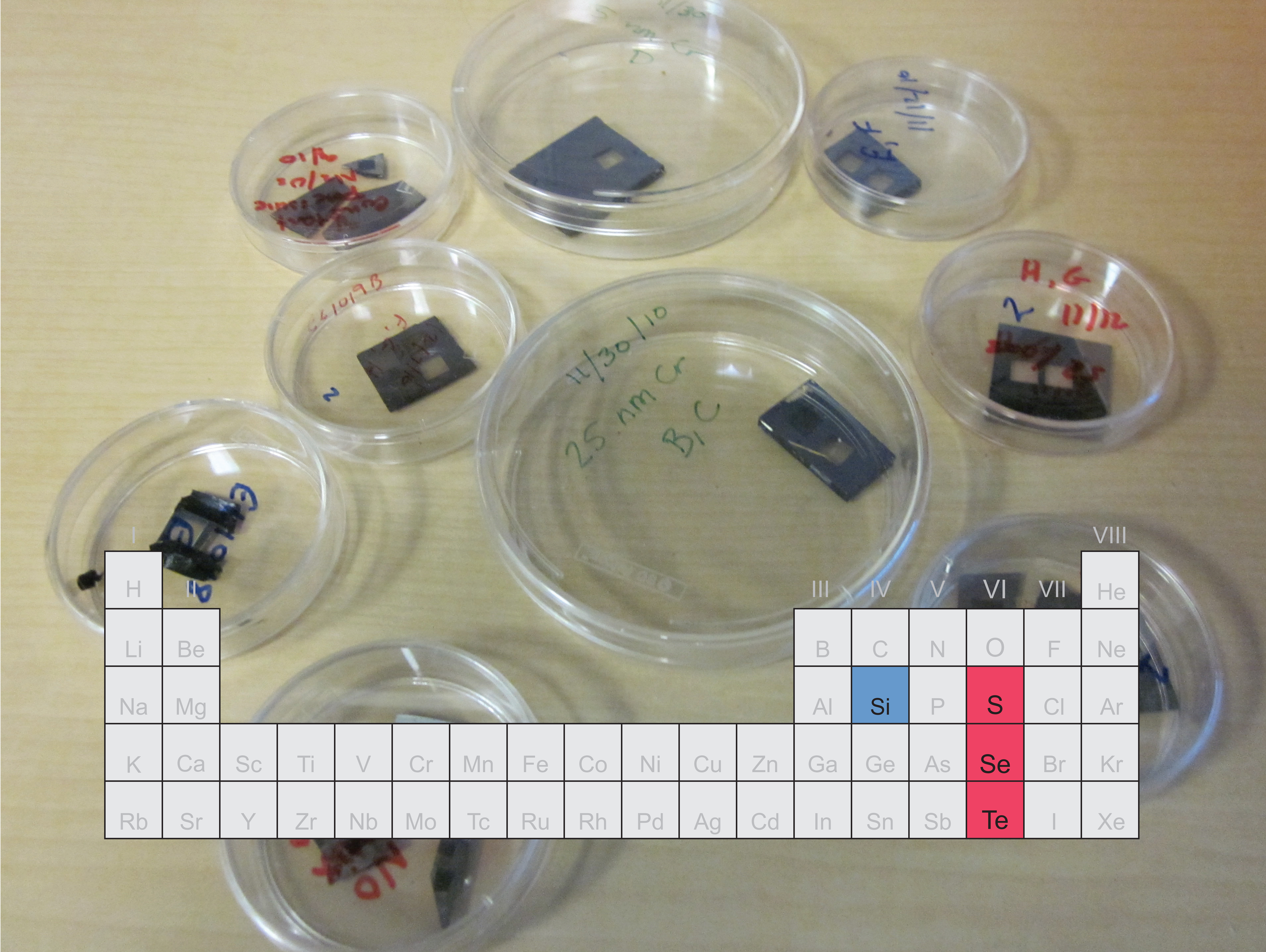
Femtosecond laser processing of titanium

