Nano-textured Surfaces

Tsing-Hua Her
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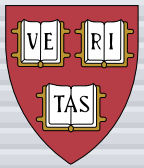
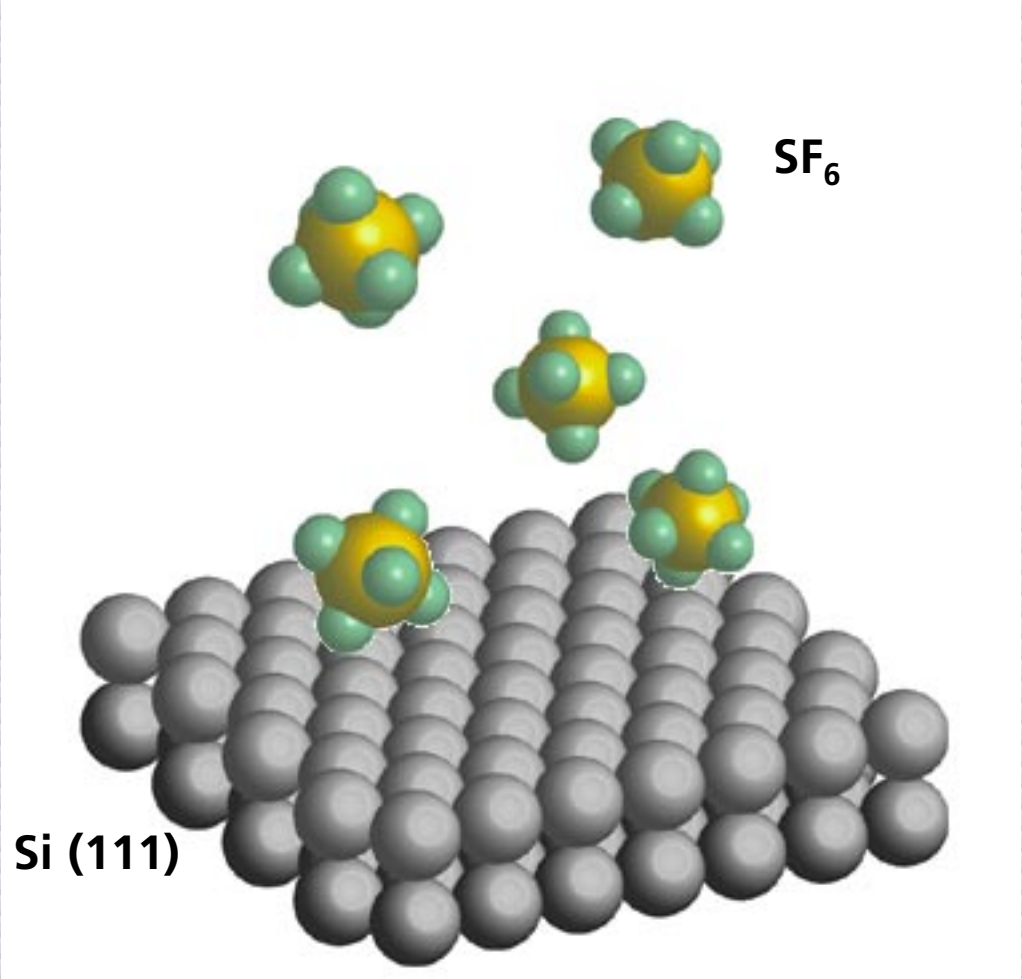
Meng Yan Shen
Catherine Crouch
Cynthia Friend

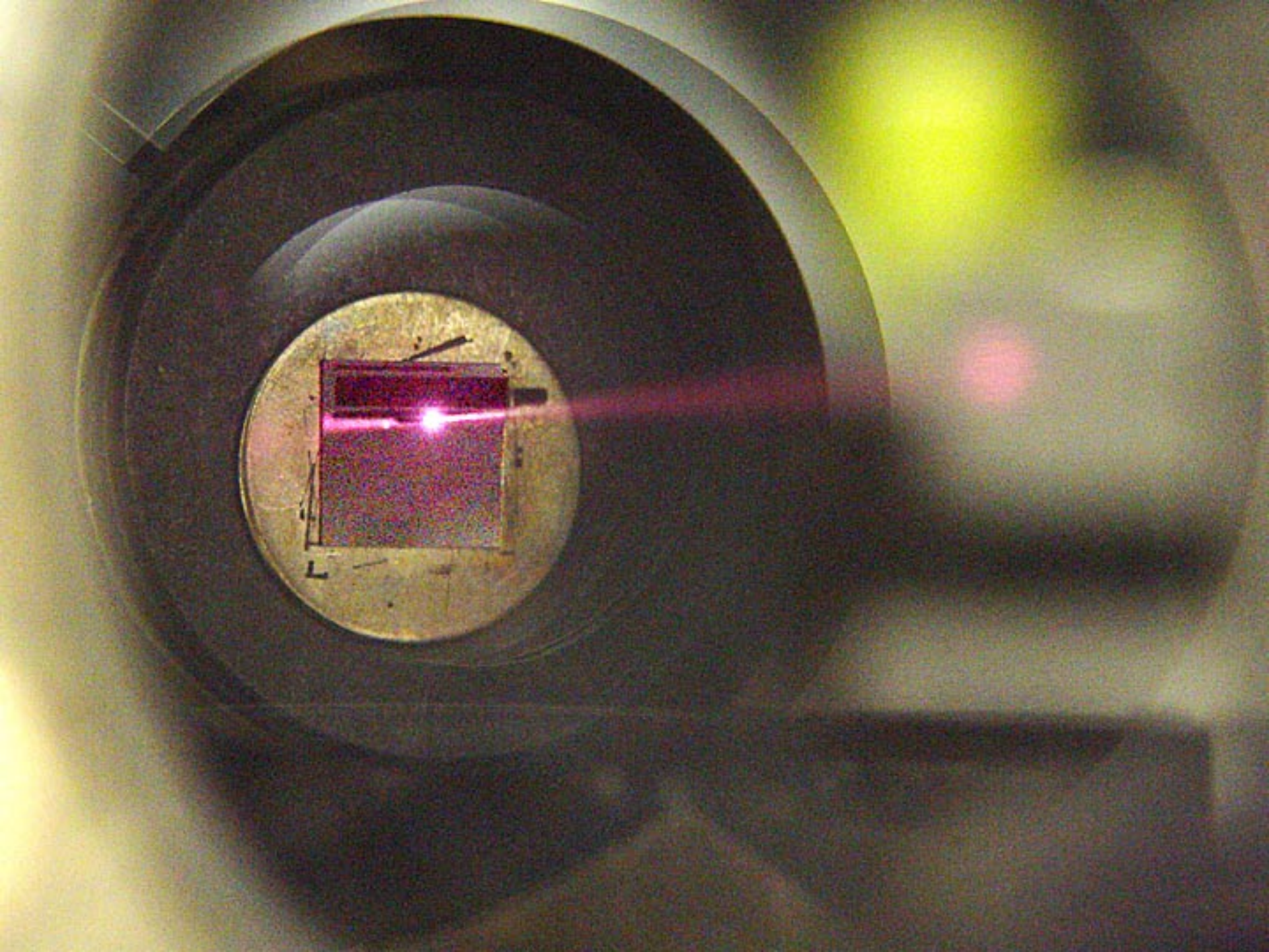
Industrial Outreach Program Workshop
11 April 2003



Introduction



irradiate with 100-fs 10 kJ/m^2 pulses



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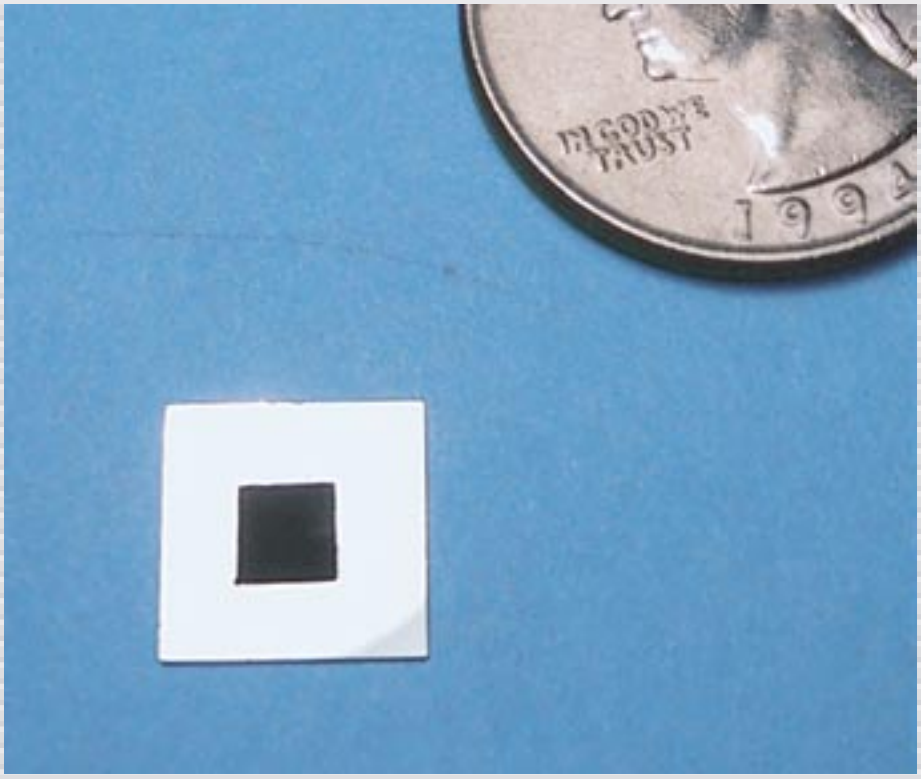
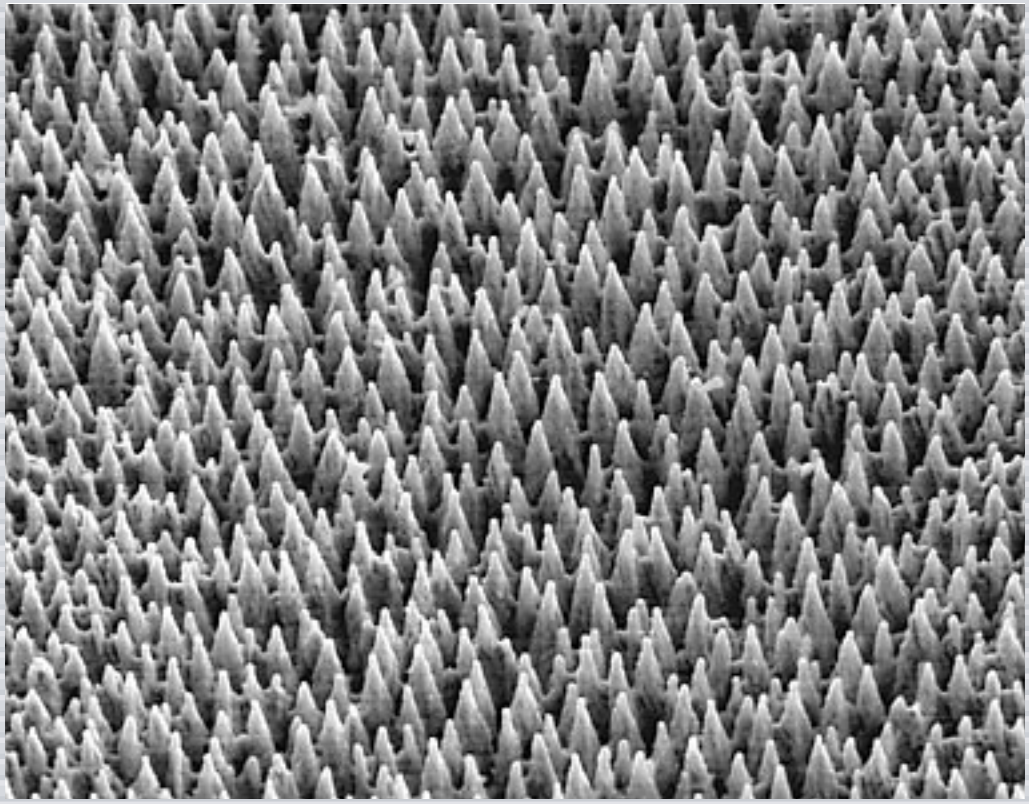


‘black silicon’

