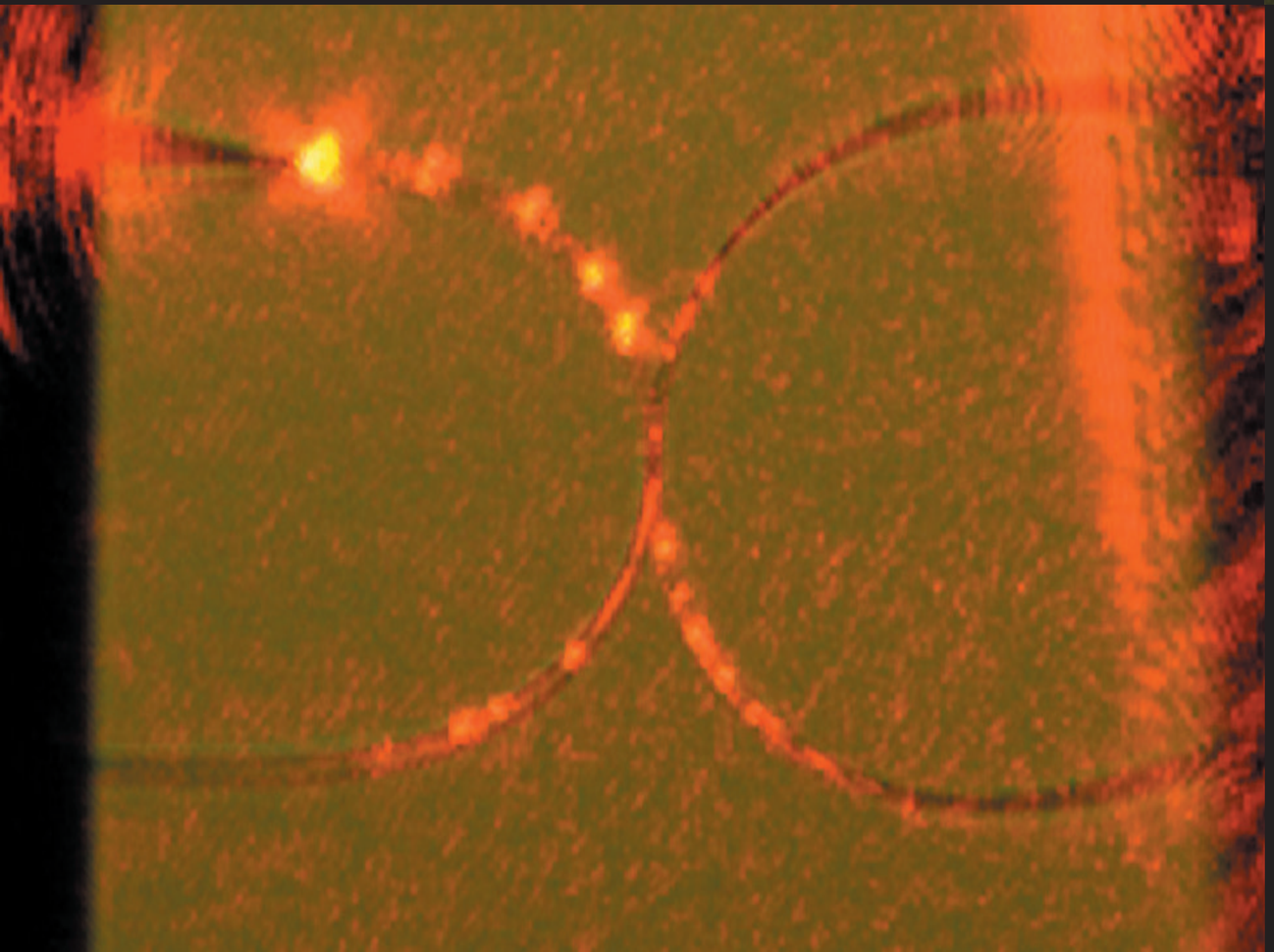


Applications:

- ‘nanophotonics’
- sensors

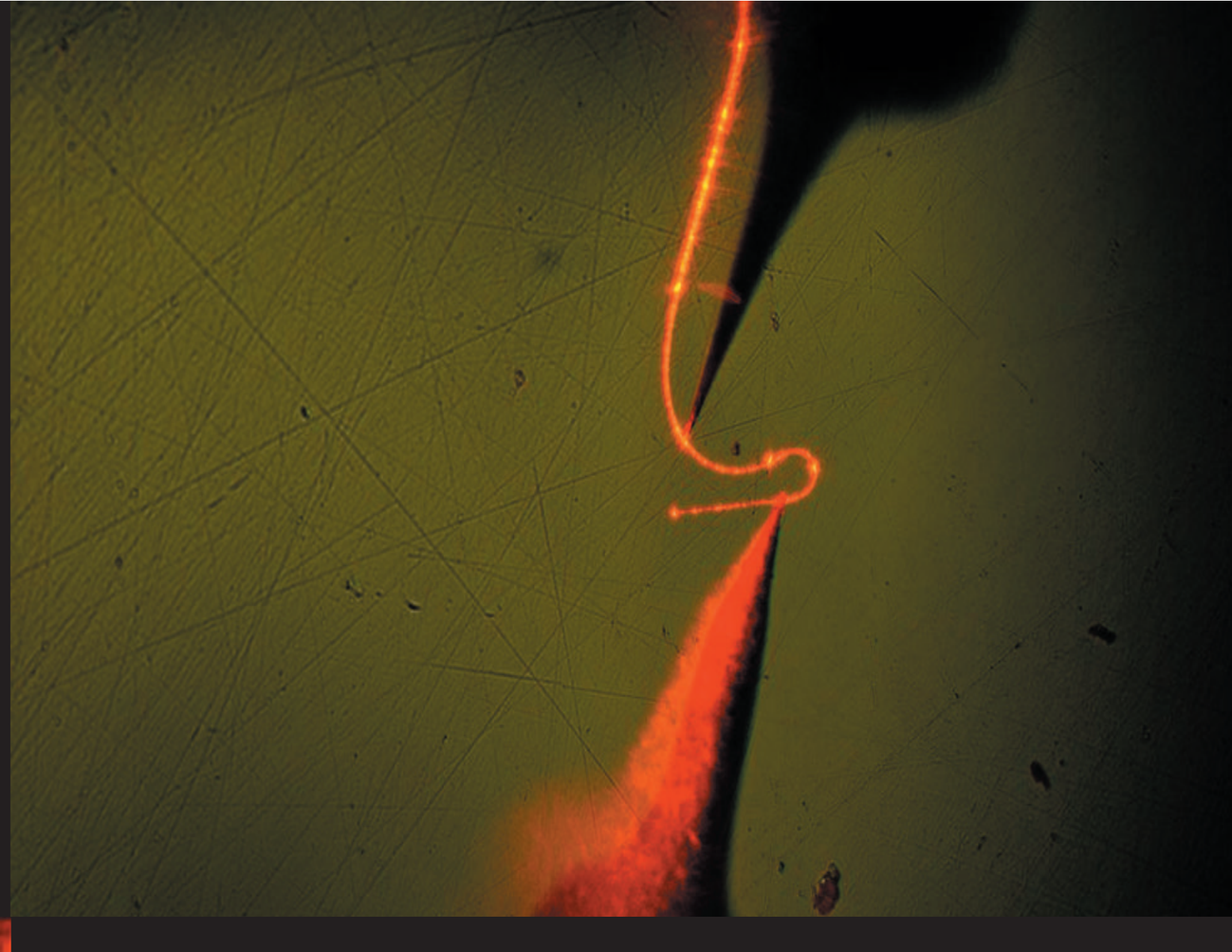
Why is smaller better?