Kasey Phillips
Beth Landis, Cynthia Friend & Eric Mazur
Harvard University

Hyperdoping Research Meetup 2011

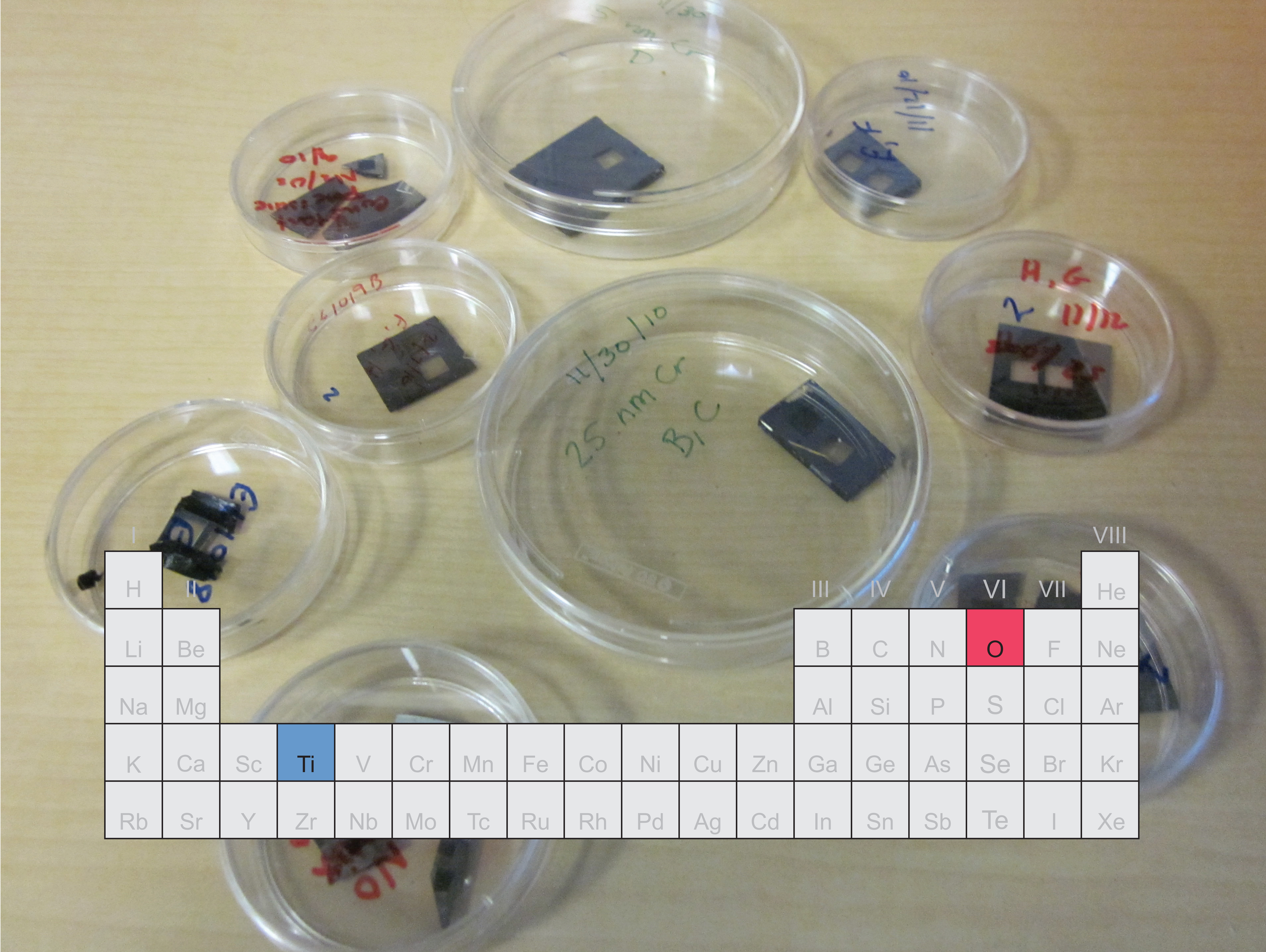


I	II											III	IV	V	VI	VII	VIII
H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe

You can dope anything
with anything.

You can dope almost anything
with almost anything.

Chemical selectivity matters



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Why TiO_2?