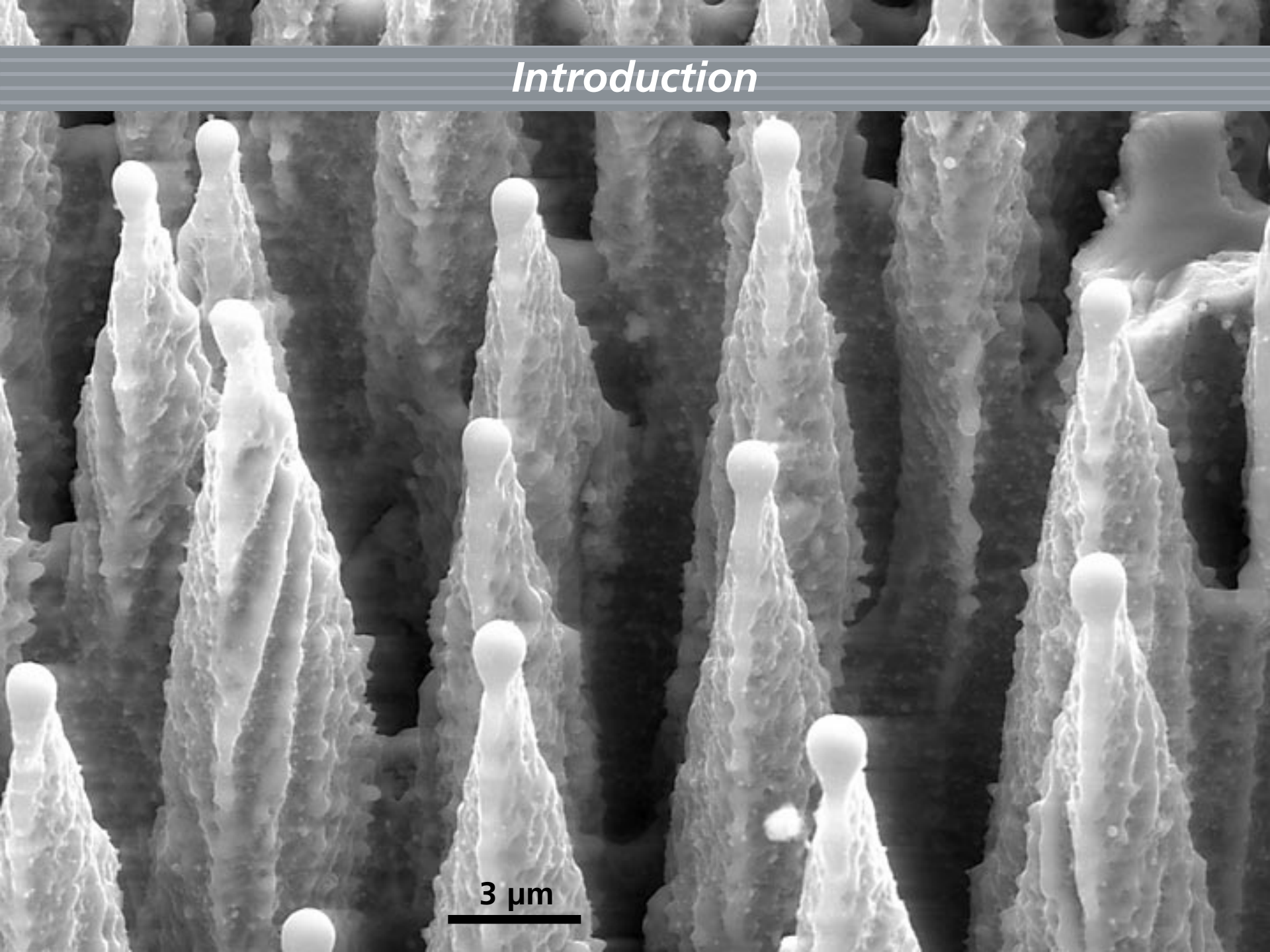
***Appl. Phys. Lett.* 73, 1673 (1998)**

Introduction



20 µm

Introduction



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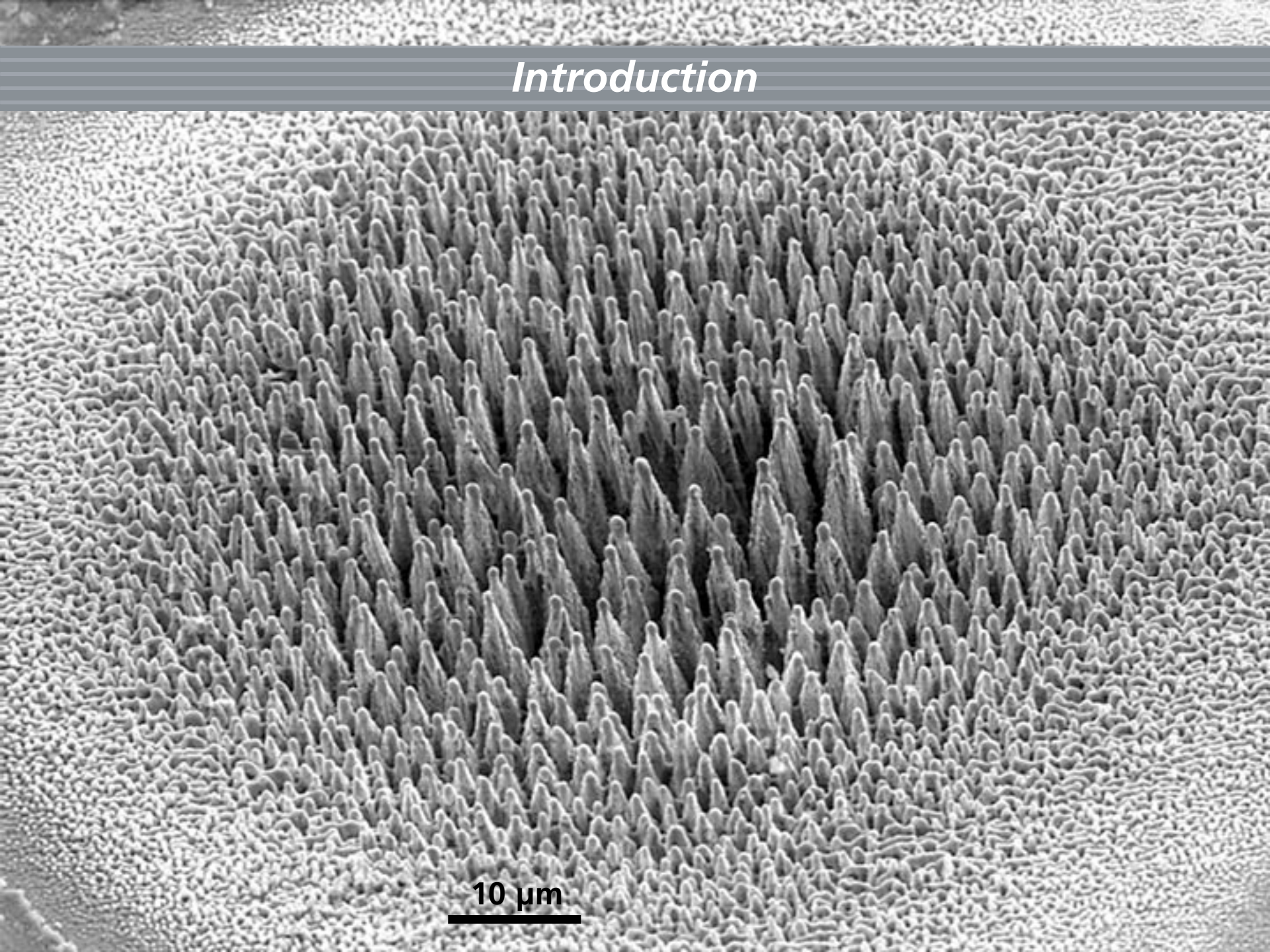

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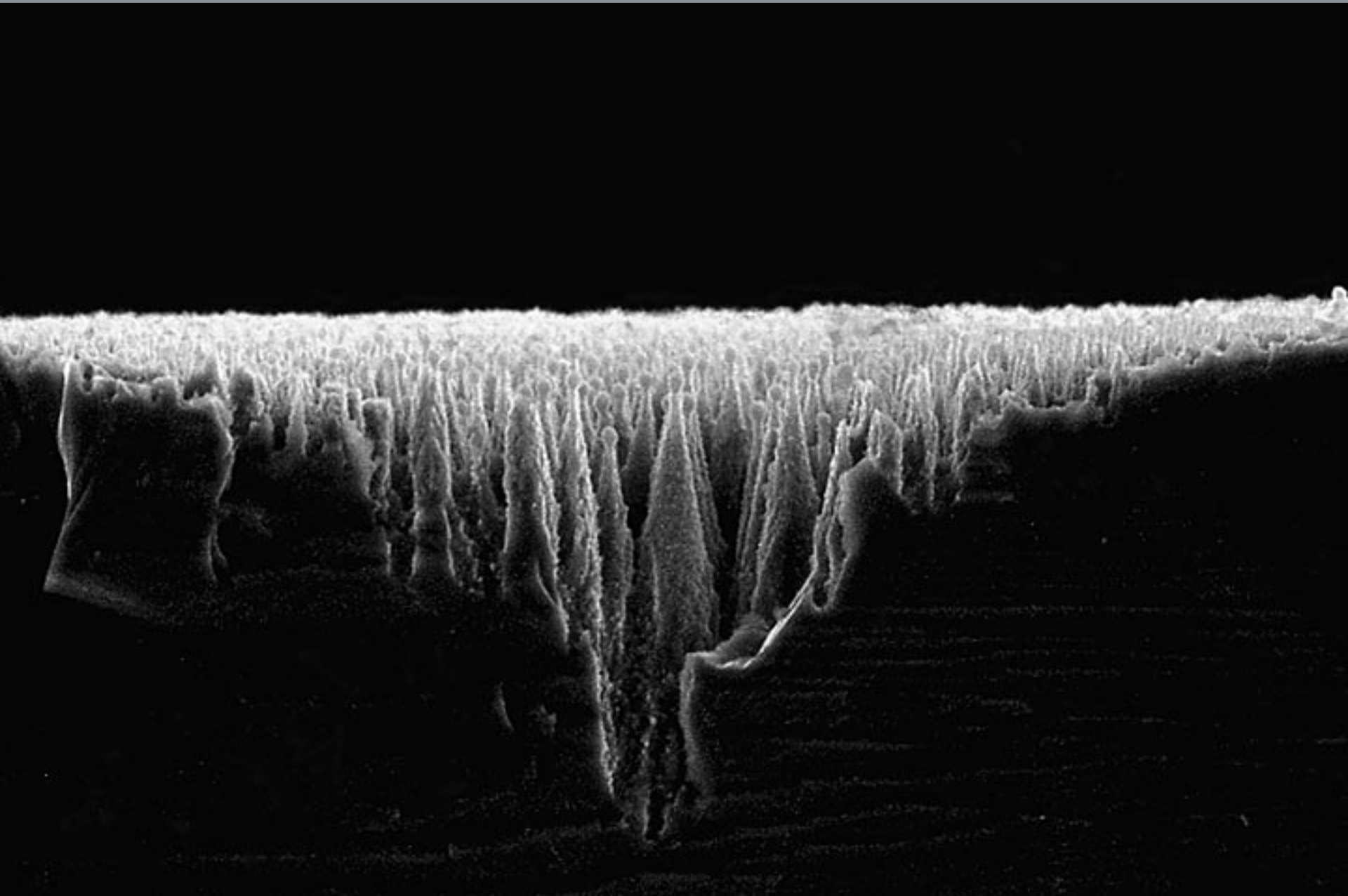

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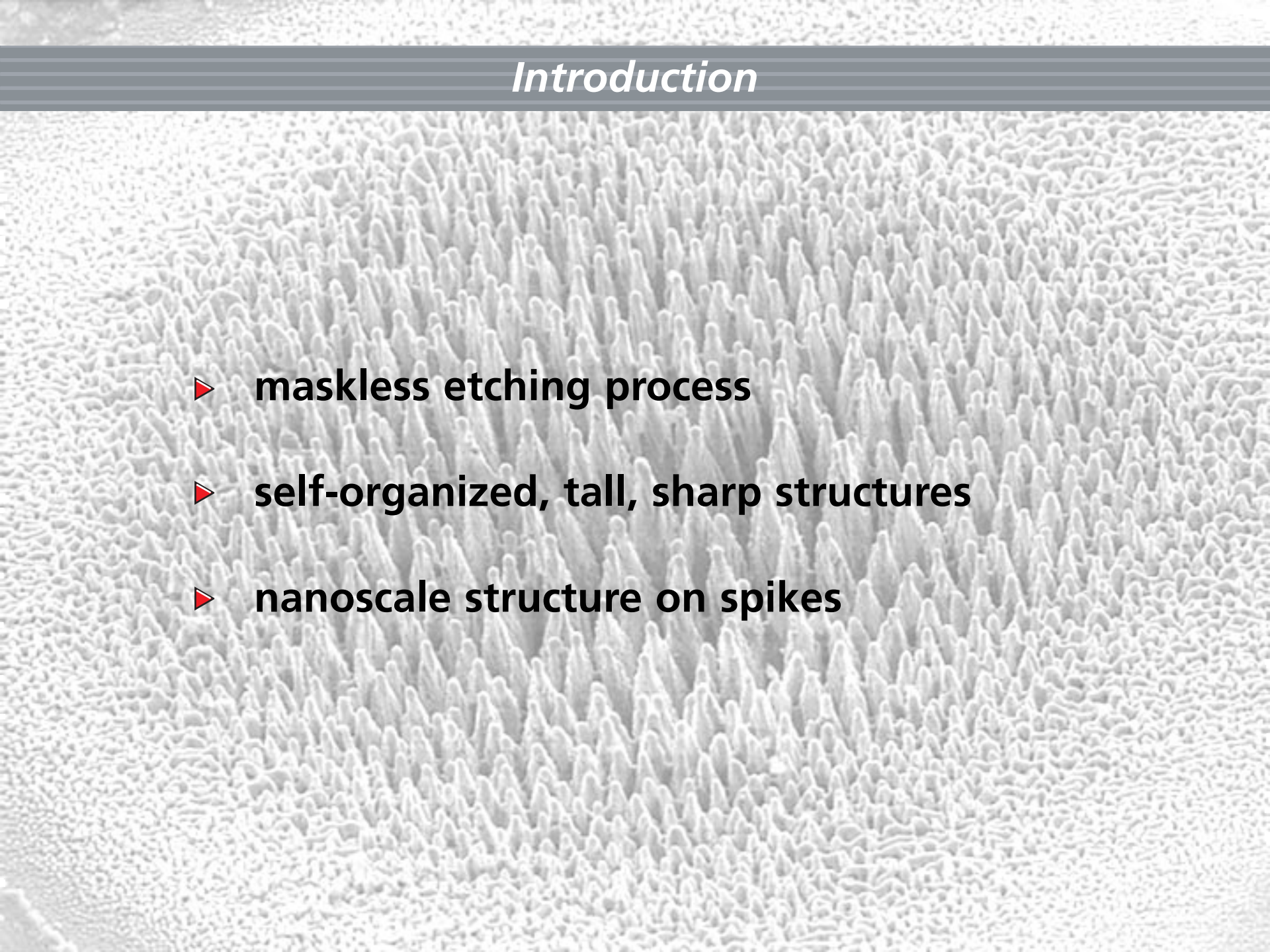
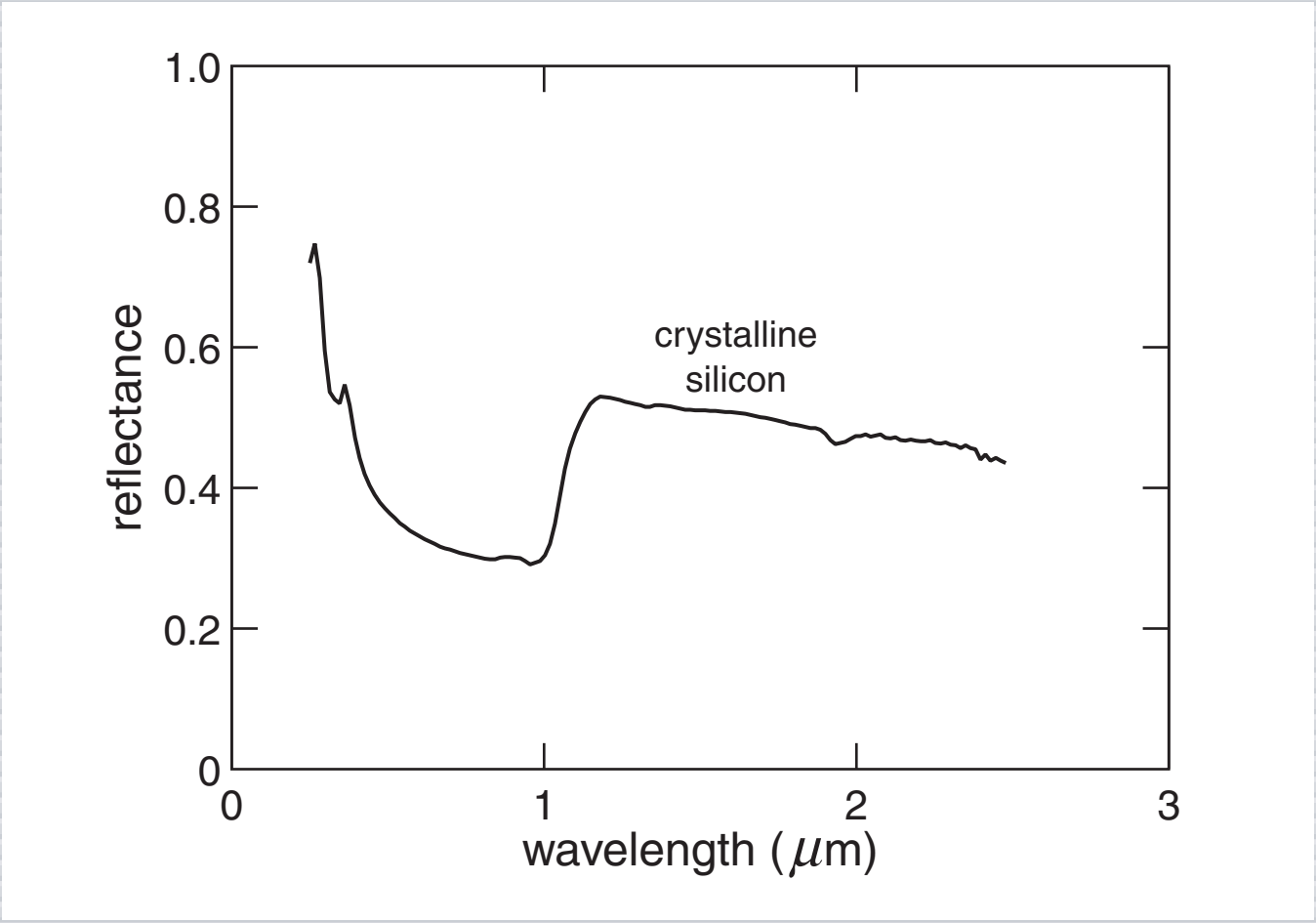


- **maskless etching process**
- **self-organized, tall, sharp structures**
- **nanoscale structure on spikes**