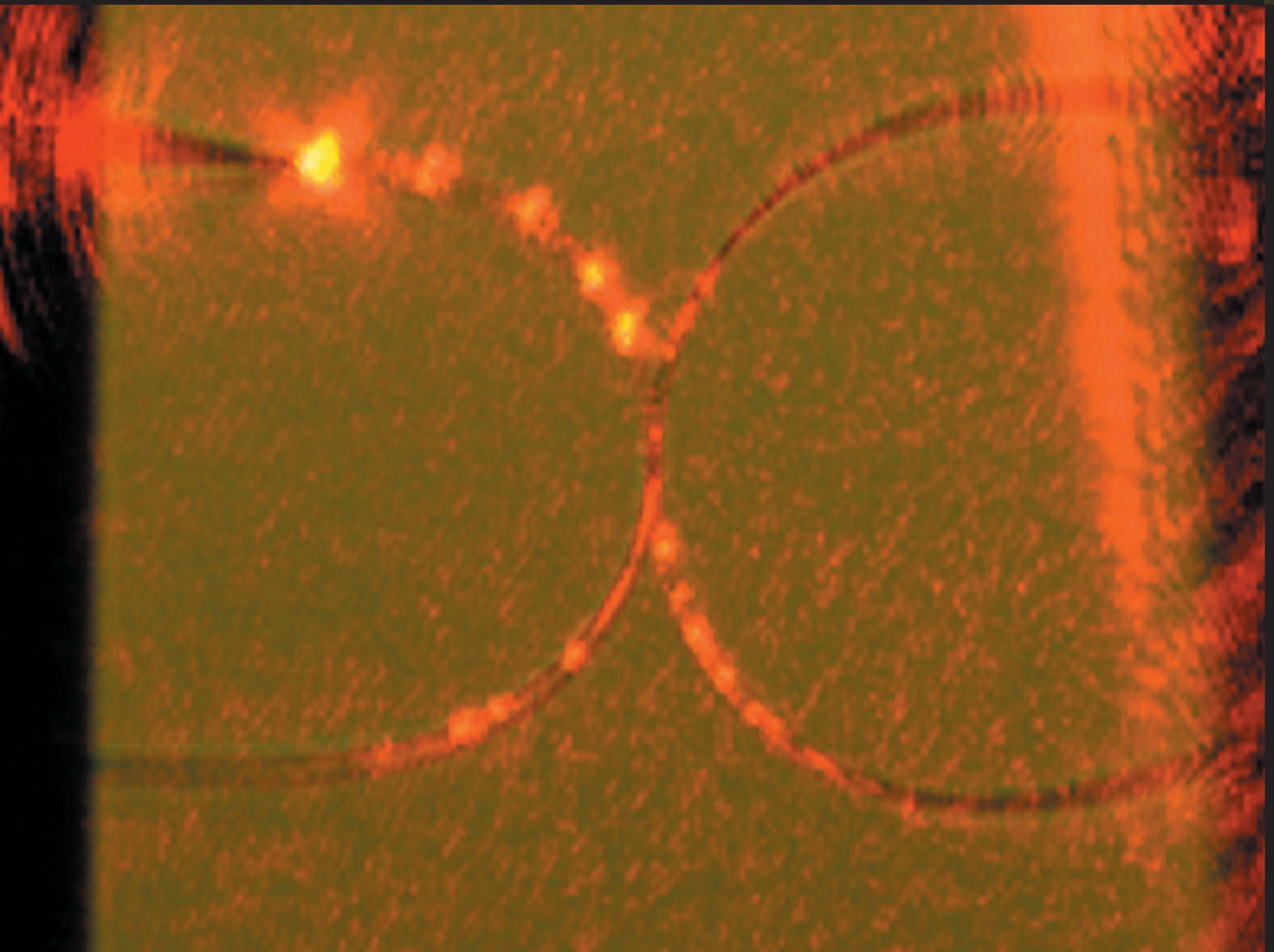




- faster

Why is smaller better?