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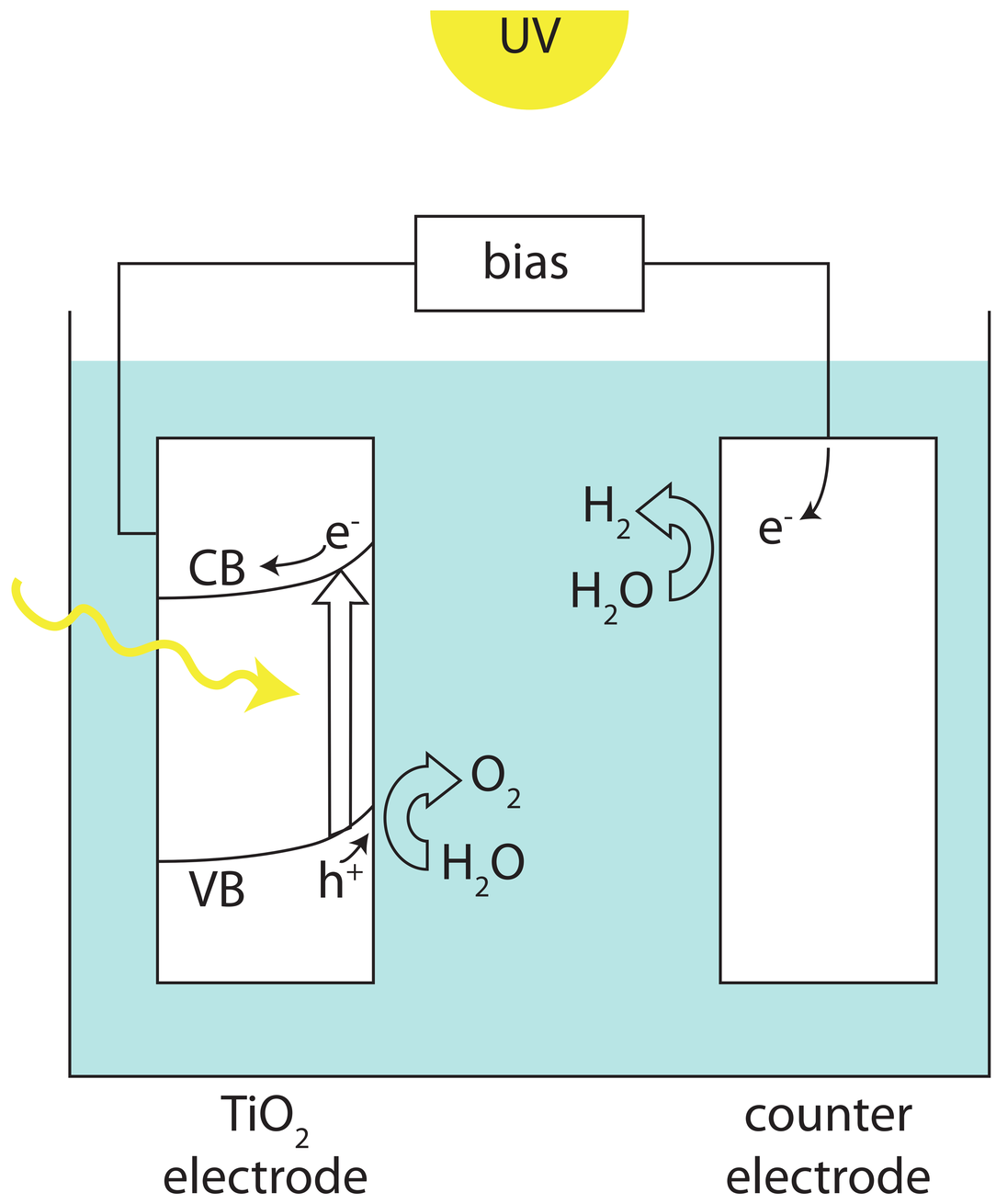
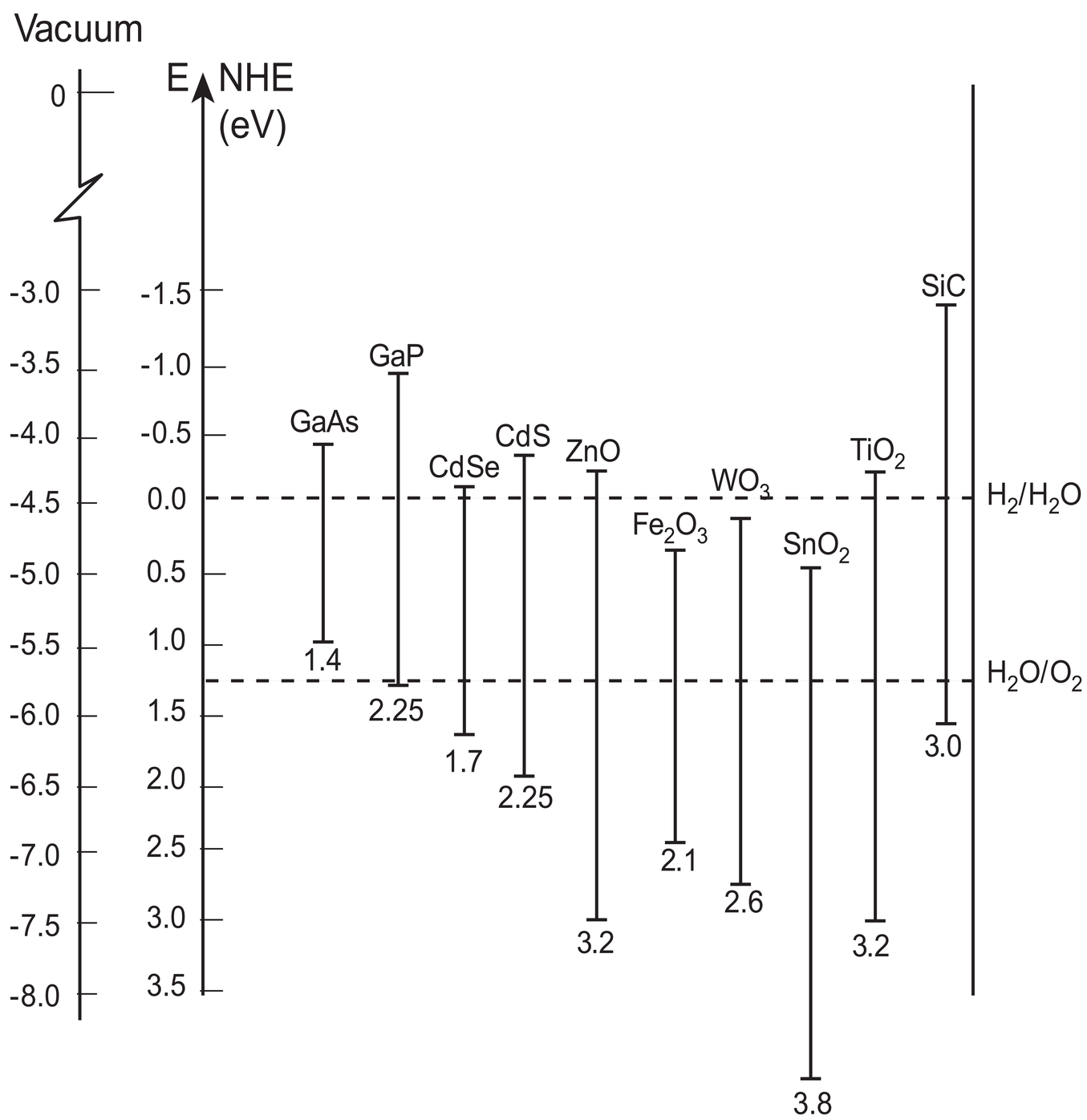