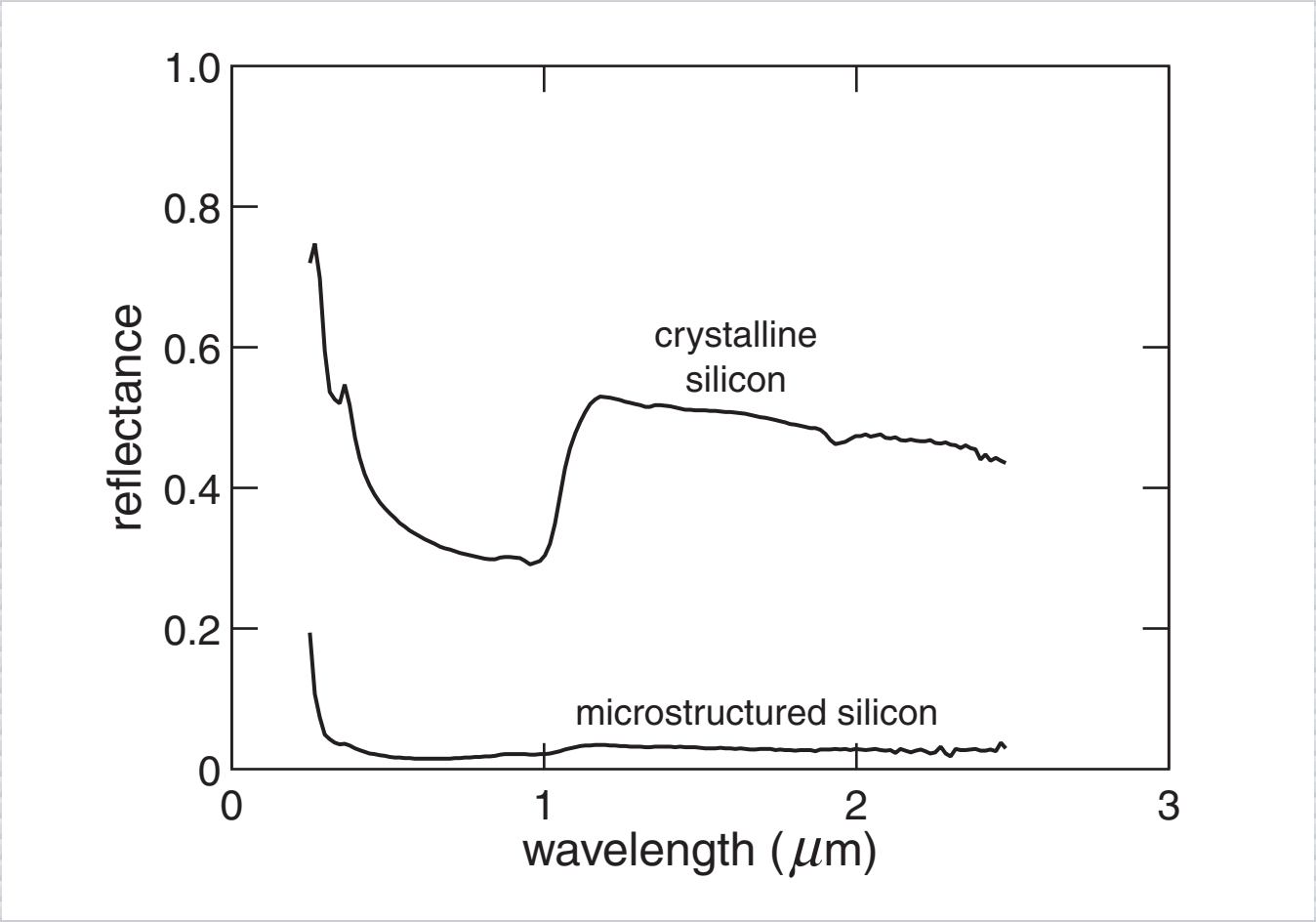
Outline

- Properties
- Structural and chemical analysis
- Outlook

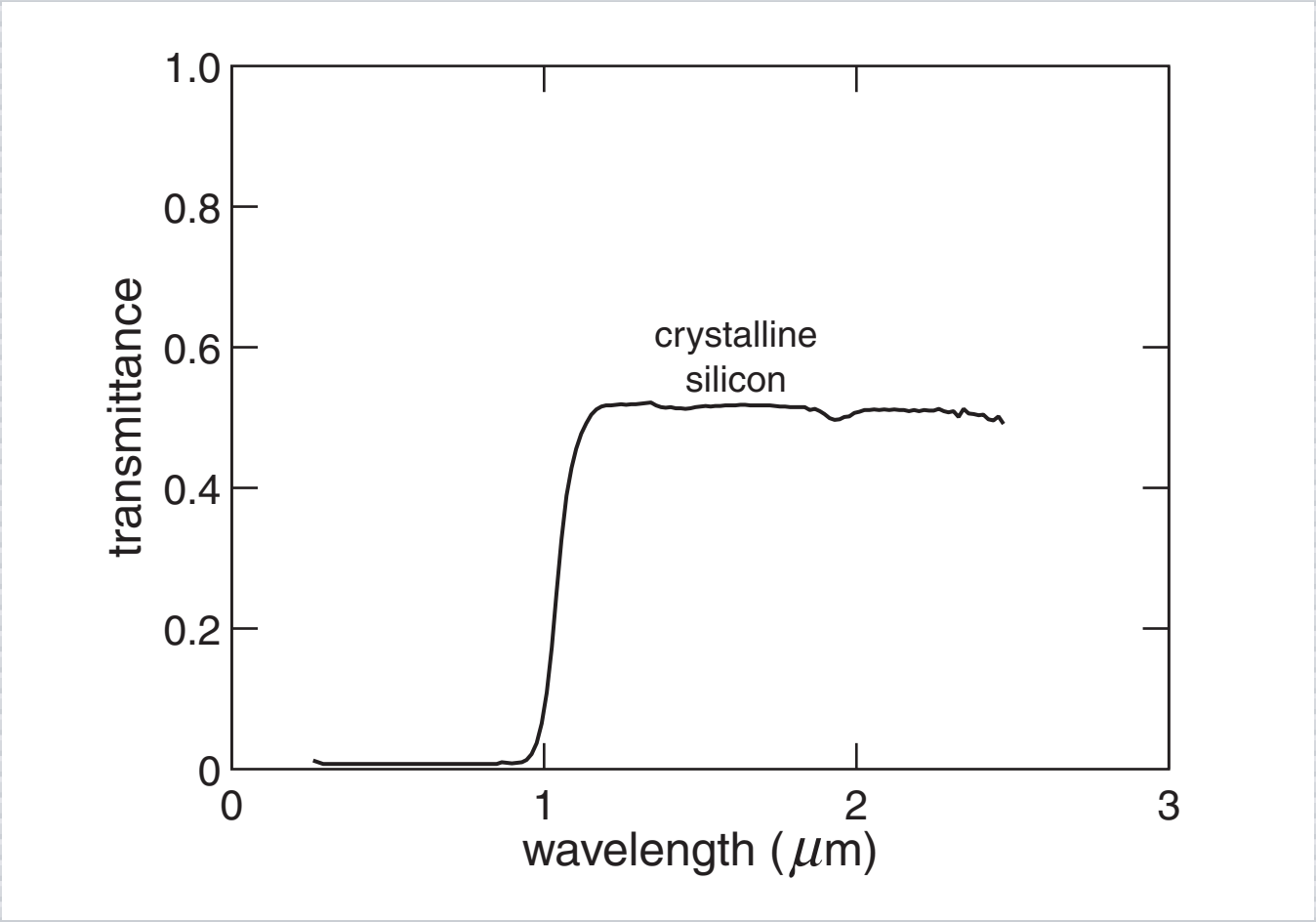
reflectance (integrating sphere)



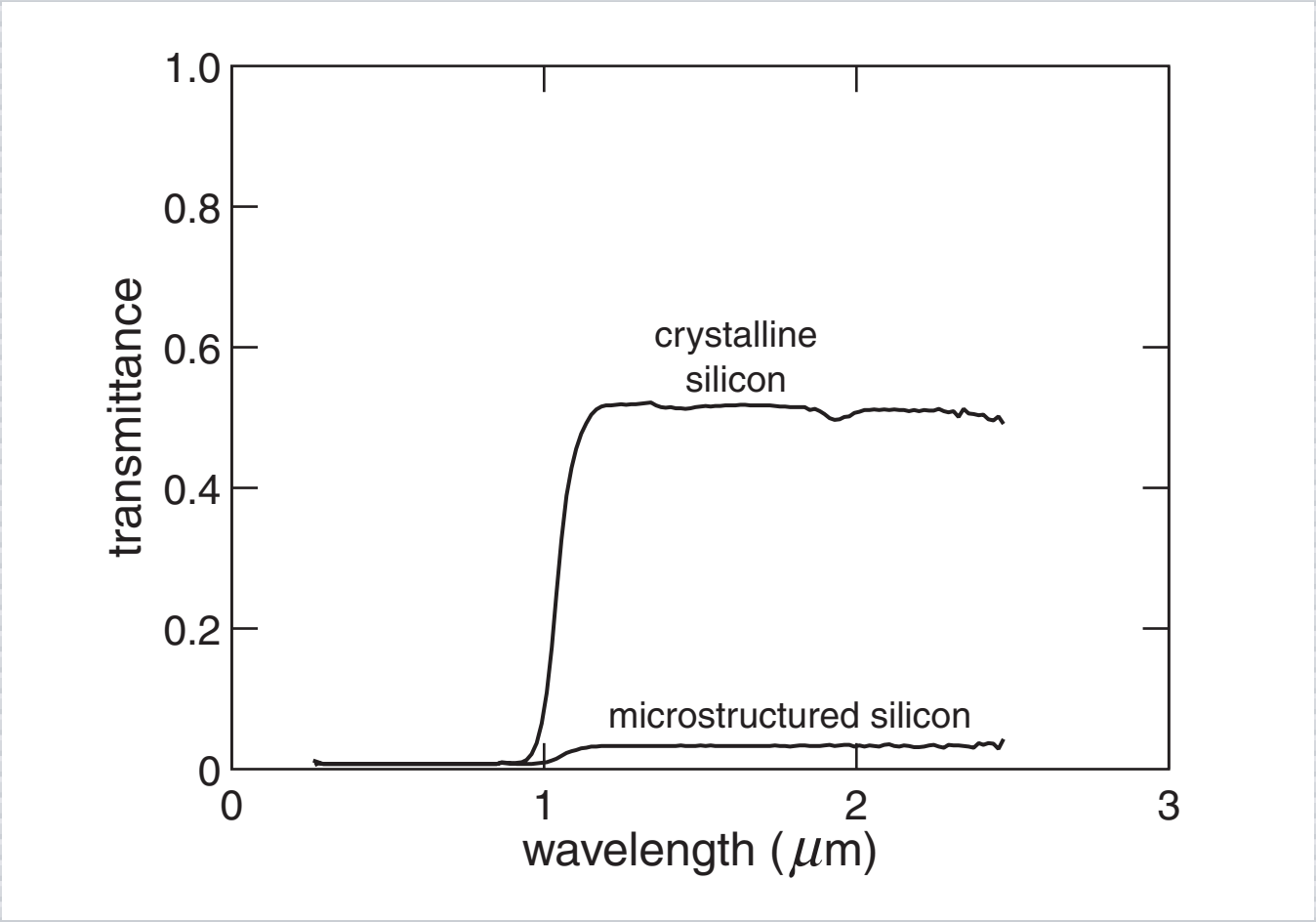
reflectance (integrating sphere)



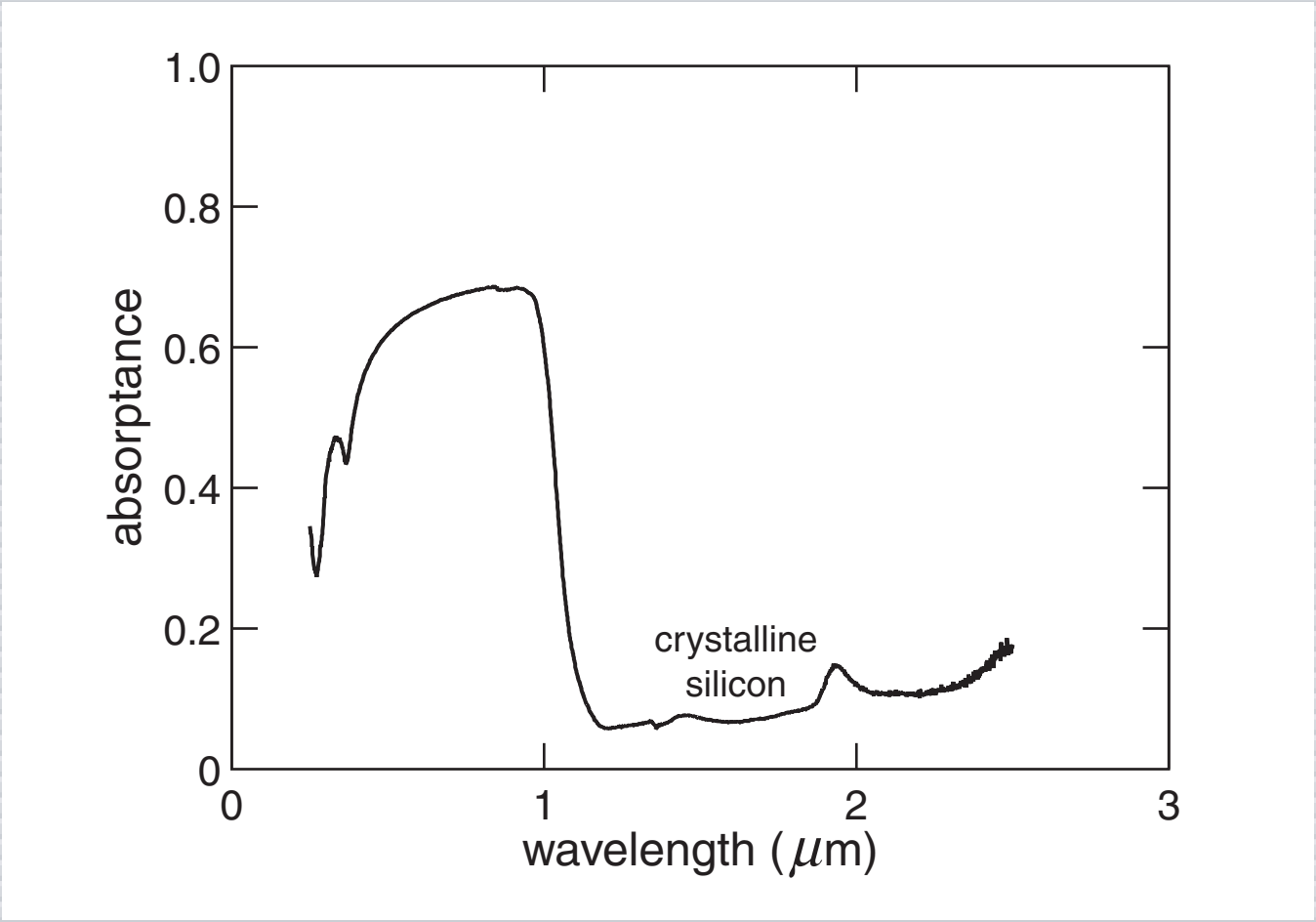
transmittance (integrating sphere)



transmittance (integrating sphere)



absorptance (1 – *R* – *T*)



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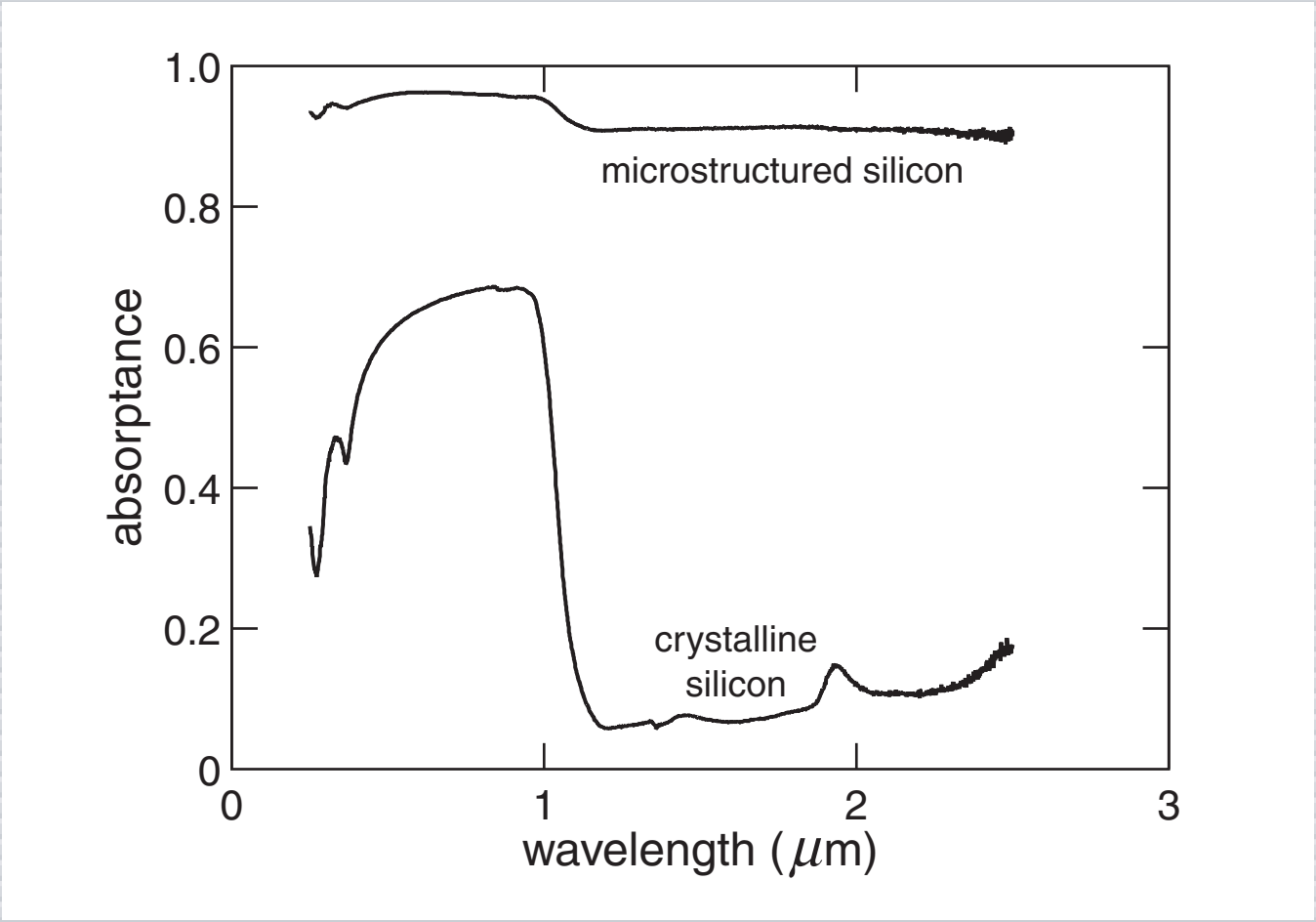


Appl. Phys. Lett. **78, 1850 (2001)**

Properties

Points to keep in mind:

- **near unity absorption**
- **sub-band gap absorption**
- **IR photoelectron generation**