- faster
- uses less resources

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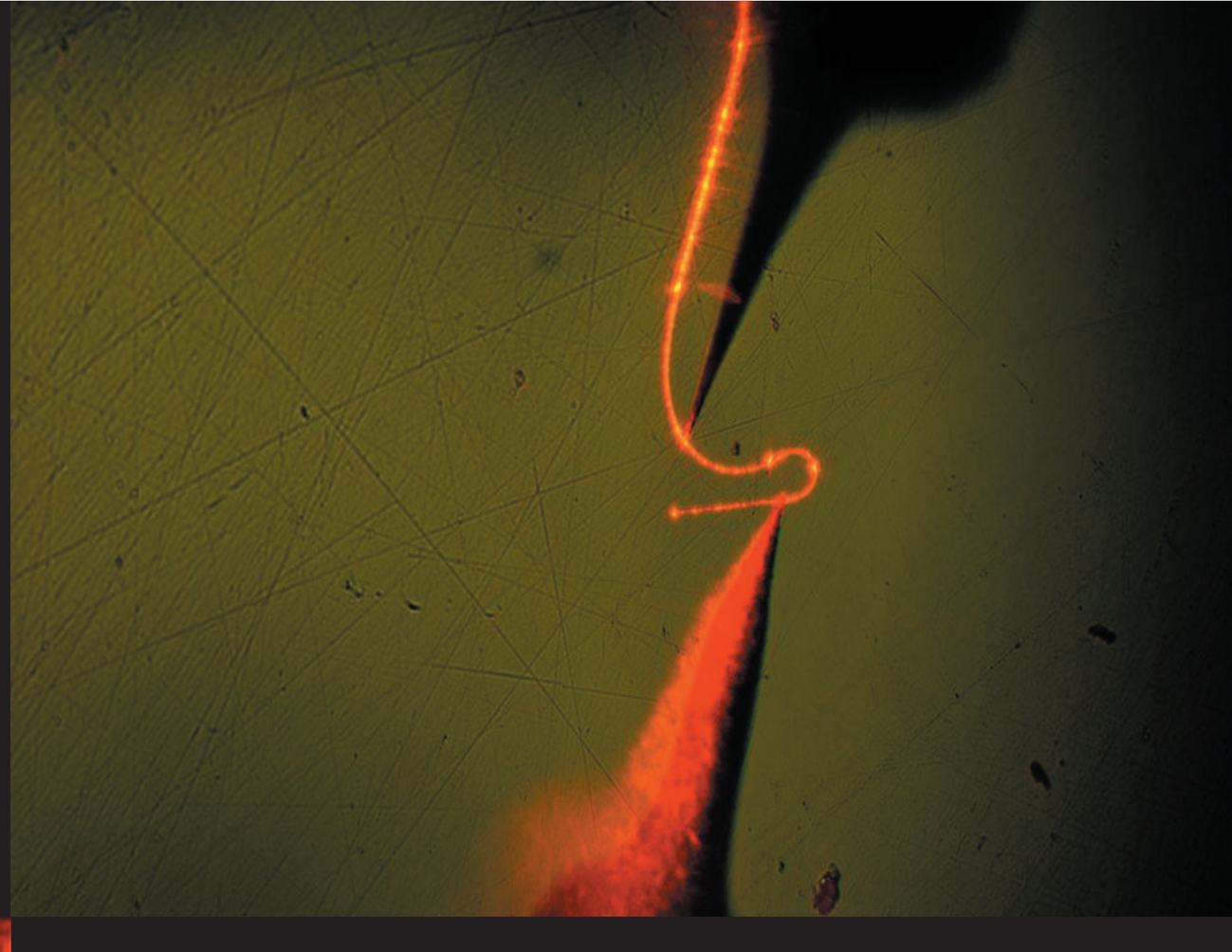