Graetzel, M. Nature (2001)

Why TiO_2?



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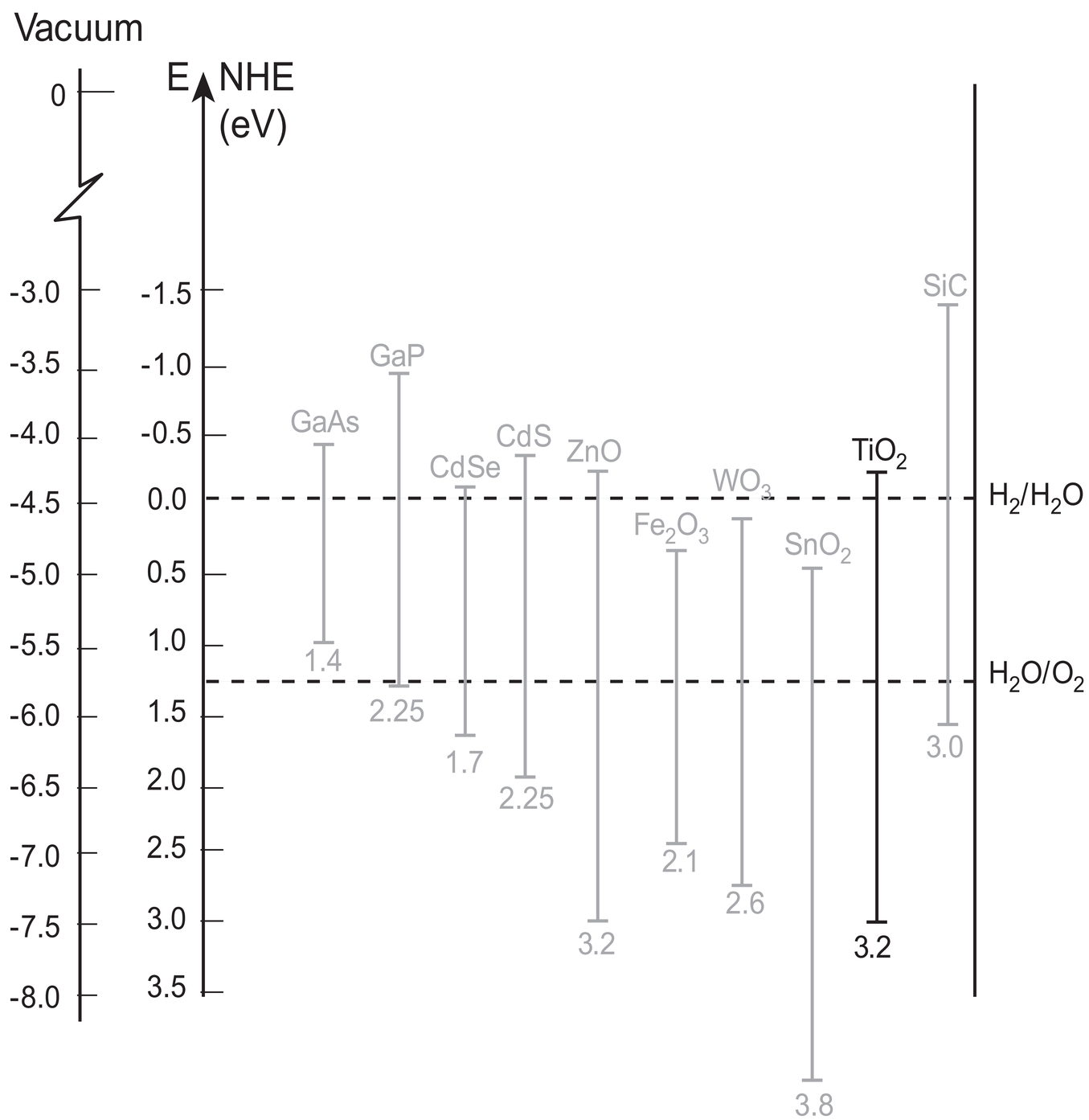