Properties

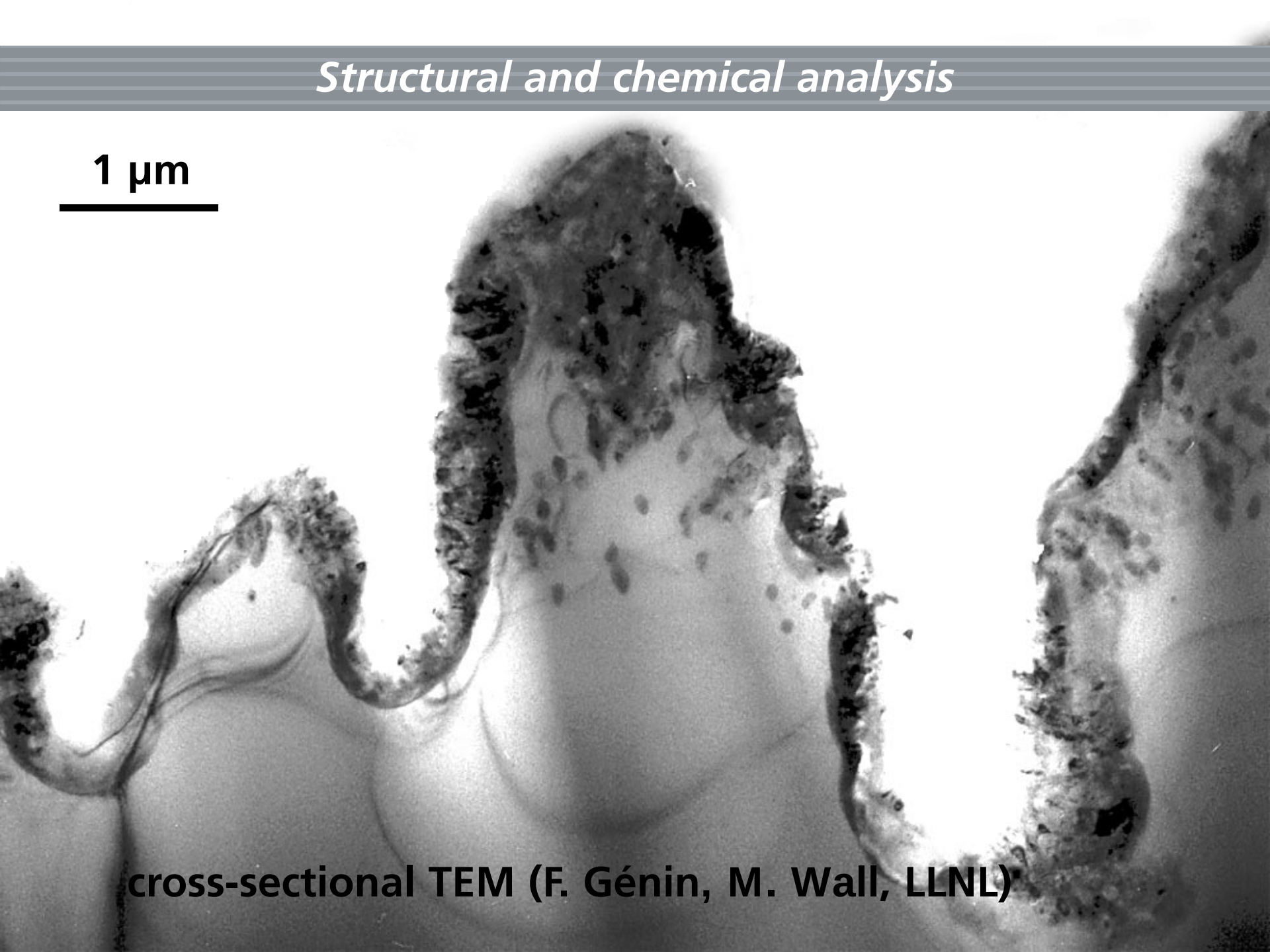
Points to keep in mind:

- **near unity absorption**
- **sub-band gap absorption**
- **IR photoelectron generation**
- **high field emission at low fields**

Outline

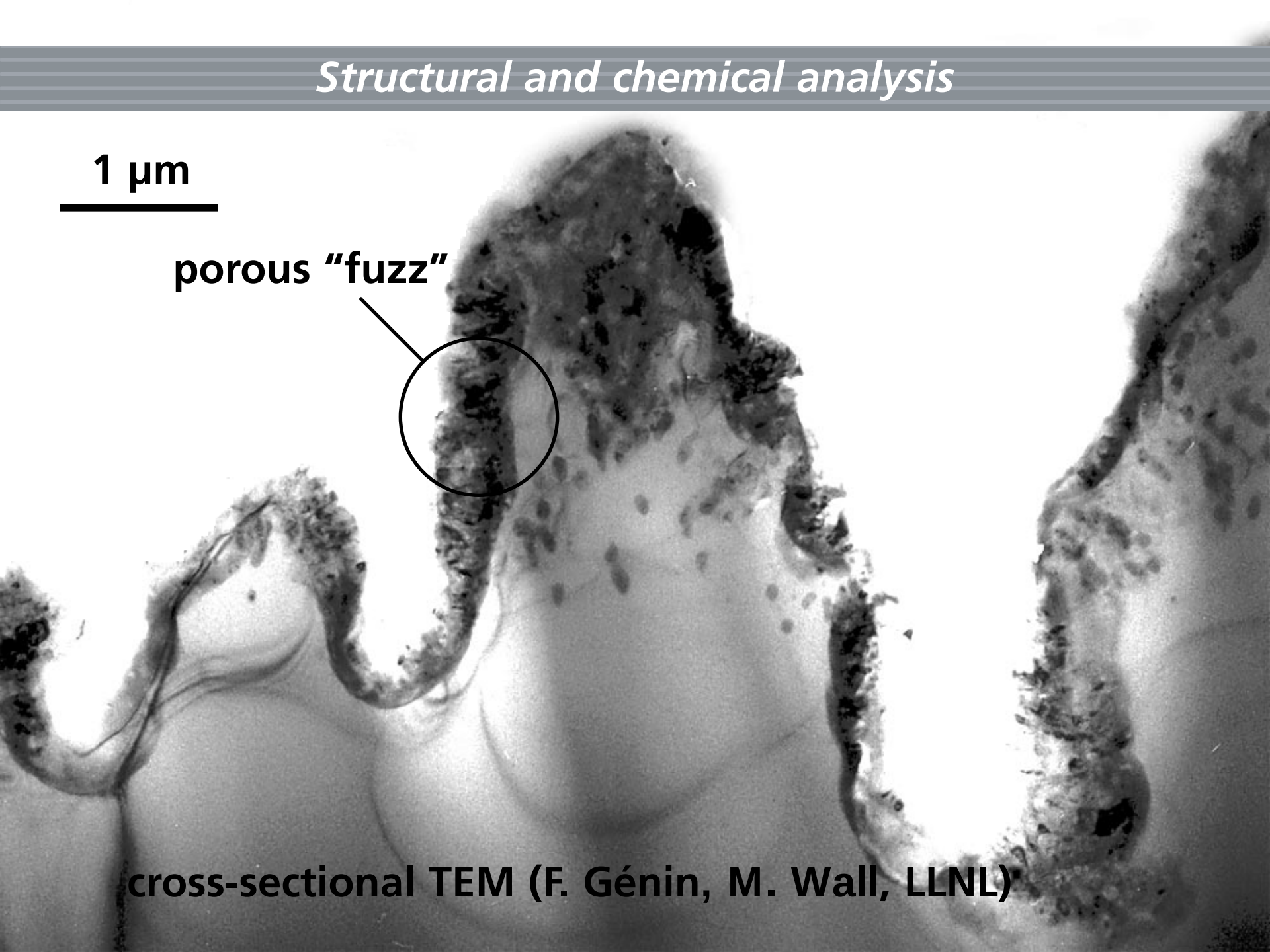
- Properties
- **Structural and chemical analysis**
- Outlook

Structural and chemical analysis



cross-sectional TEM (F. Génin, M. Wall, LLNL)

Structural and chemical analysis



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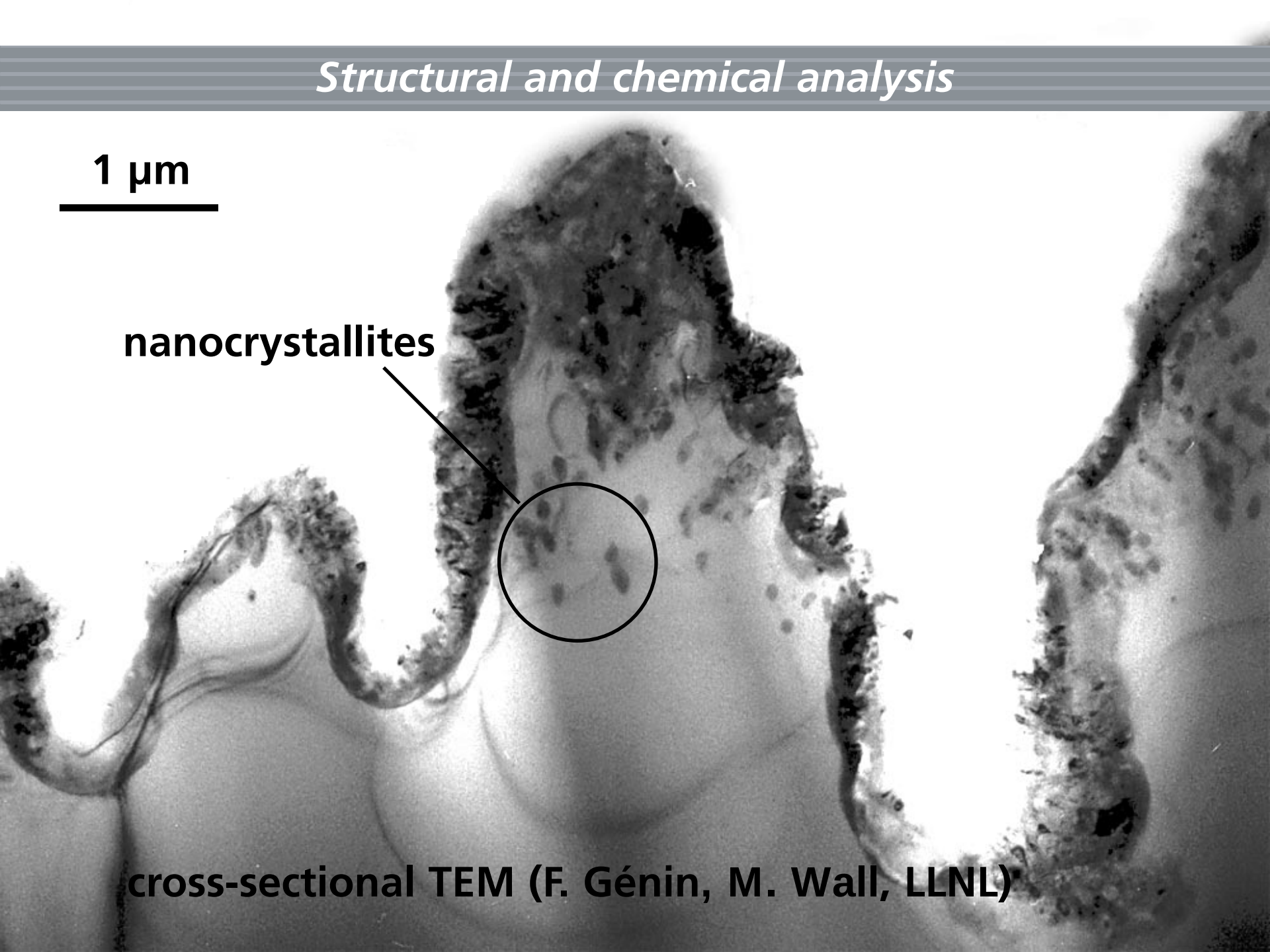

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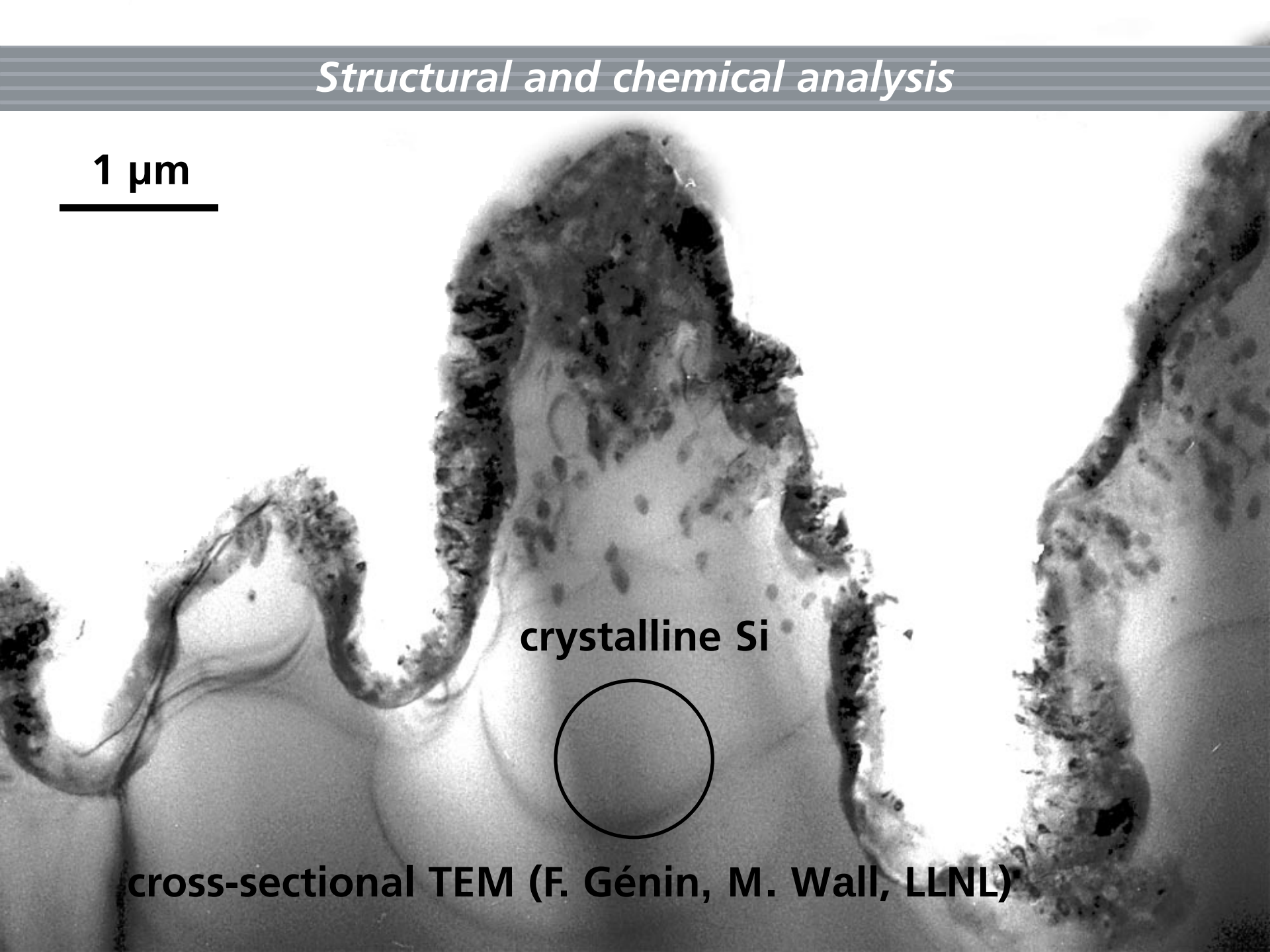