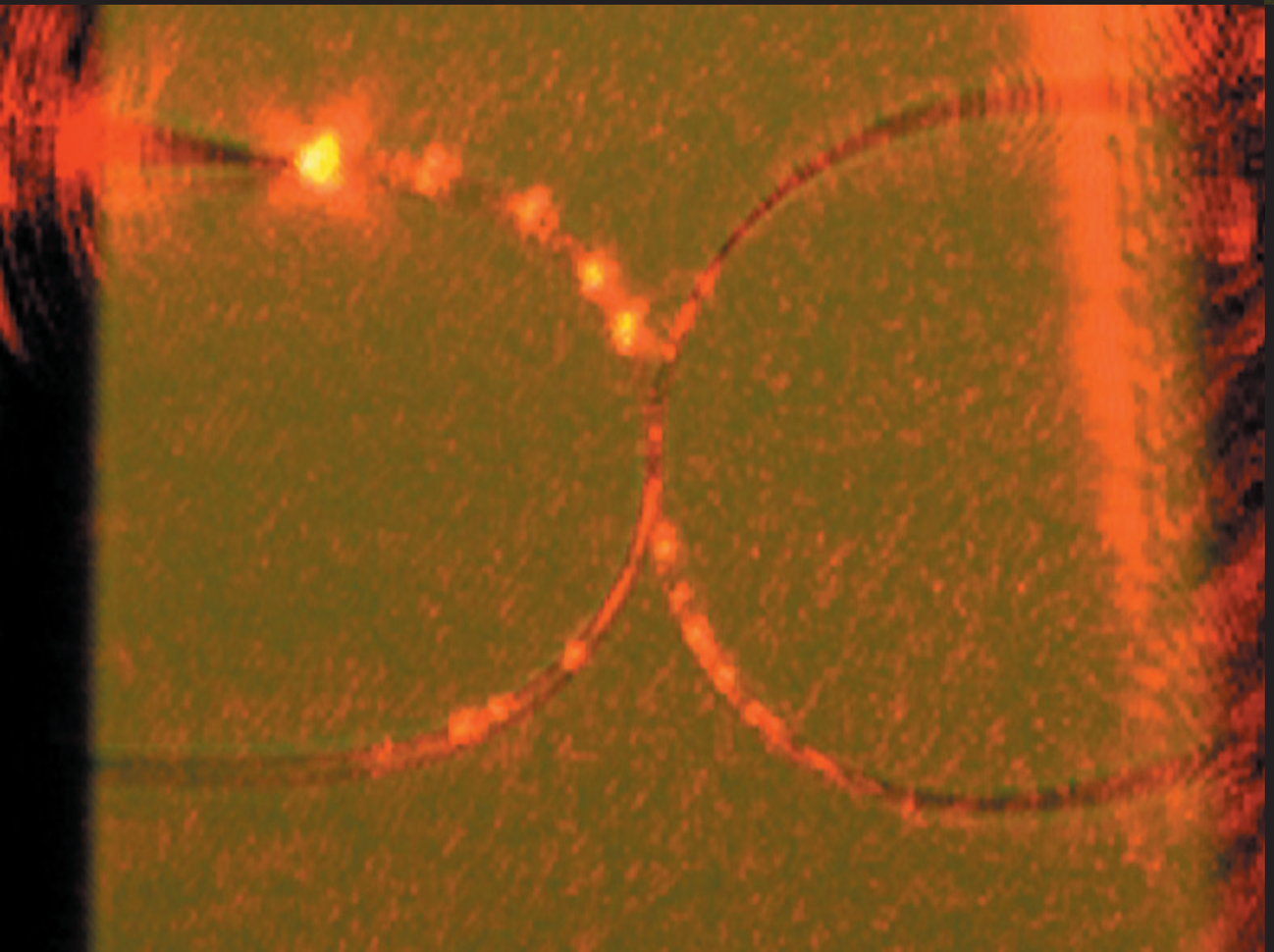

- faster
- uses less resources
- dense integration