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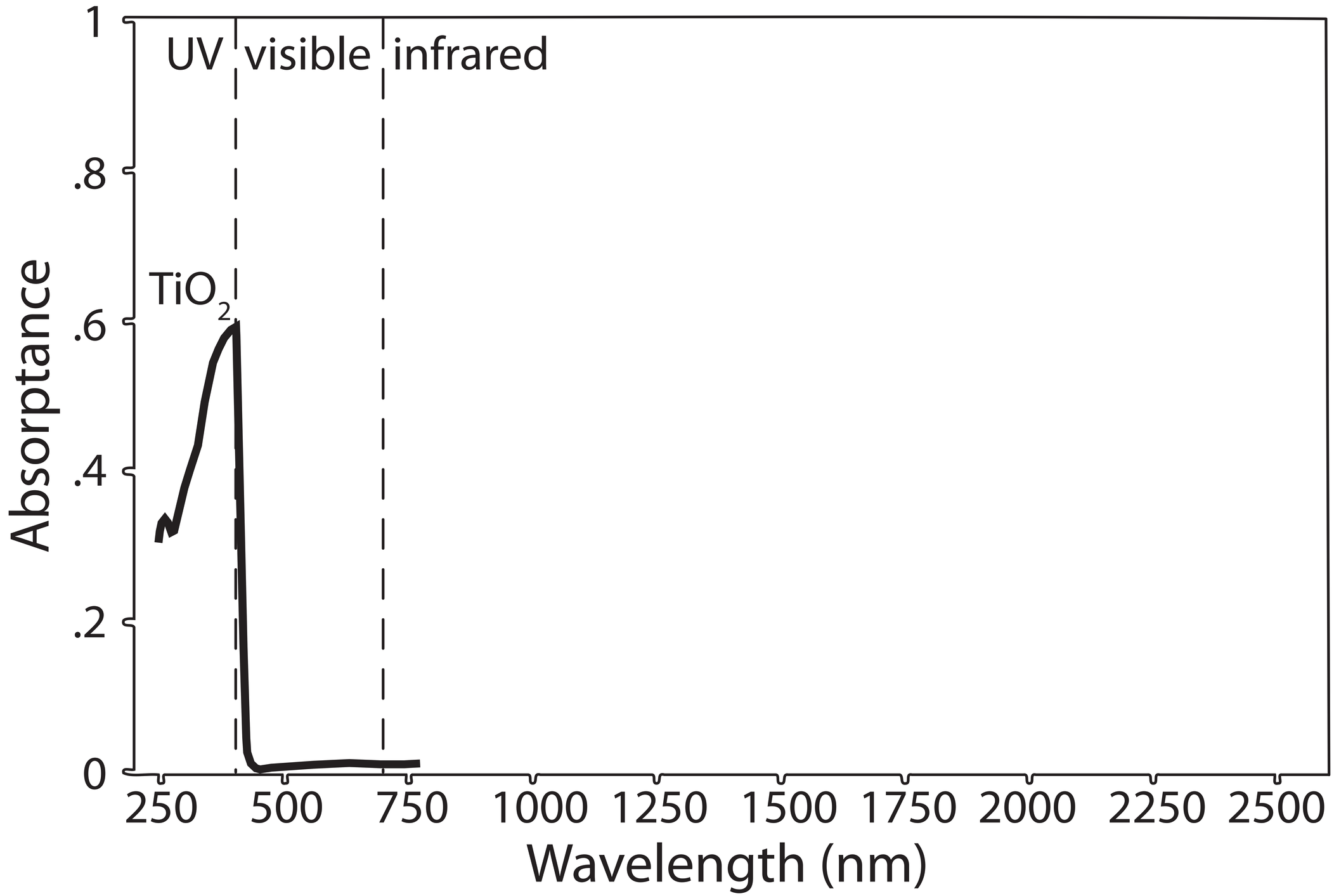
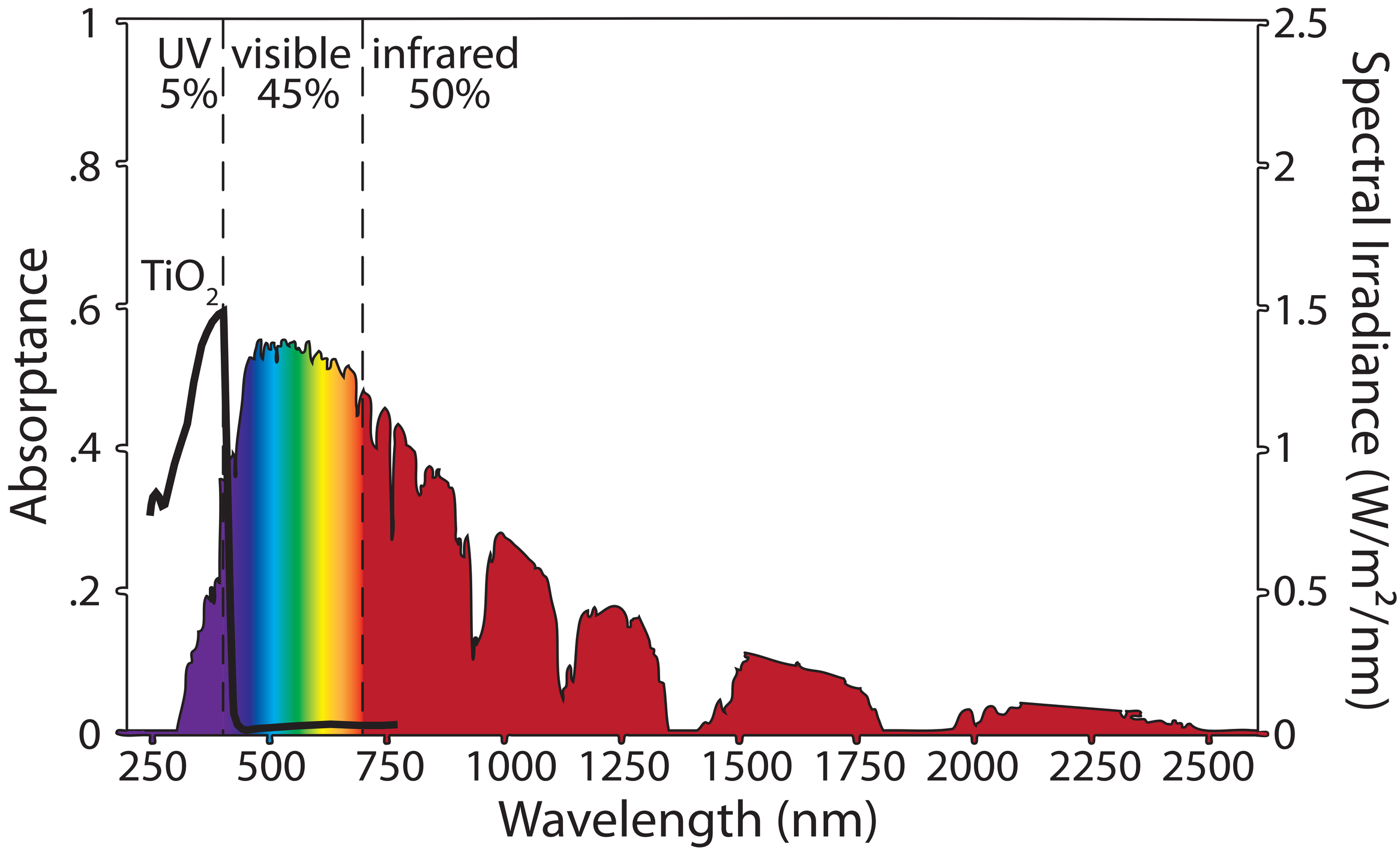