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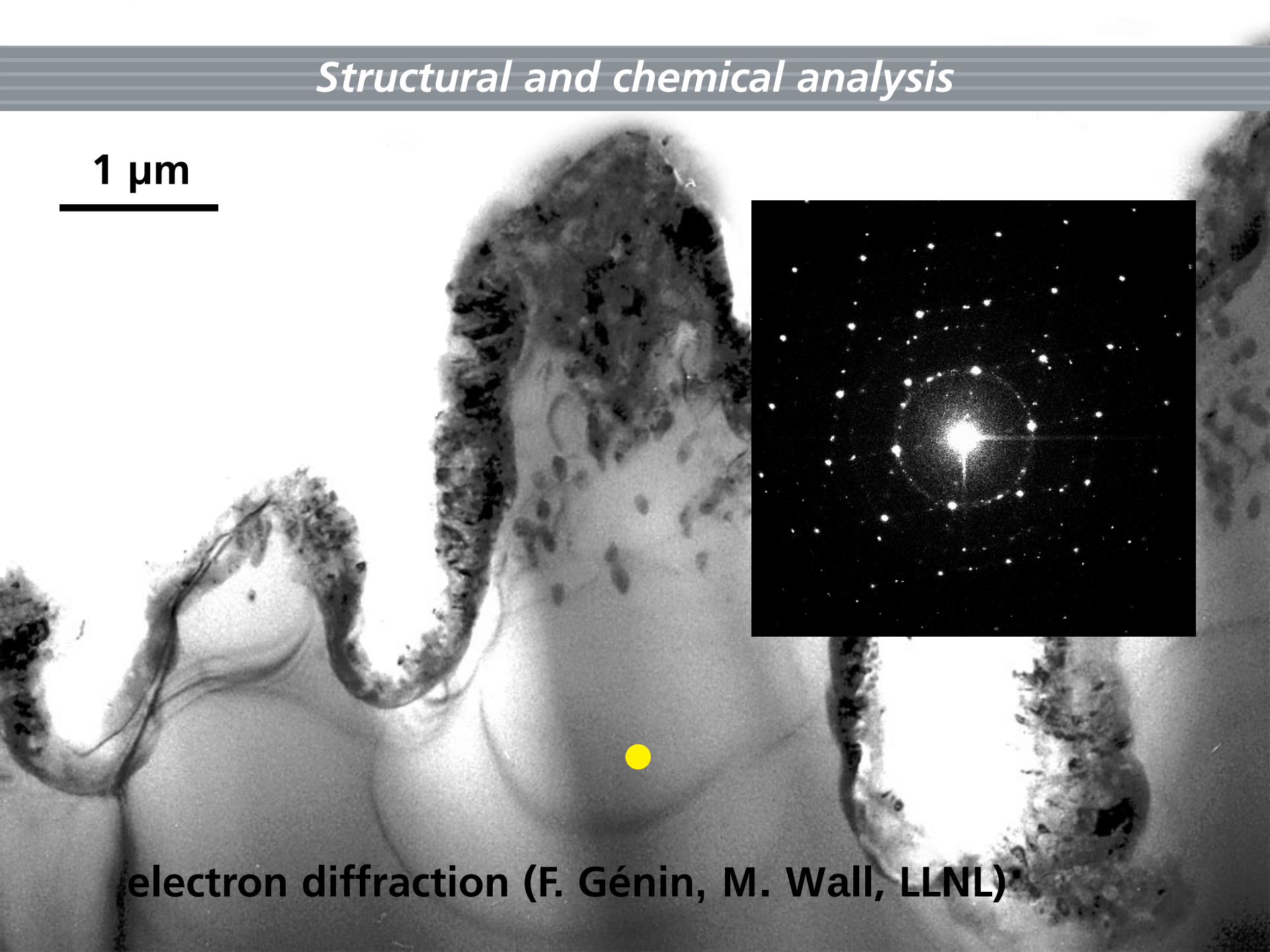
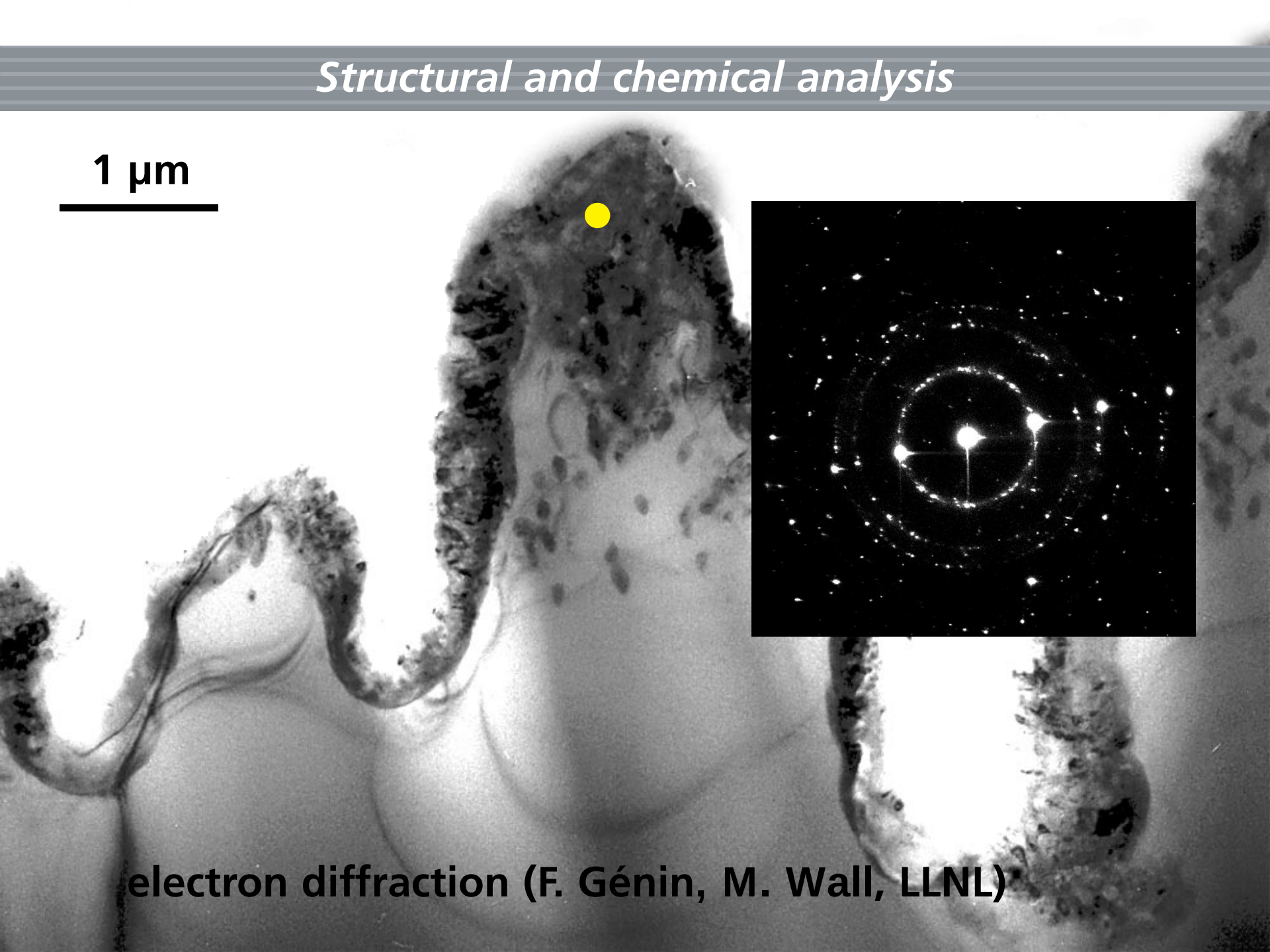


electron diffraction (F. Génin, M. Wall, LLNL)

Structural and chemical analysis



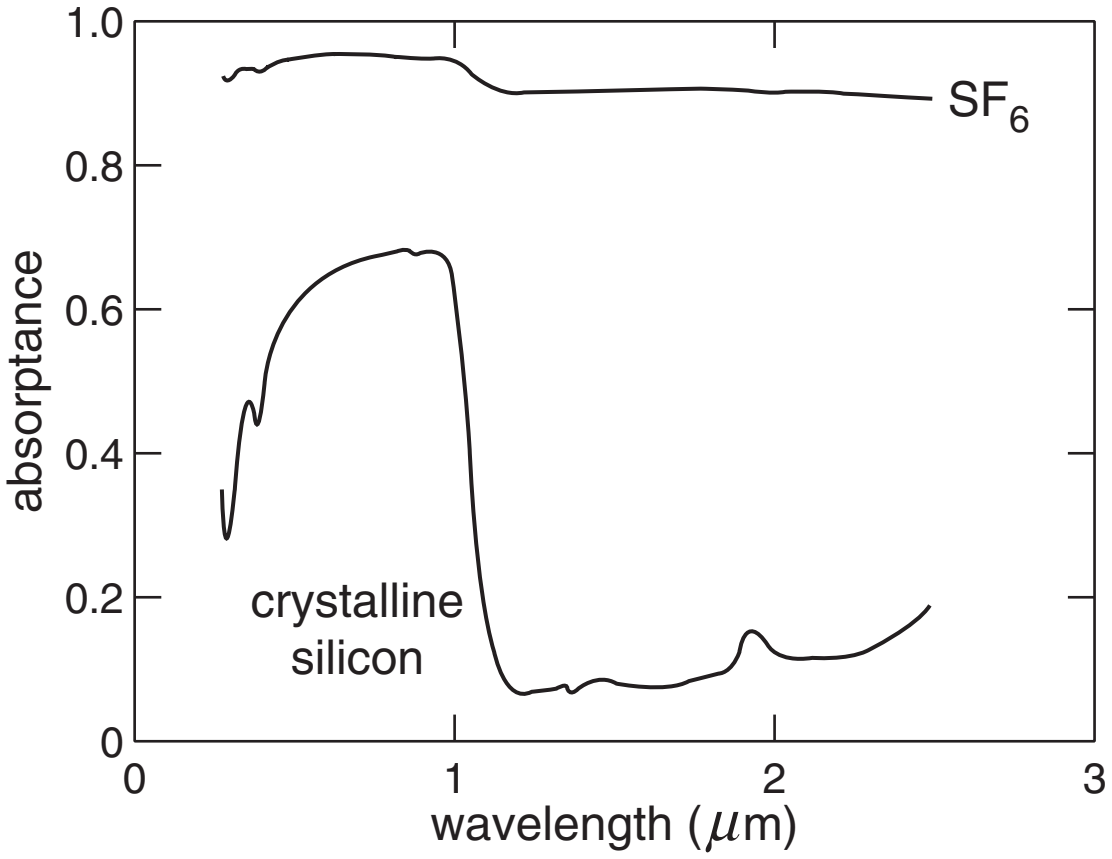
electron diffraction (F. Génin, M. Wall, LLNL)

Structural and chemical analysis

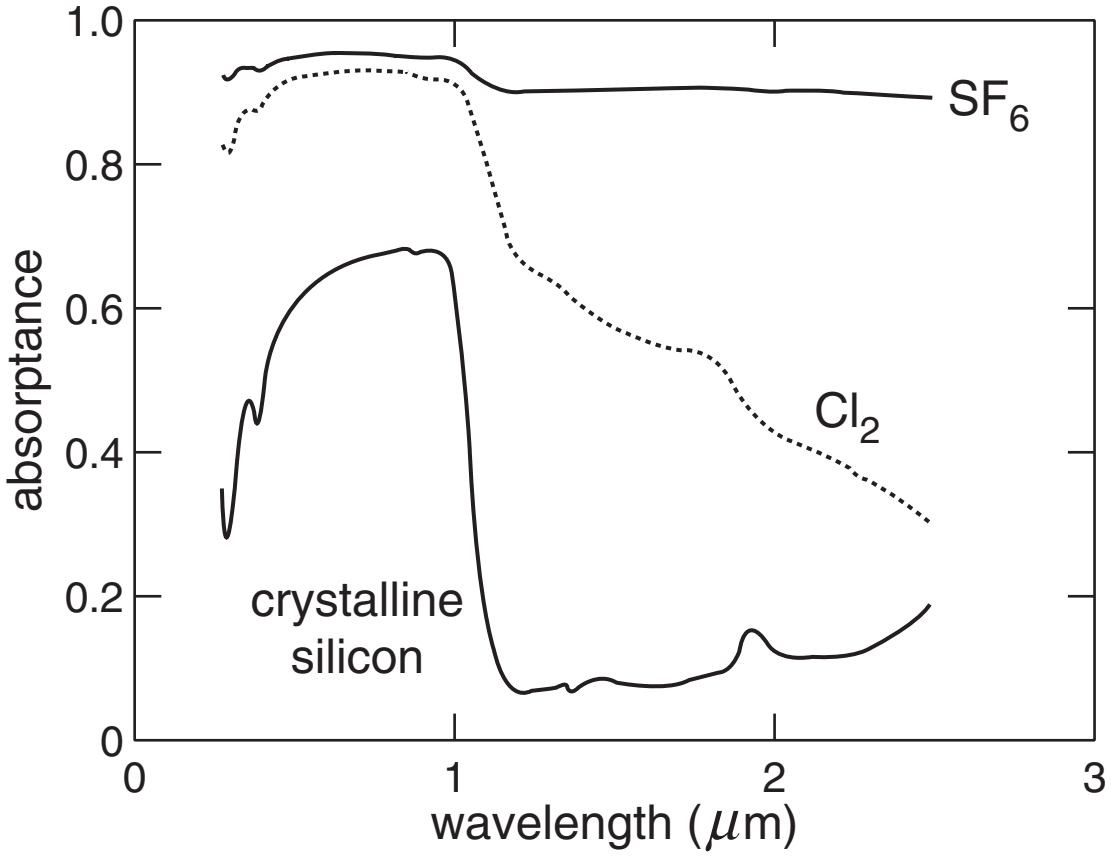
cross-sectional TEM:

- **core of spikes: undisturbed Si**
- **surface layer: disordered Si, impurities, nanocrystallites and pores**

effect of ambient gas on absorptance



effect of ambient gas on absorptance



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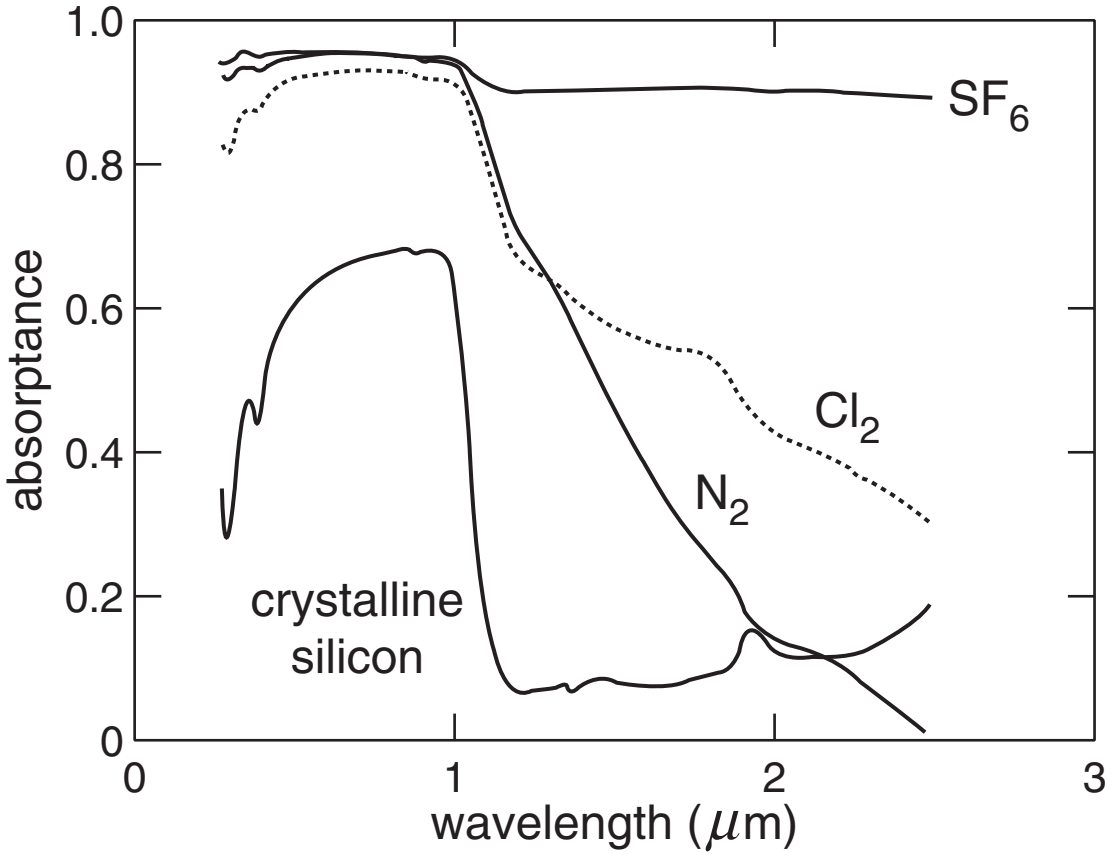

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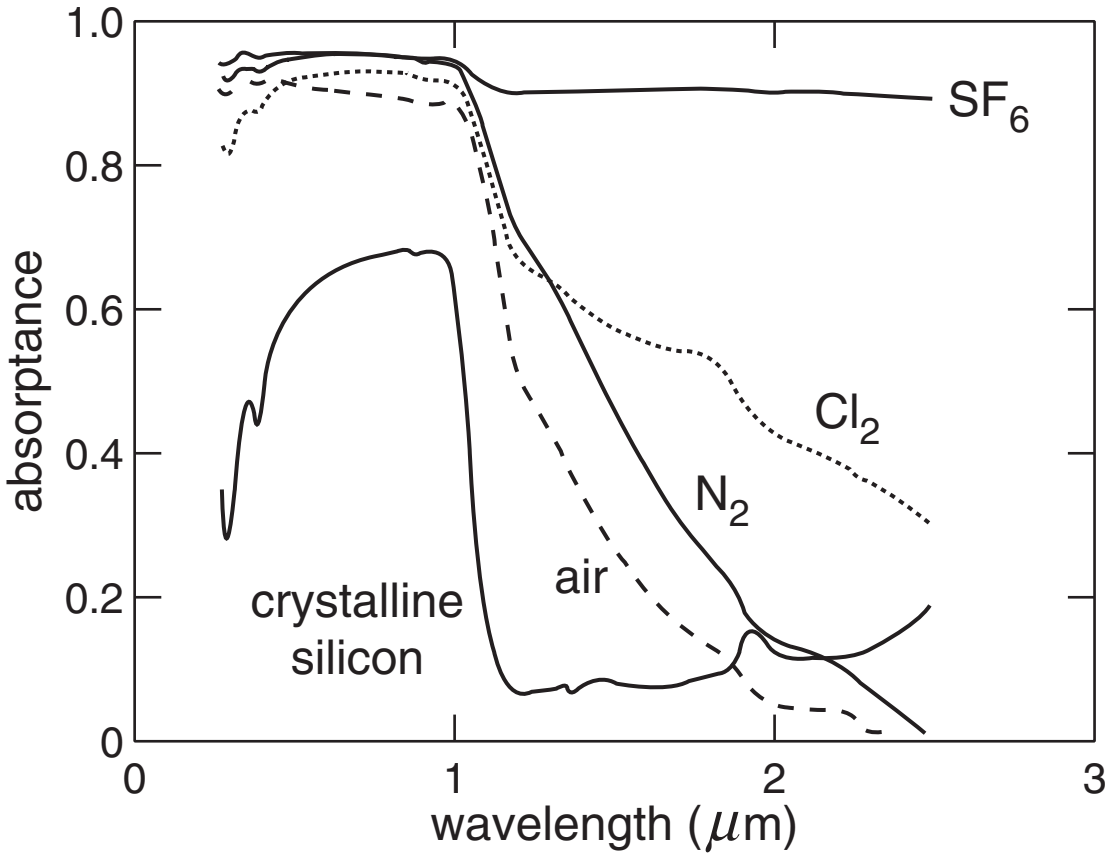