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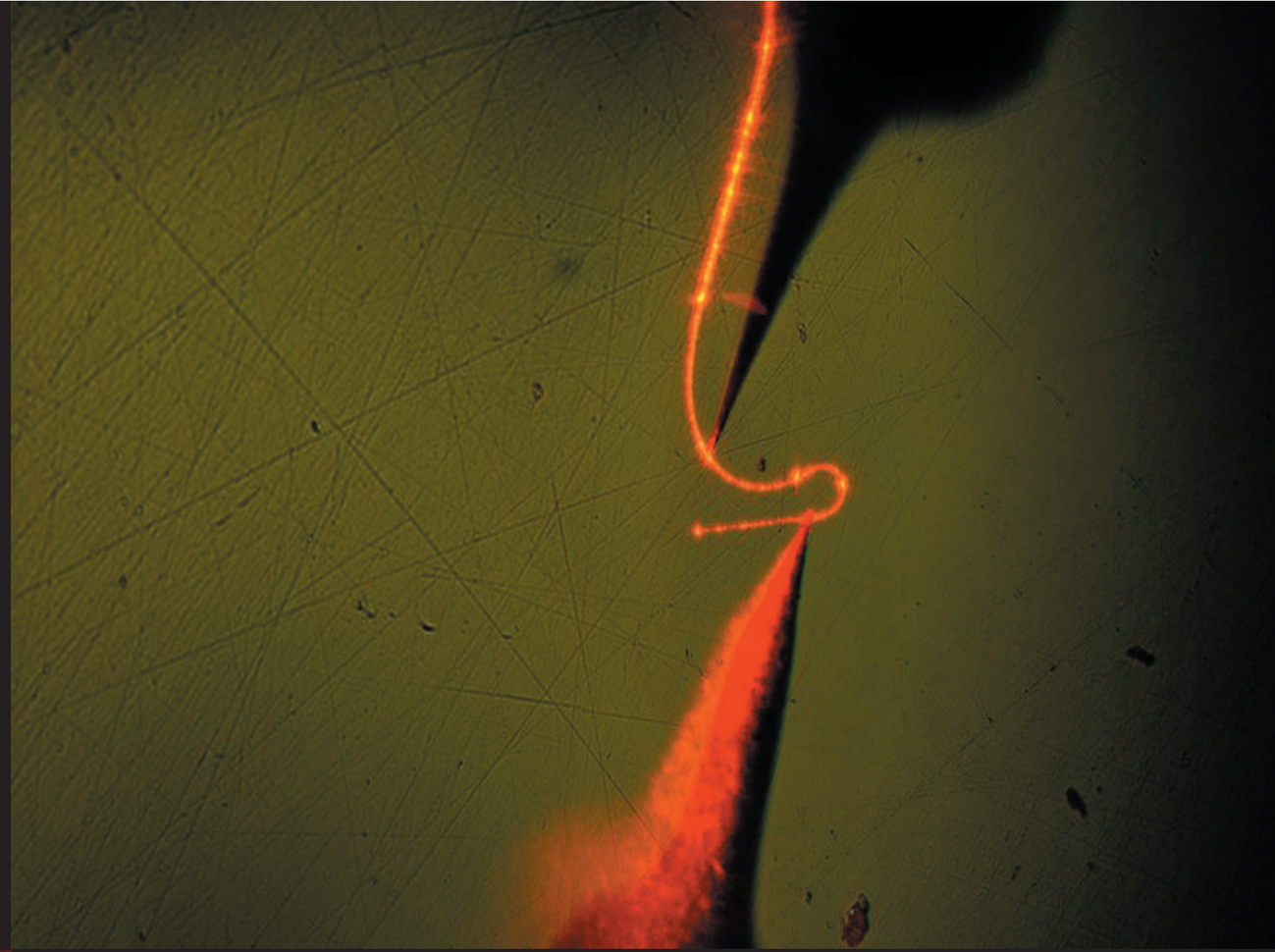