http://bouman.chem.georgetown.edu/S02/lect23/lect23green.html

Why TiO_2?



http://bouman.chem.georgetown.edu/S02/lect23/lect23green.html

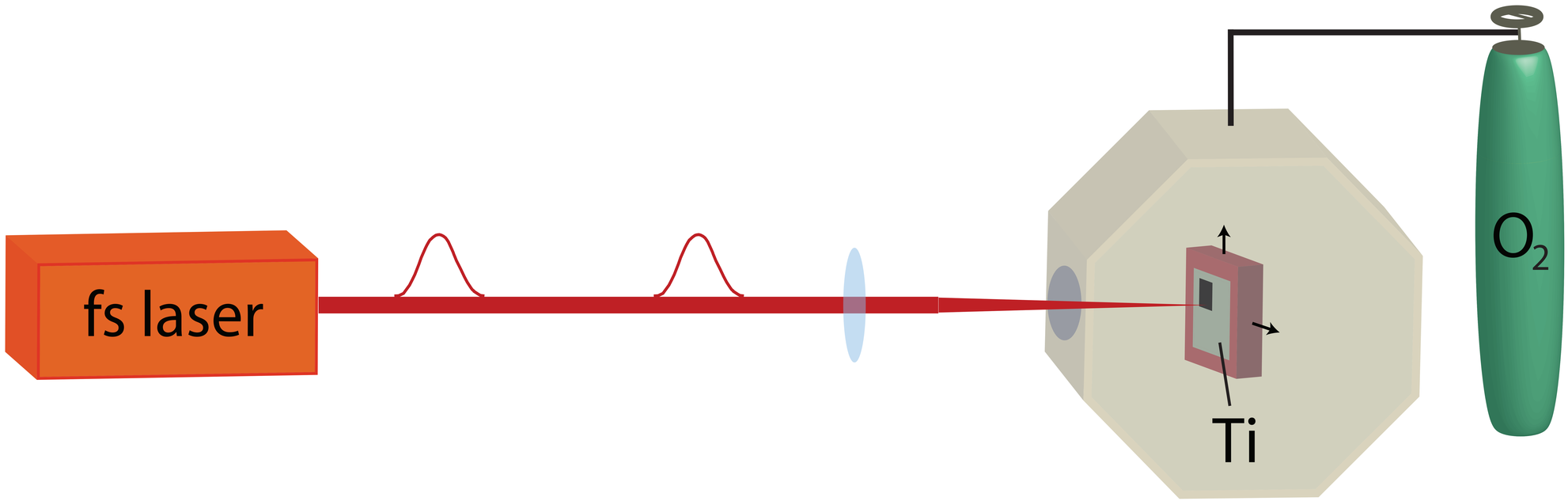
Research Aims