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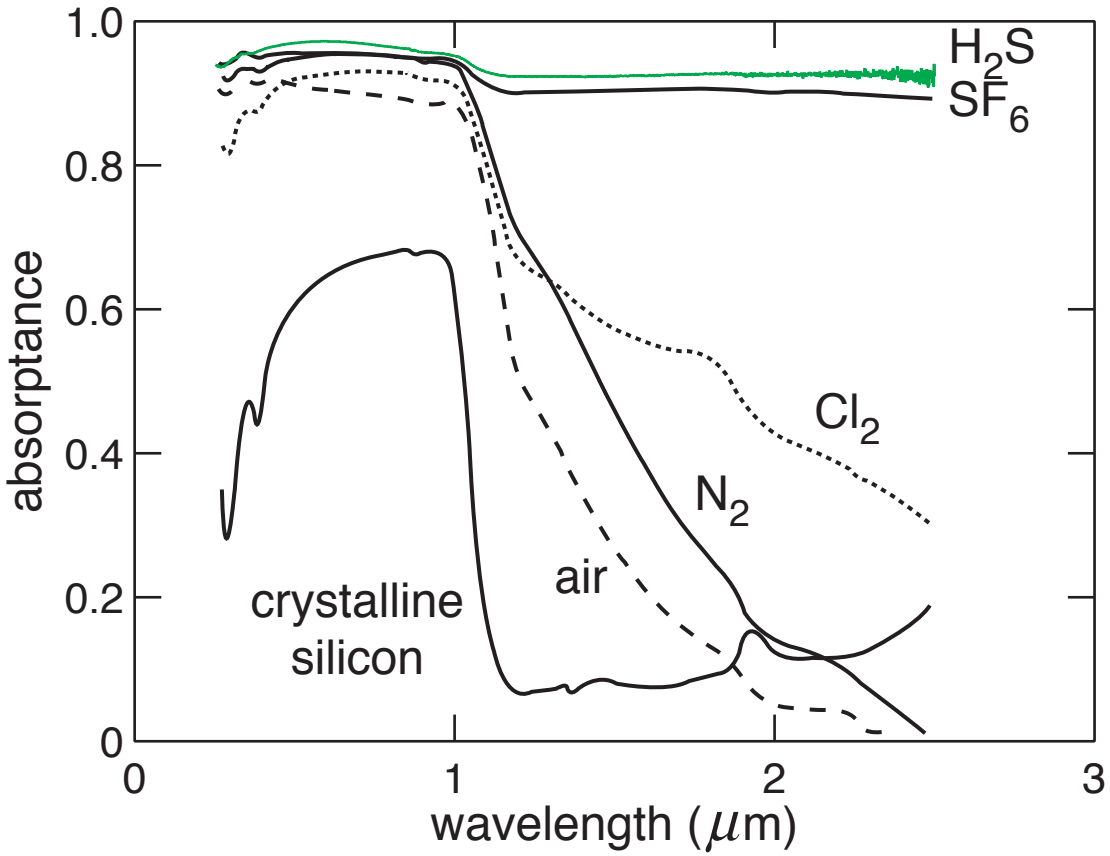

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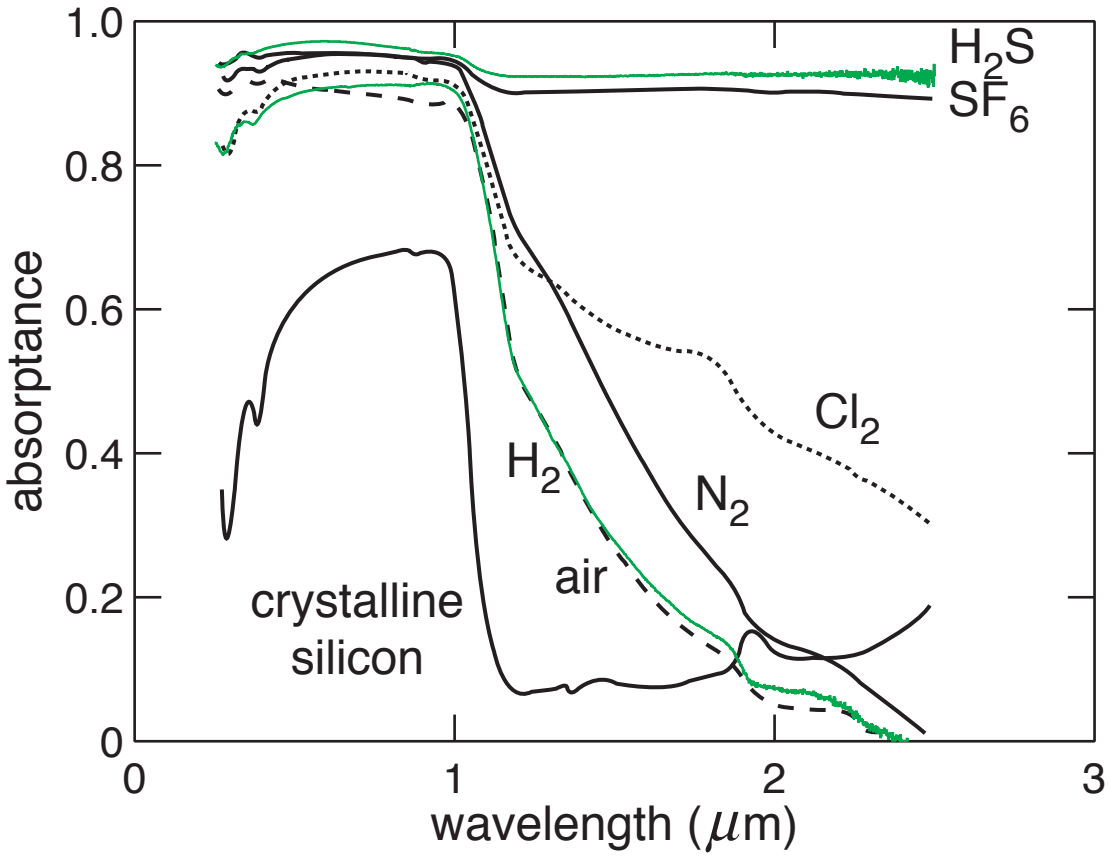
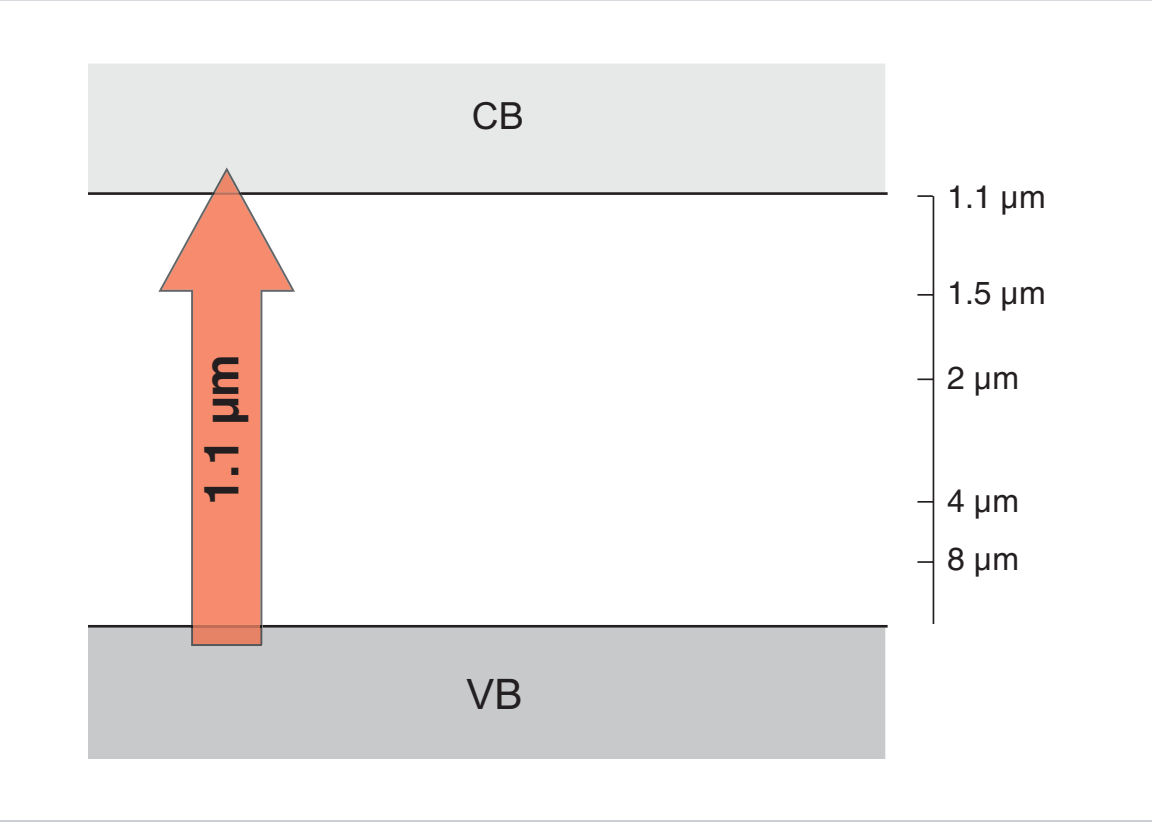


sulfur introduces states in the gap



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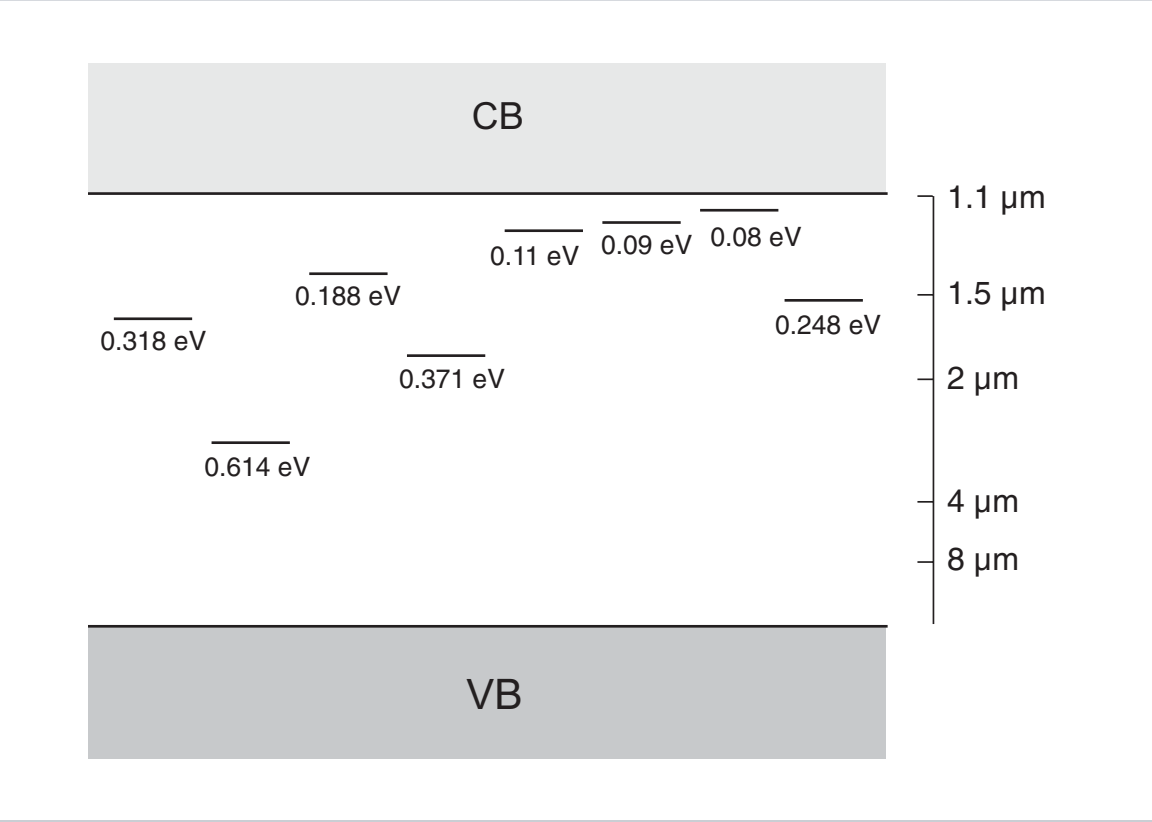
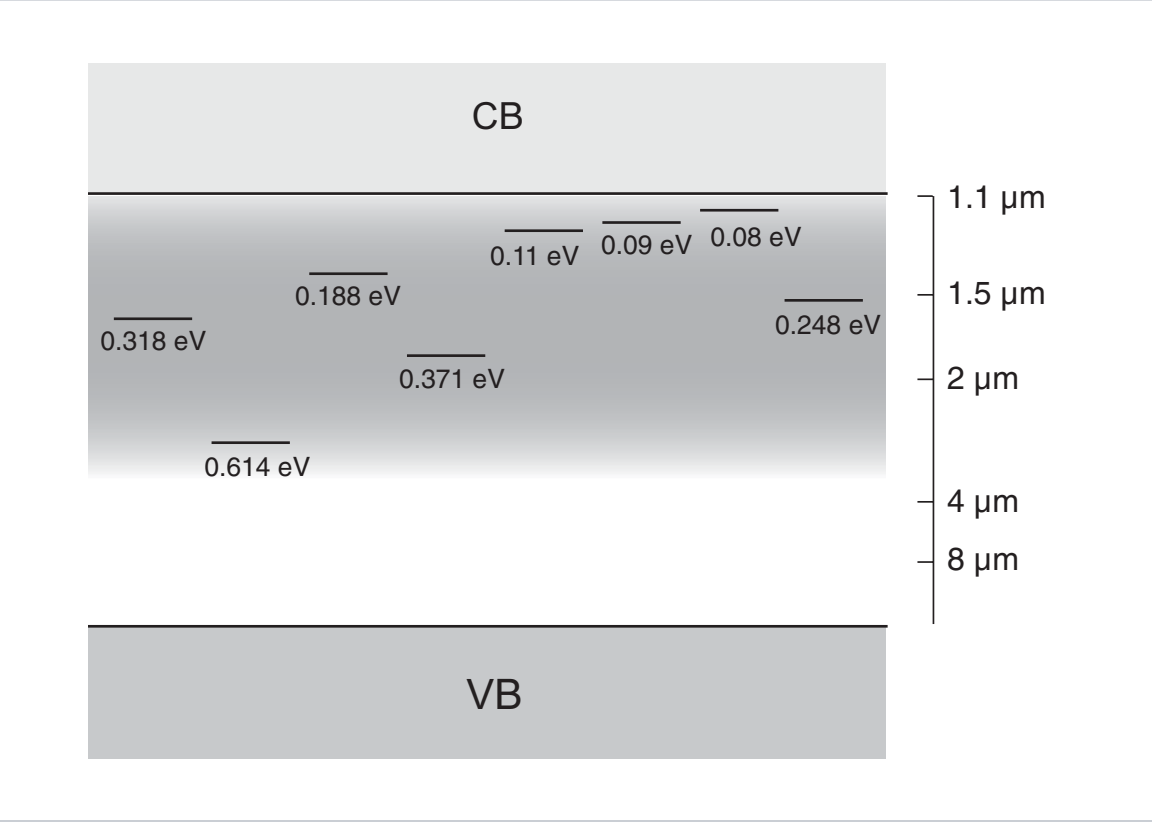
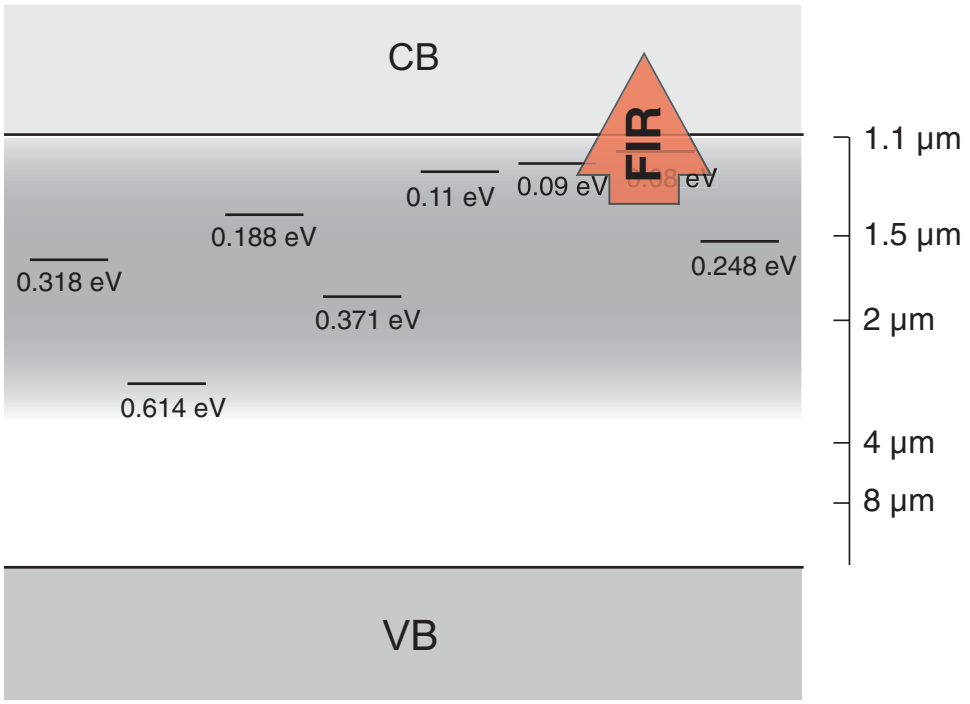