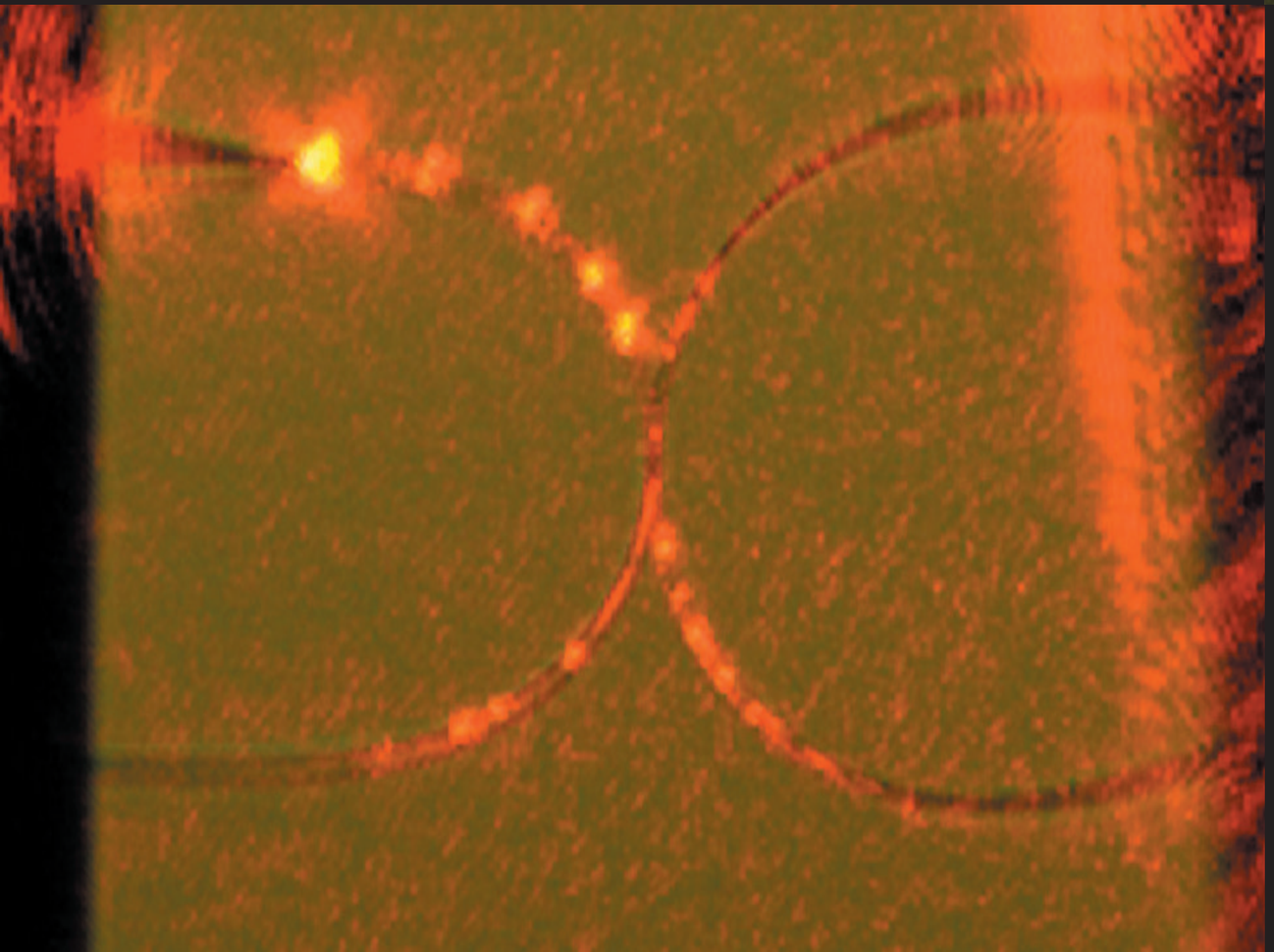
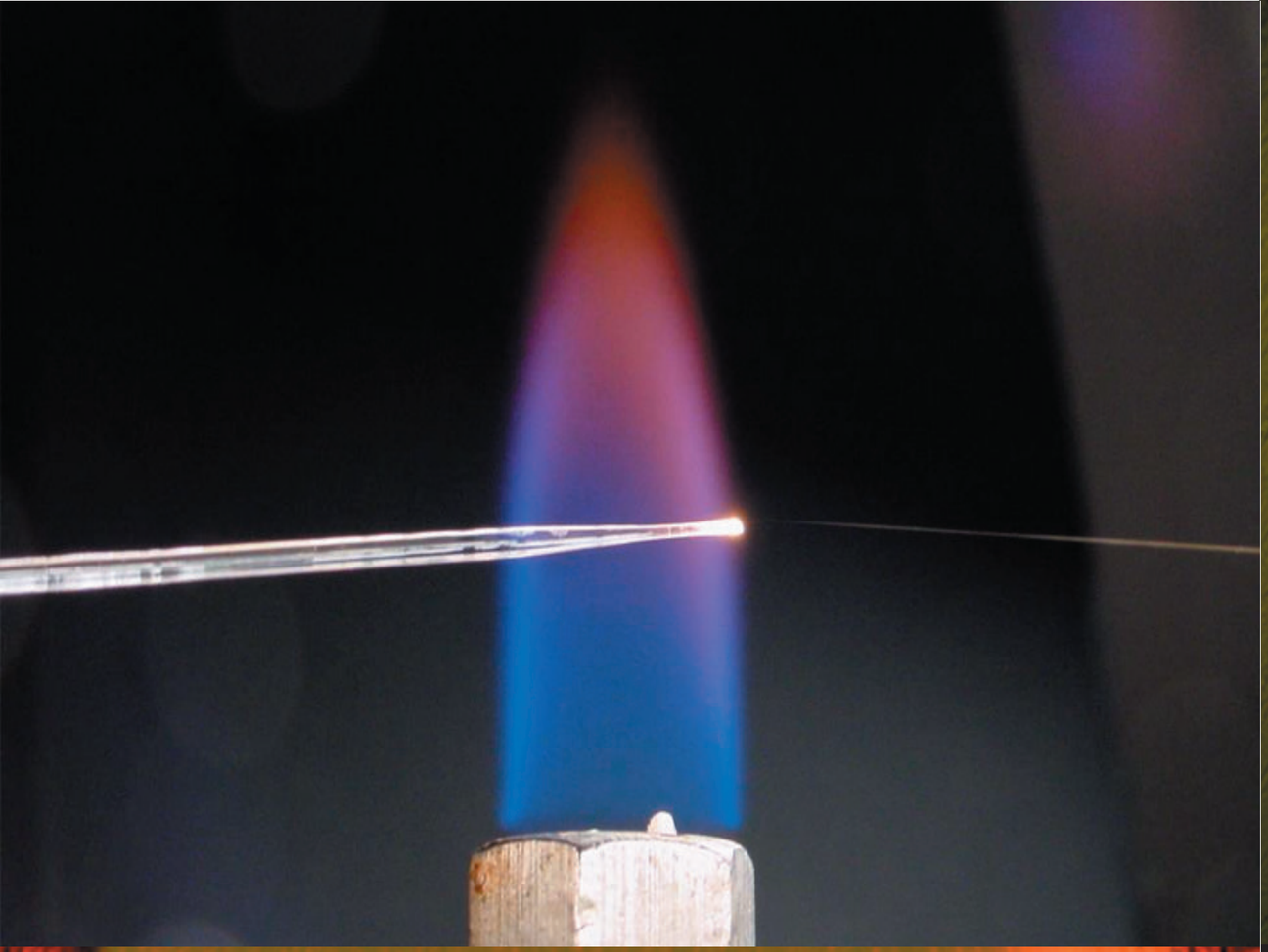