Produce structured TiO_2 surfaces using femtosecond laser processing

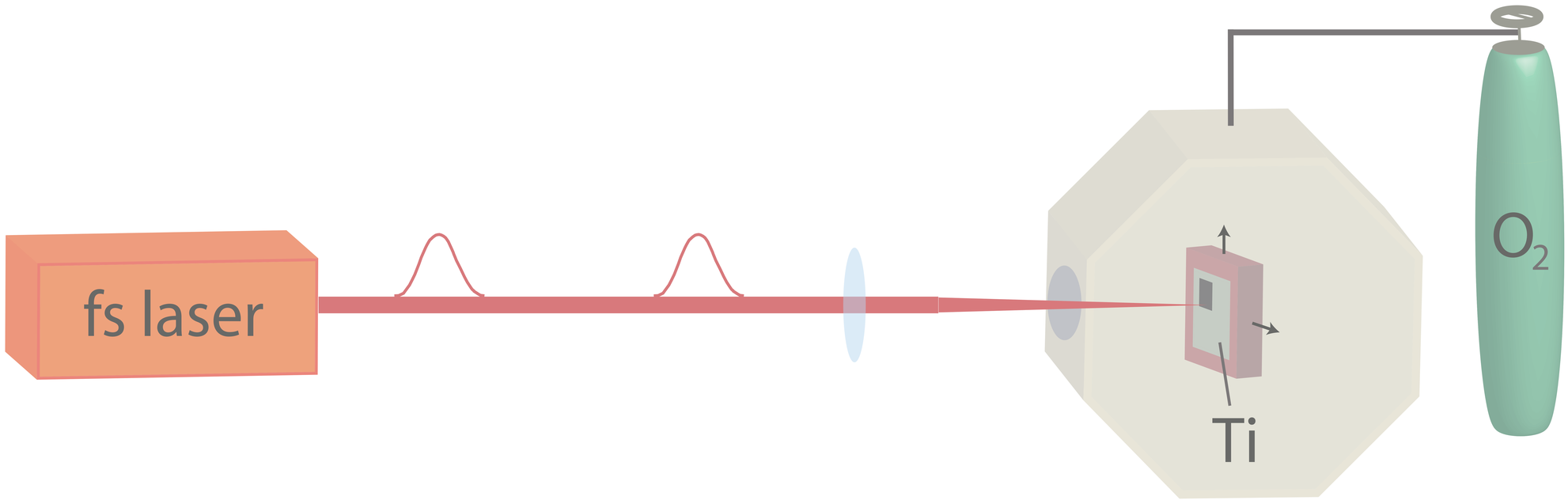
Dope TiO_2 with nitrogen and chromium

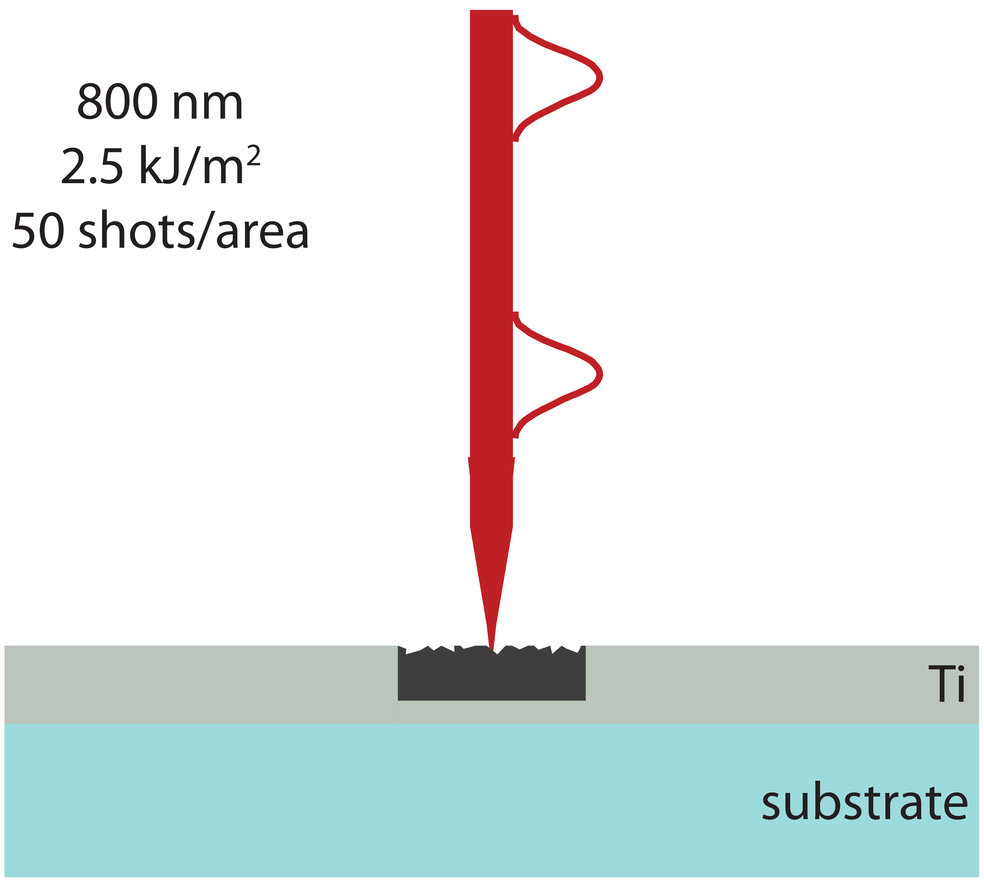
Improve photocatalysis of water at doped TiO_2 electrodes