Janzén, *et al.*, *Phys. Rev. B* **29**,1907 (1984)

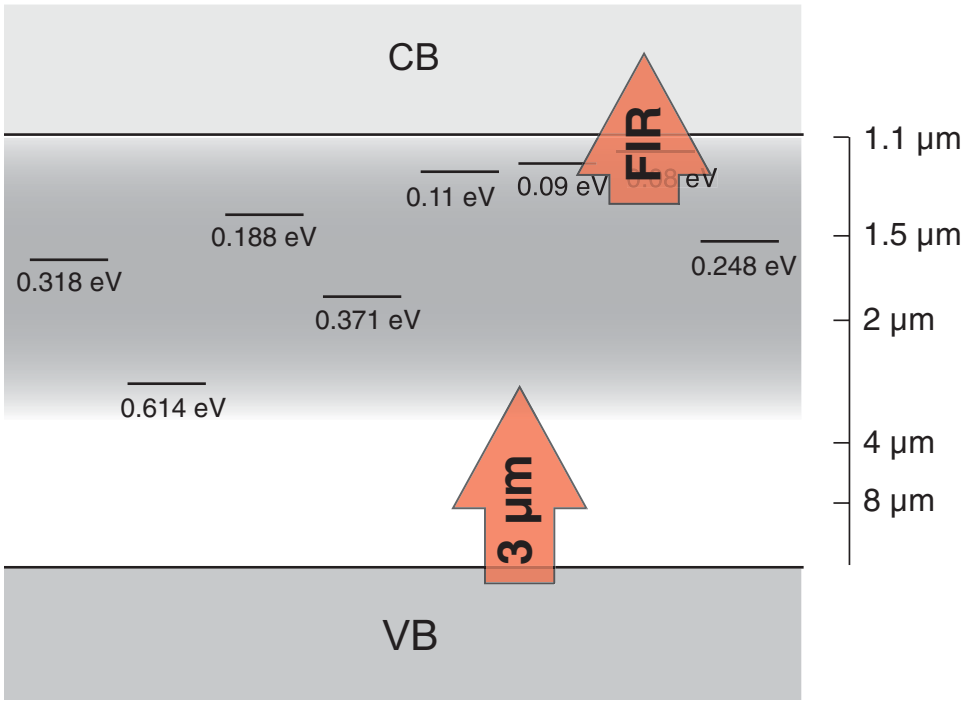
states broaden into a band



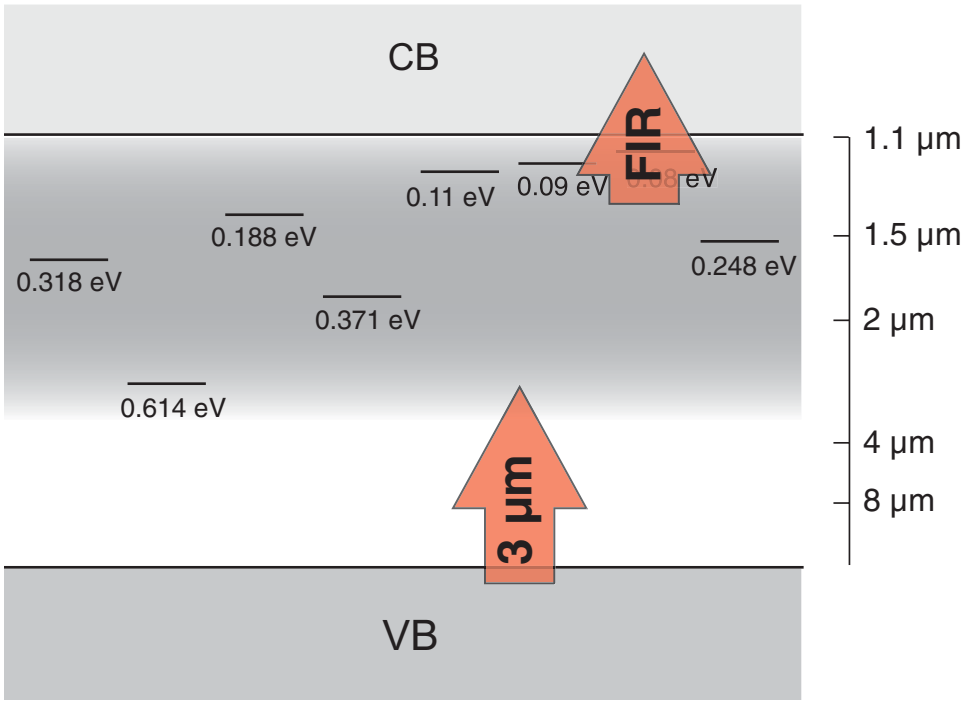
donor: metal-like behavior



acceptor: absorption until 3 µm



acceptor: absorption out to 3 μm

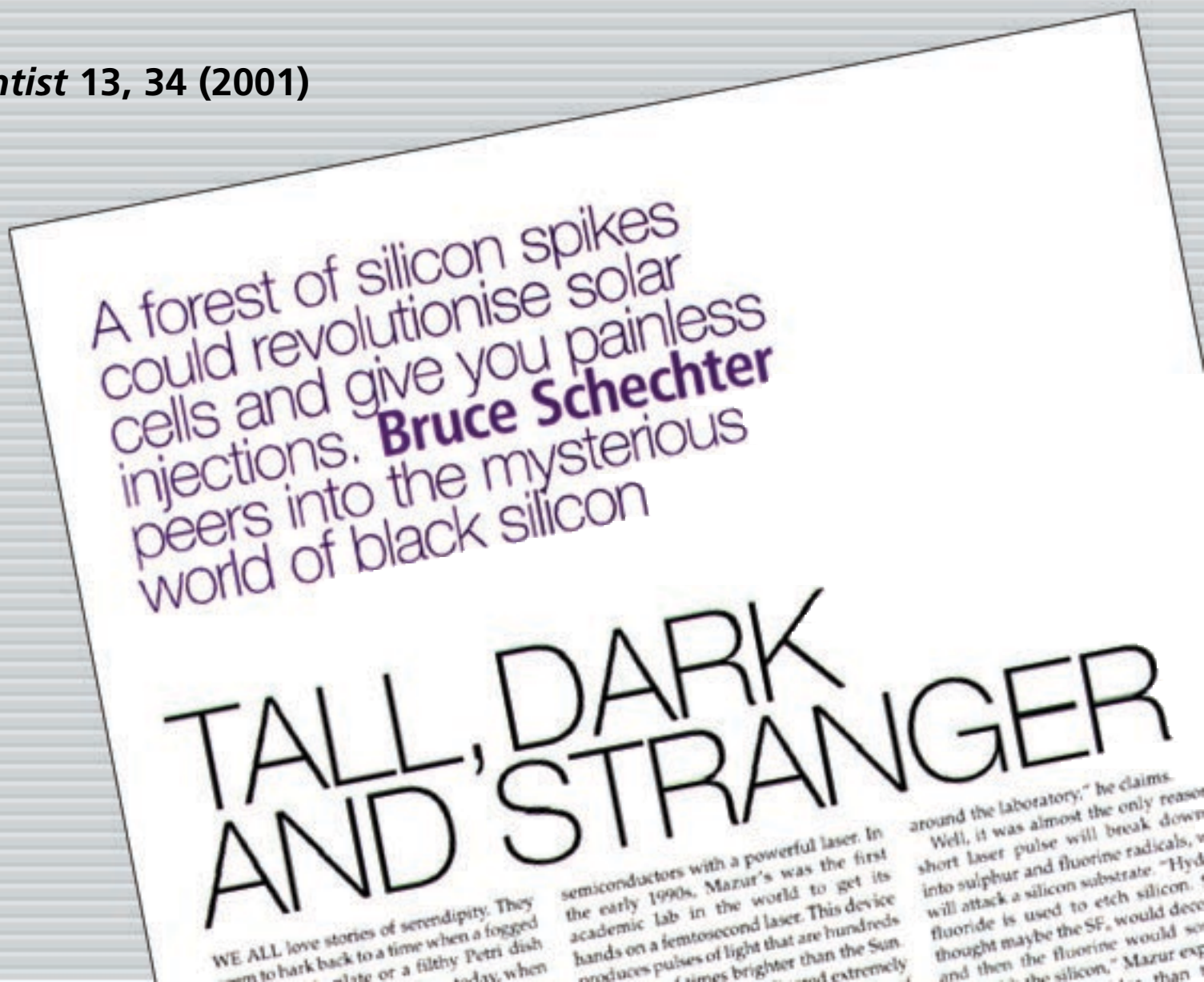


near-IR transmittance rises around 3 μm

Outline

- Properties
- Structural and chemical analysis
- **Outlook**

New Scientist 13, 34 (2001)



A forest of silicon spikes could revolutionise solar cells and give you painless injections. **Bruce Schechter** peers into the mysterious world of black silicon

TALL, DARK AND STRANGER

WE ALL love stories of serendipity. They seem to hark back to a time when a fogged photographic plate or a filthy Petri dish

semiconductors with a powerful laser. In the early 1990s, Mazur's was the first academic lab in the world to get its hands on a femtosecond laser. This device produces pulses of light that are hundreds

around the laboratory," he claims.

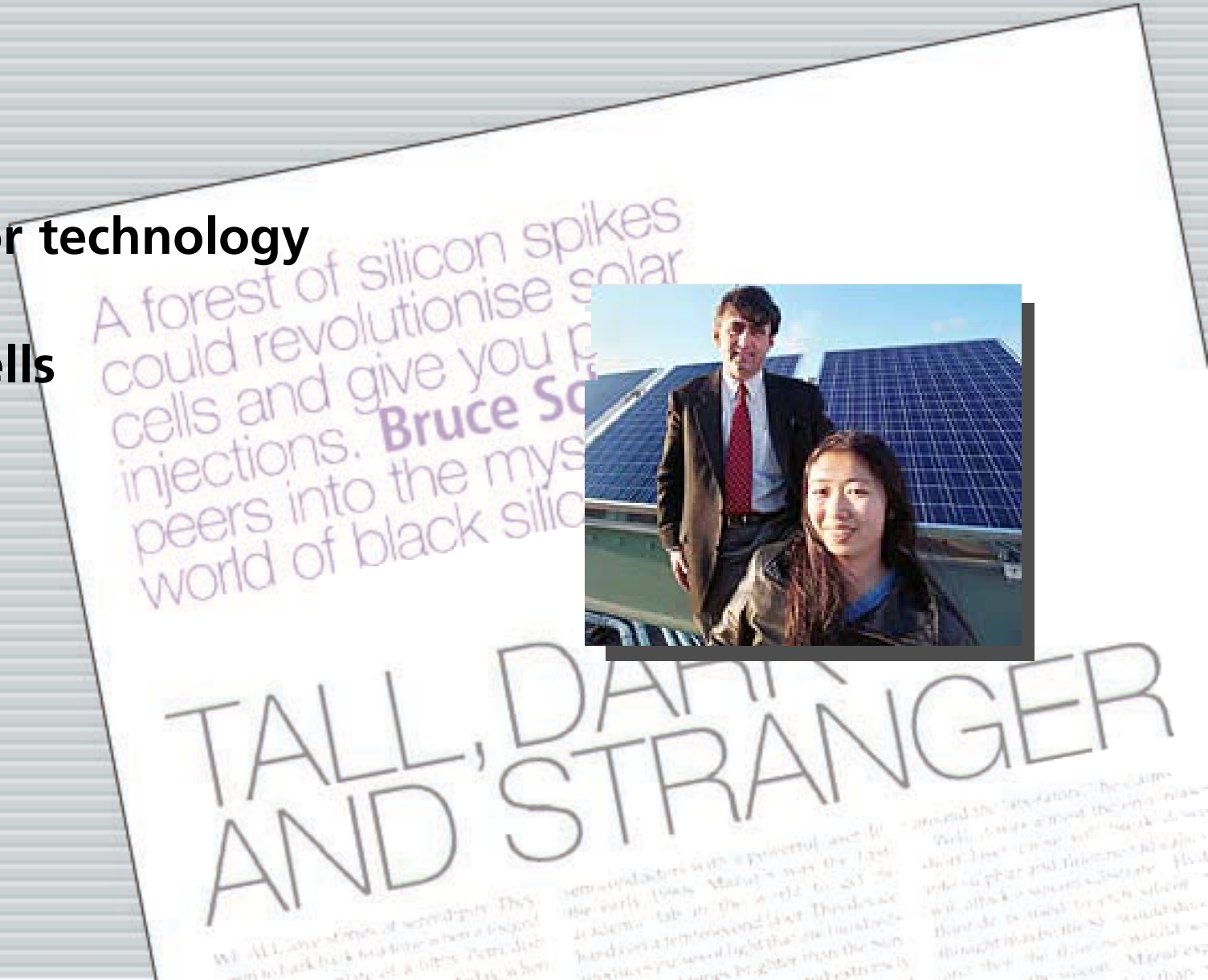
Well, it was almost the only reason short laser pulse will break down into sulphur and fluorine radicals, which will attack a silicon substrate. "Hydrofluoride is used to etch silicon. thought maybe the SF_6 would decompose and then the fluorine would react with the silicon," Mazur explains, than

Outlook

- **detector technology**

Outlook

- **detector technology**
- **solar cells**

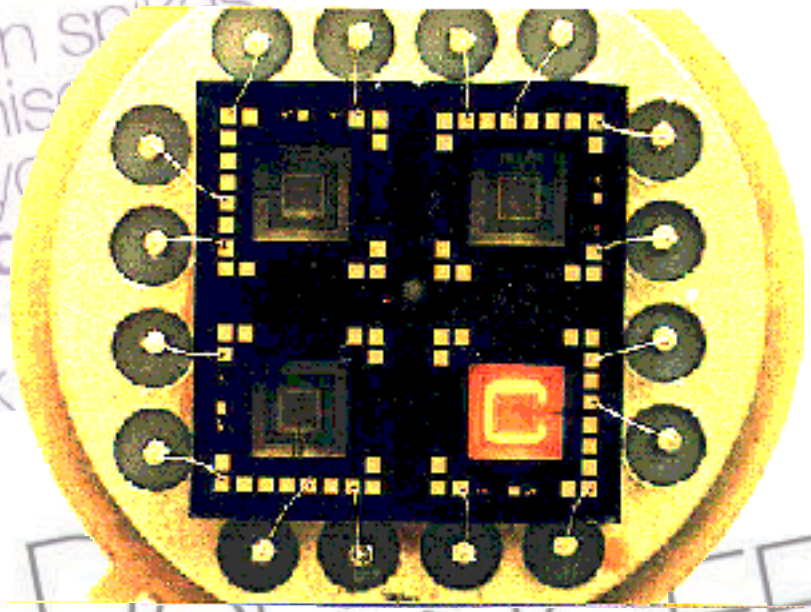


Outlook

- detector technology
- solar cells
- display technology

Outlook

- detector technology
- solar cells
- display technology
- sensors



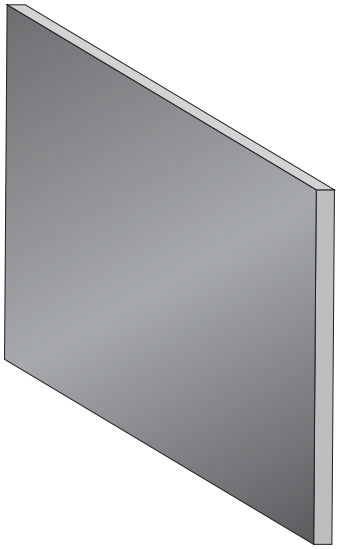
Outlook

- development of spikes
- spike formation through grids
- cell adhesion
- functionalization

Outlook

can ordering of spikes be improved by using a grid?