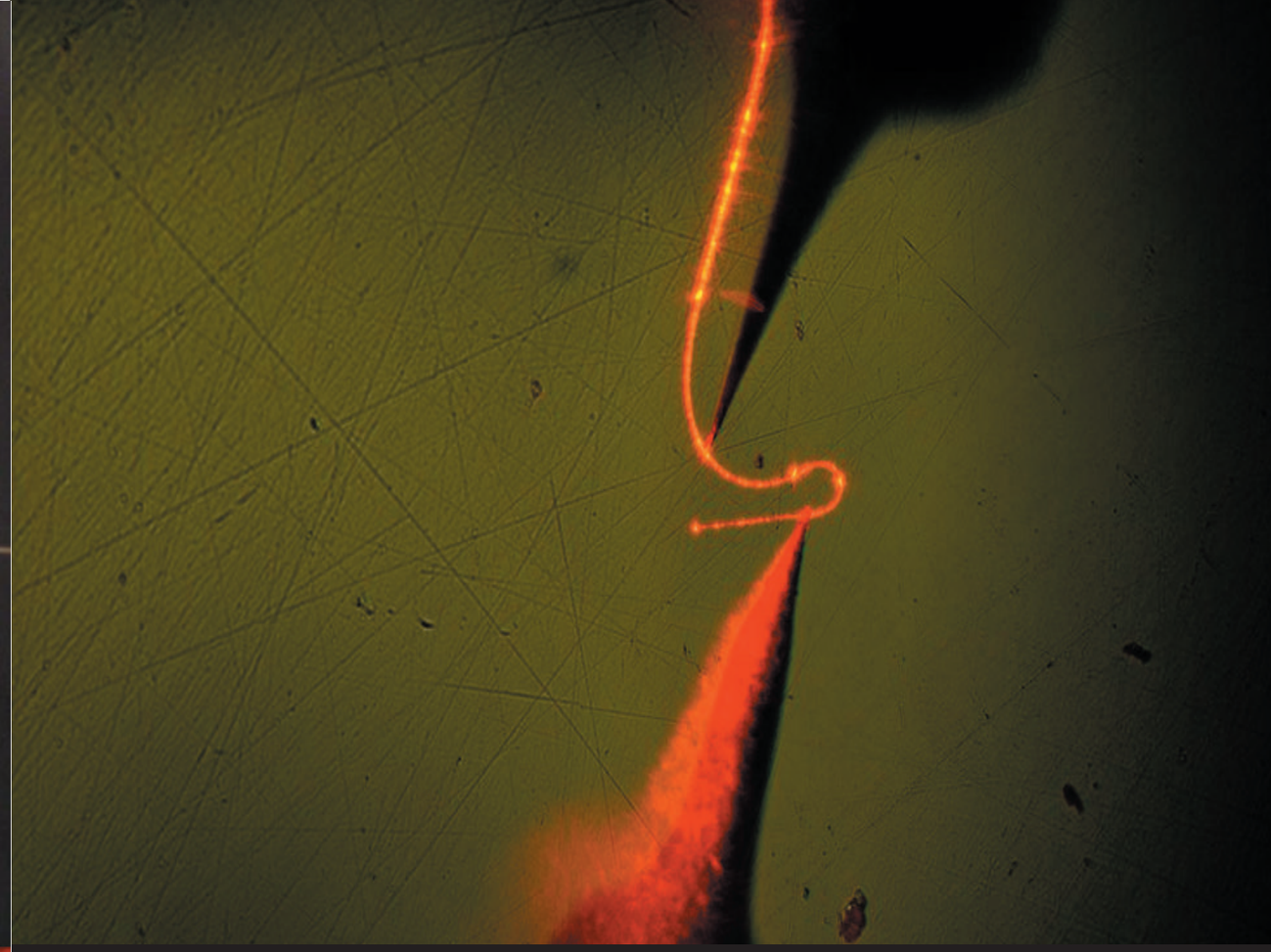
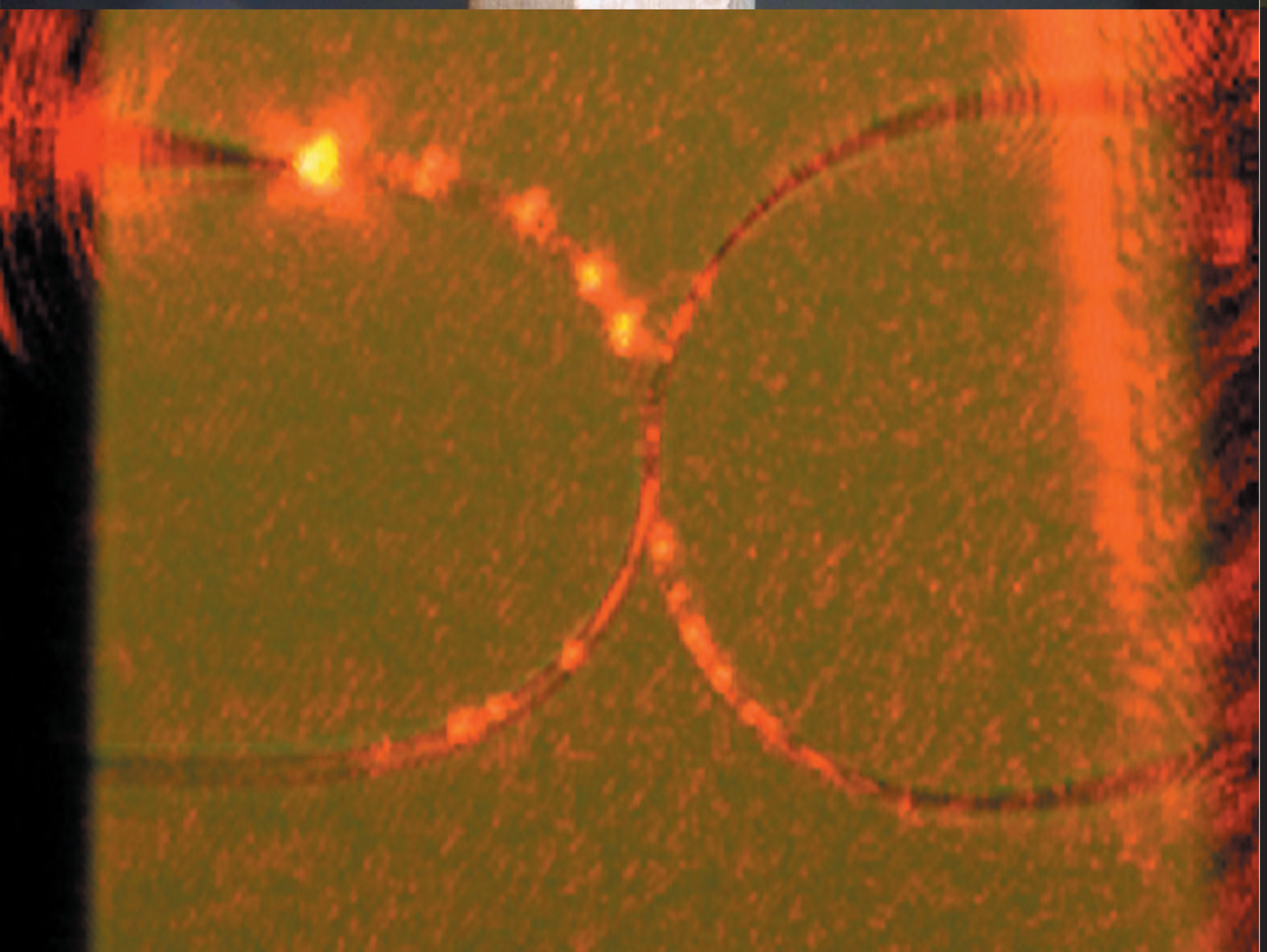