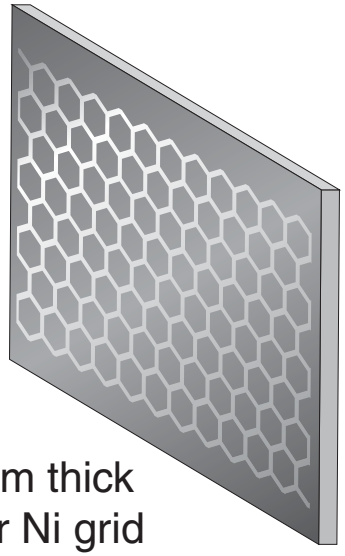
Outlook



Si or Ti substrate

Outlook

place grid in front of substrate

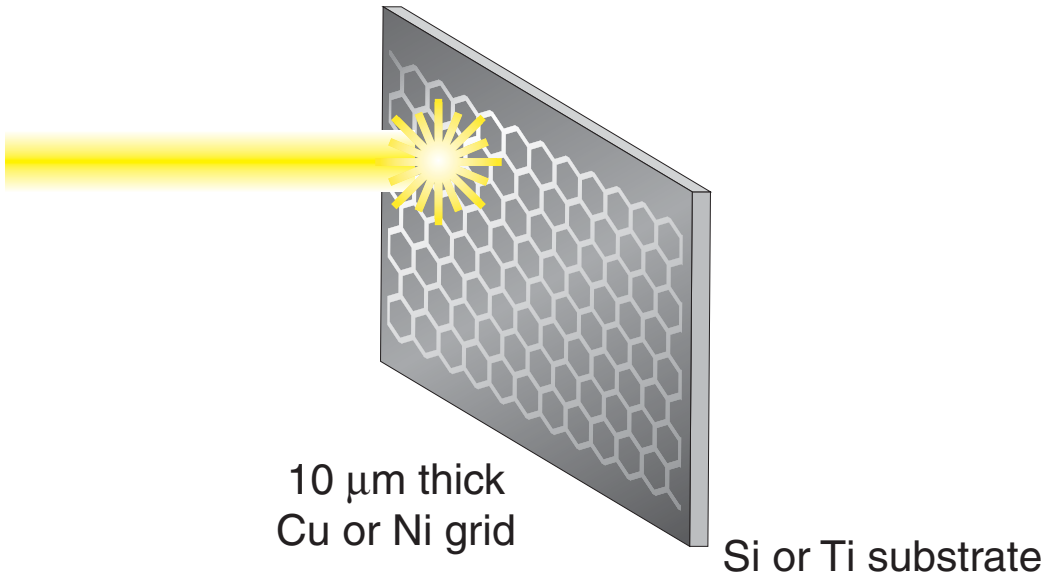


10 μm thick
Cu or Ni grid

Si or Ti substrate

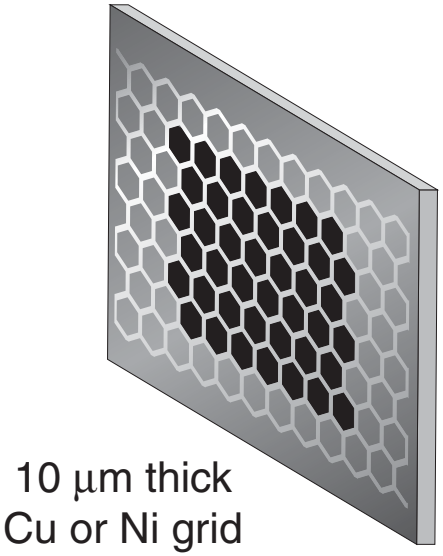
Outlook

scan laser beam



Outlook

scan laser beam

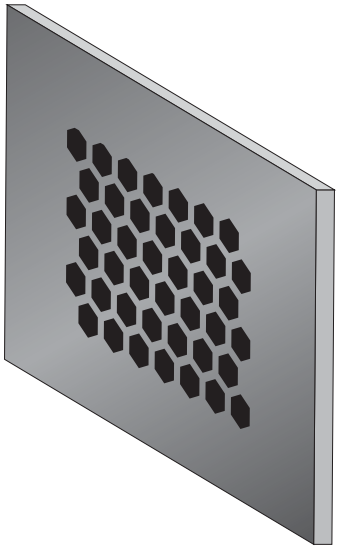


10 μm thick
Cu or Ni grid

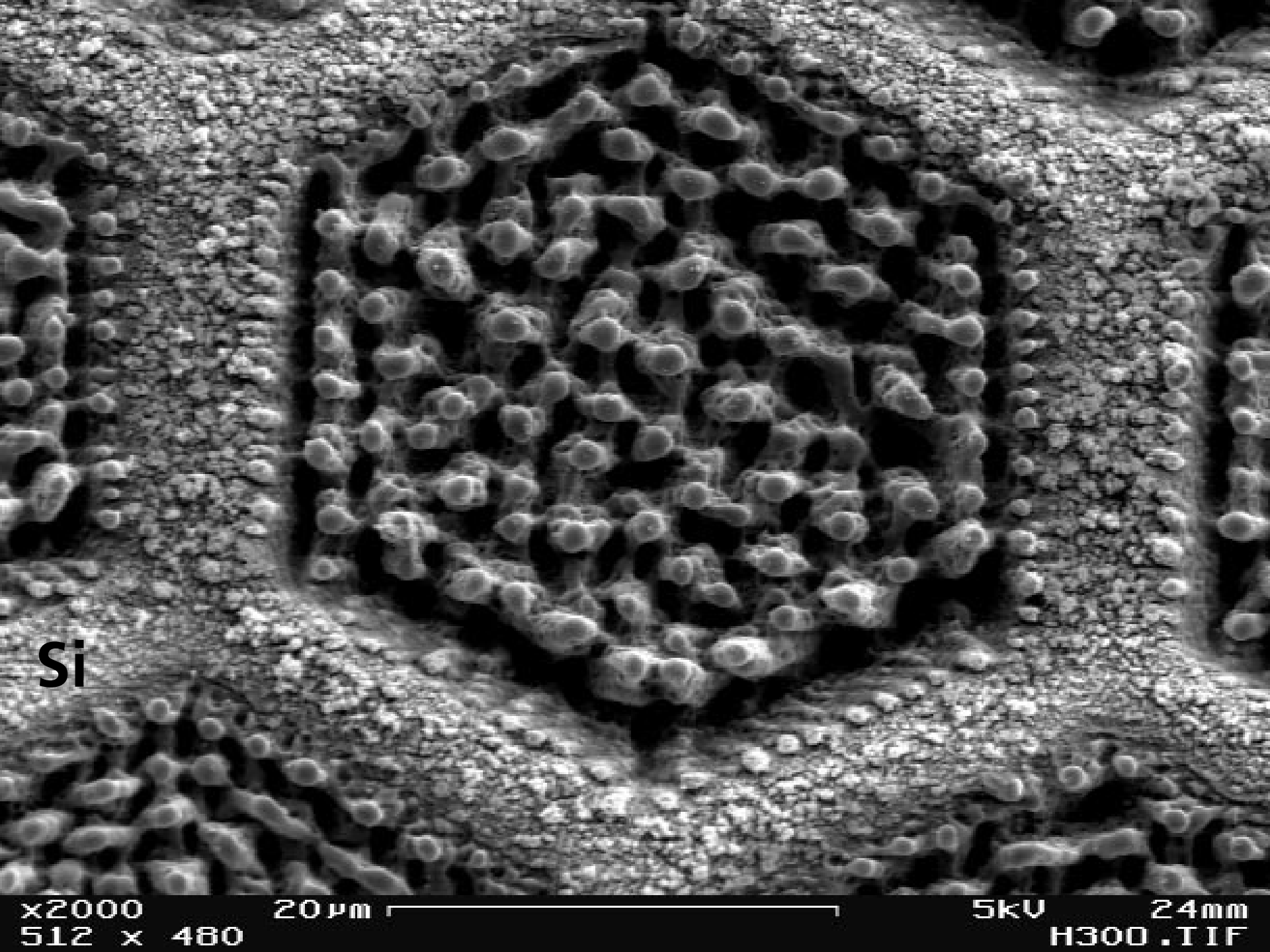
Si or Ti substrate

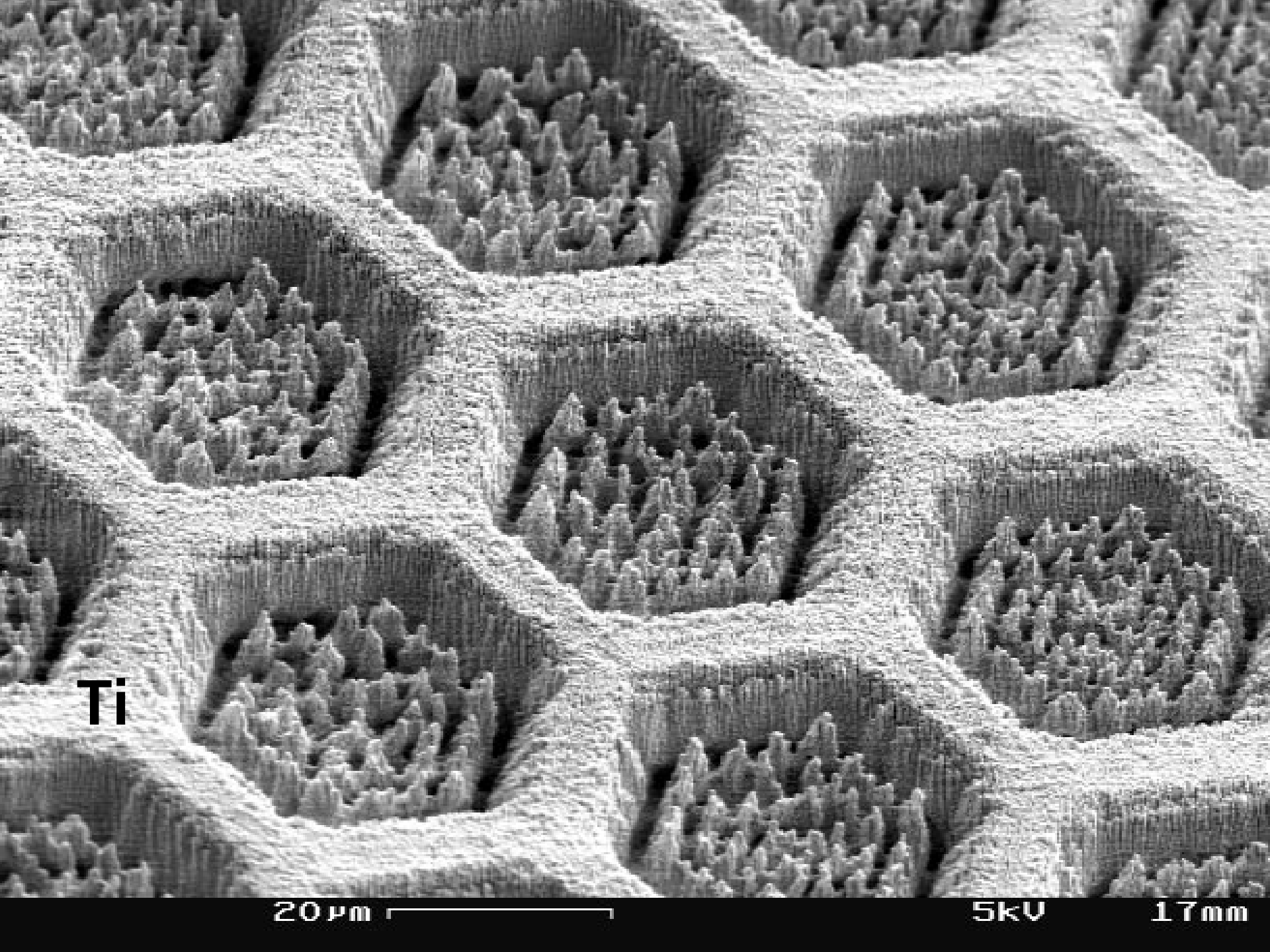
Outlook

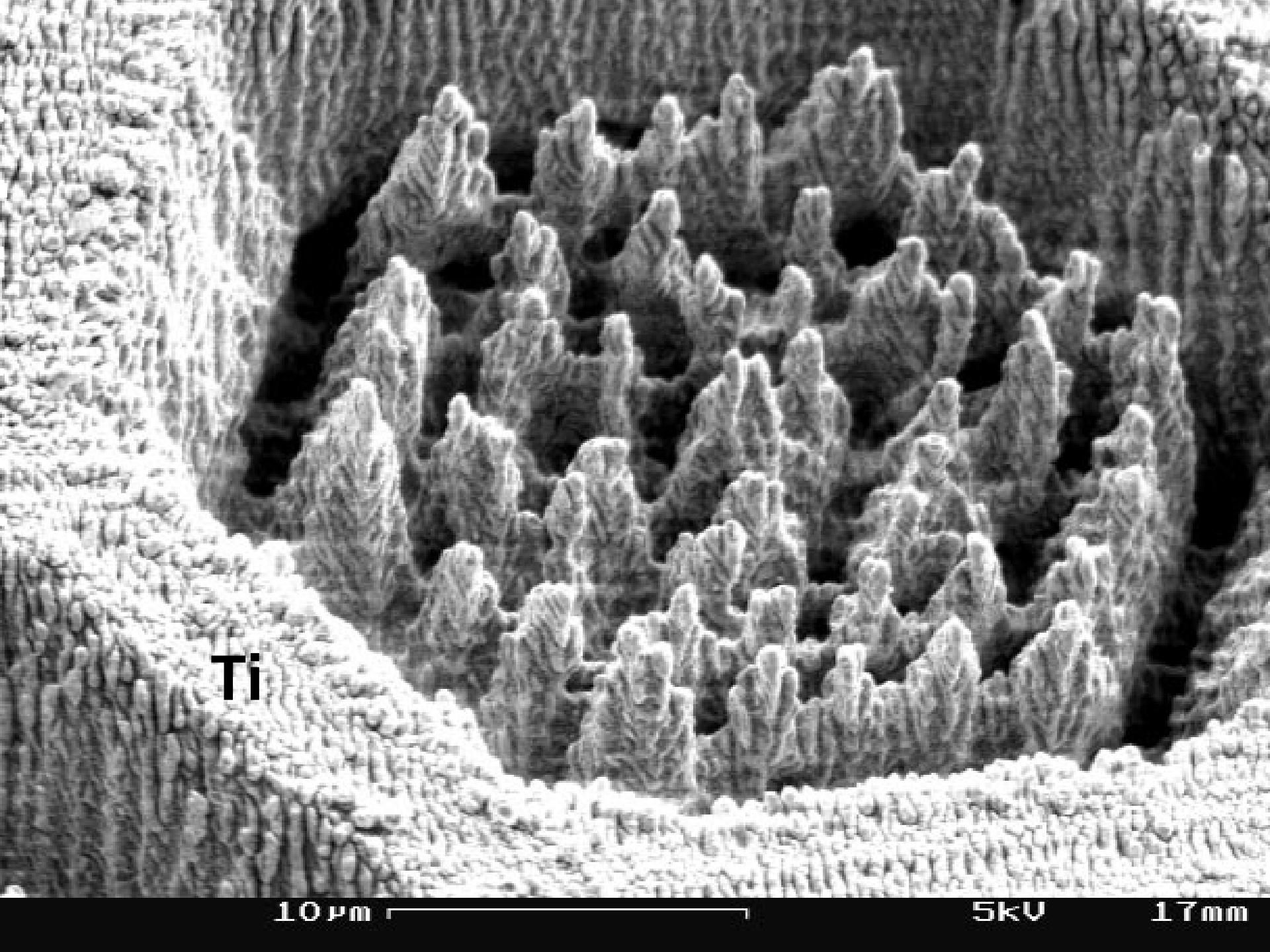
remove grid



Si or Ti substrate


Si
x2000 20µm 5kV 24mm
512 x 480 H300.TIF


Ti
20µm
5kV
17mm


Ti
10µm
5kV
17mm

Outlook

Summary

Microstructured silicon

- **fabricated by simple, maskless process**

Summary

Microstructured silicon

- **fabricated by simple, maskless process**
- **can be integrated with microelectronics**


GORDON McKAY
LABORATORY OF
APPLIED SCIENCE

Funding: ARO, DoE, NDSEG

Acknowledgments:

Dr. François Génin (LLNL)
Dr. Arieh Karger (Radiation Monitoring Devices)
Dr. Alf Bjørseth (Scanwafer)
Dr. Tom Mates (UCSB)
Dr. John Chervinsky (Harvard University)
Prof. Mike Aziz (Harvard University)

For a copy of this talk and additional information, see:

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