- faster
- uses less resources
- dense integration
- new phenomena







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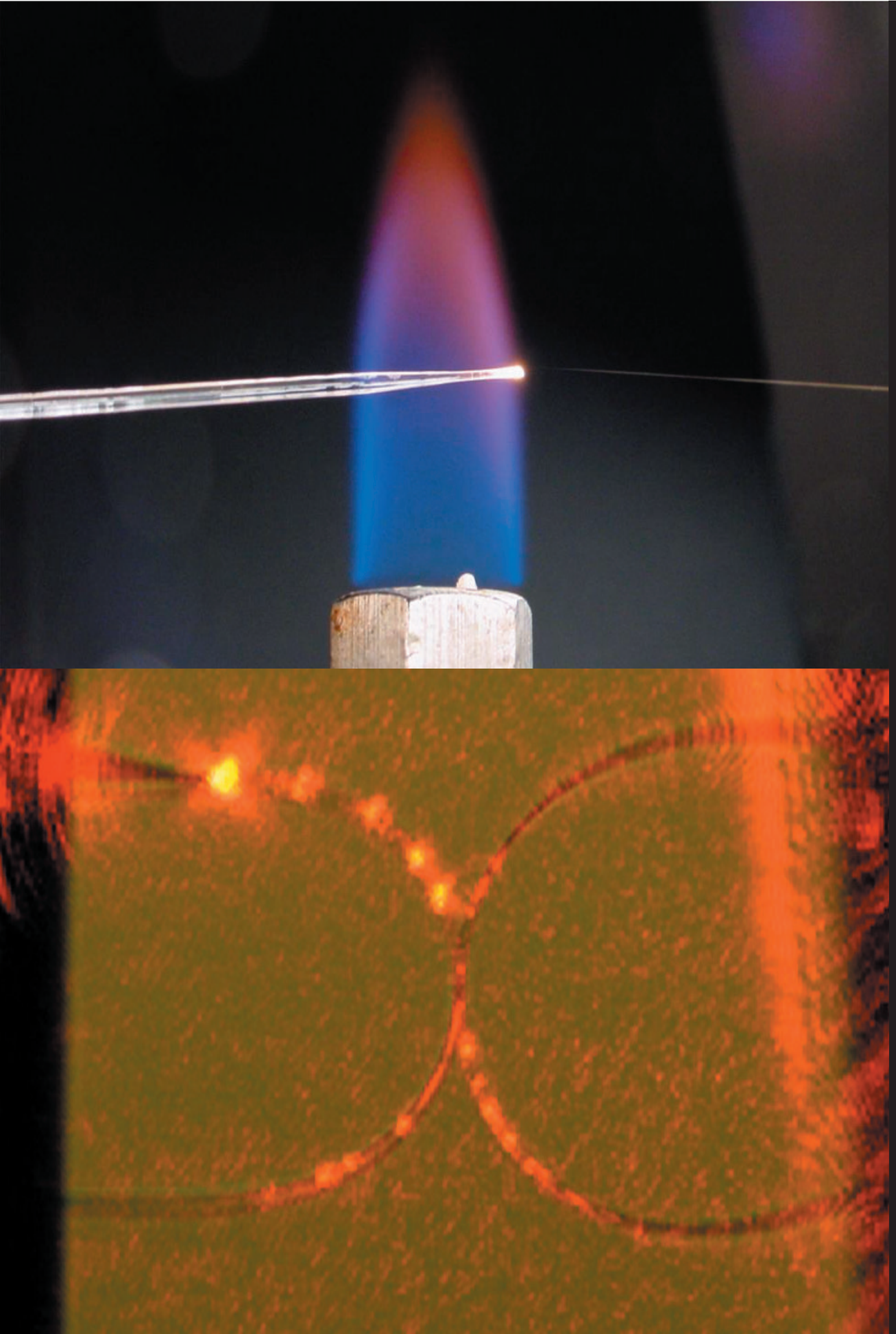
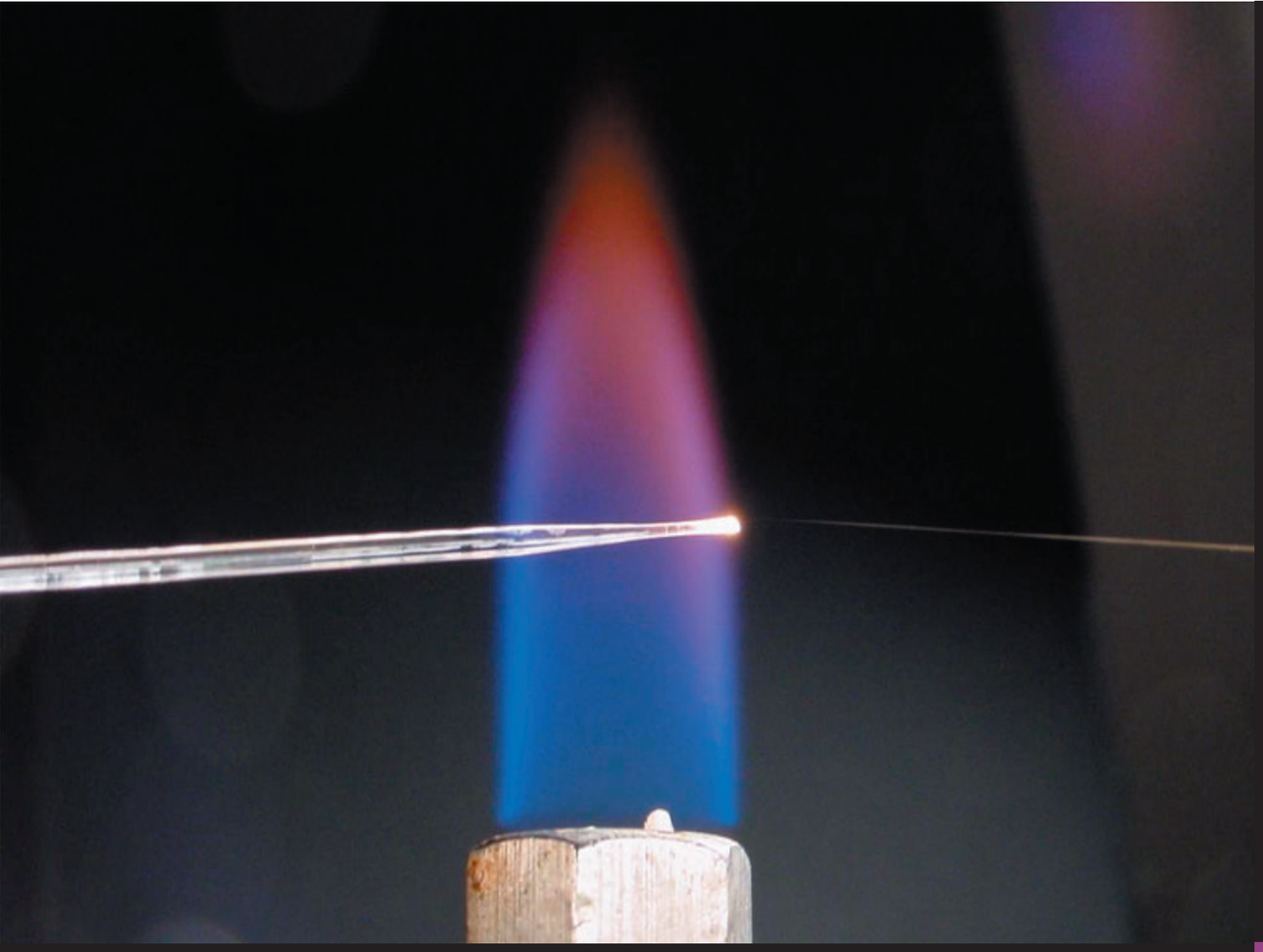


Nanotechnology can be simple!

- faster
- uses less resources
- dense integration
- new phenomena



Nanotechnology can be simple!

More information:

http://mazur-www.harvard.edu