Production of TiO_2



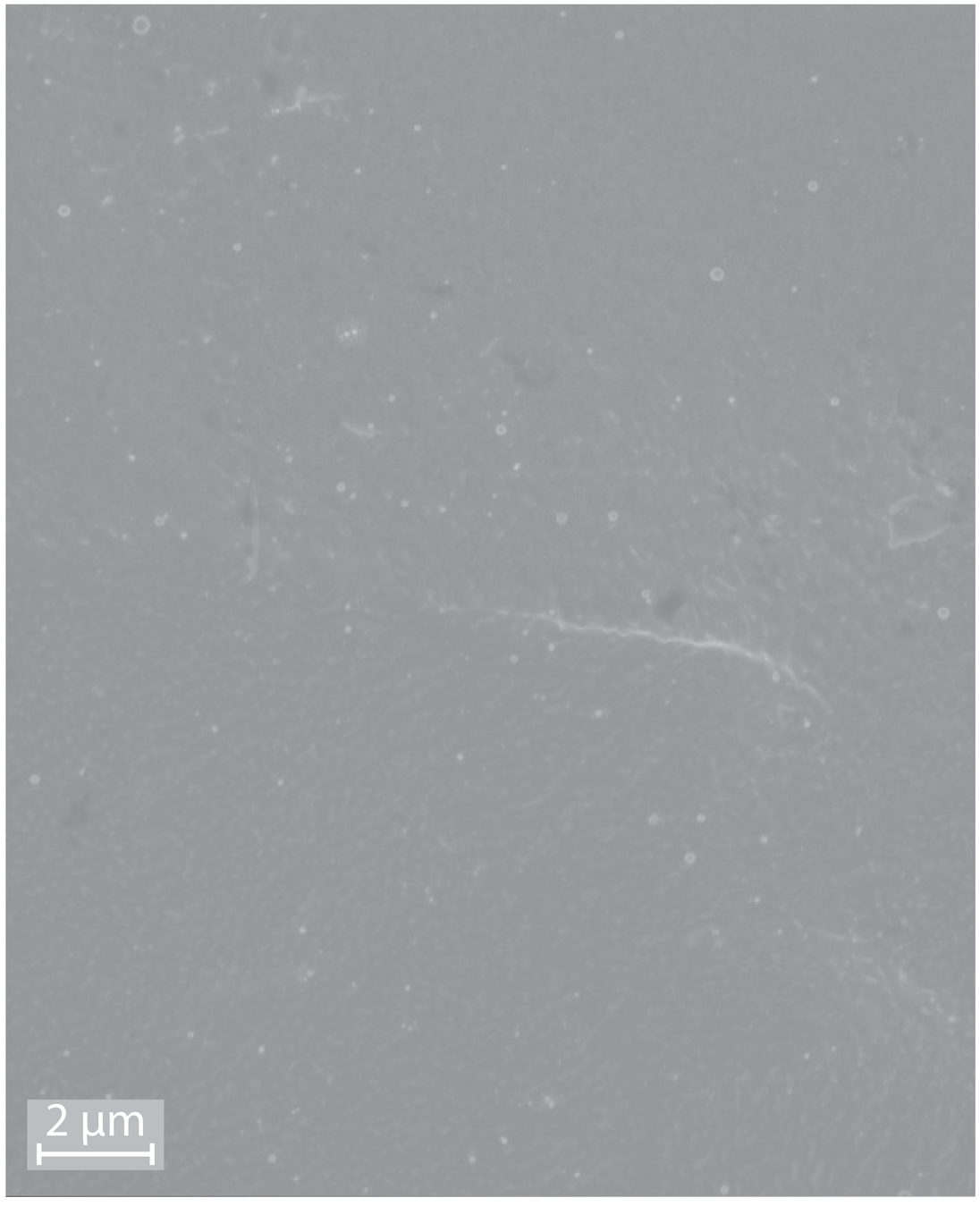
Production of TiO_2



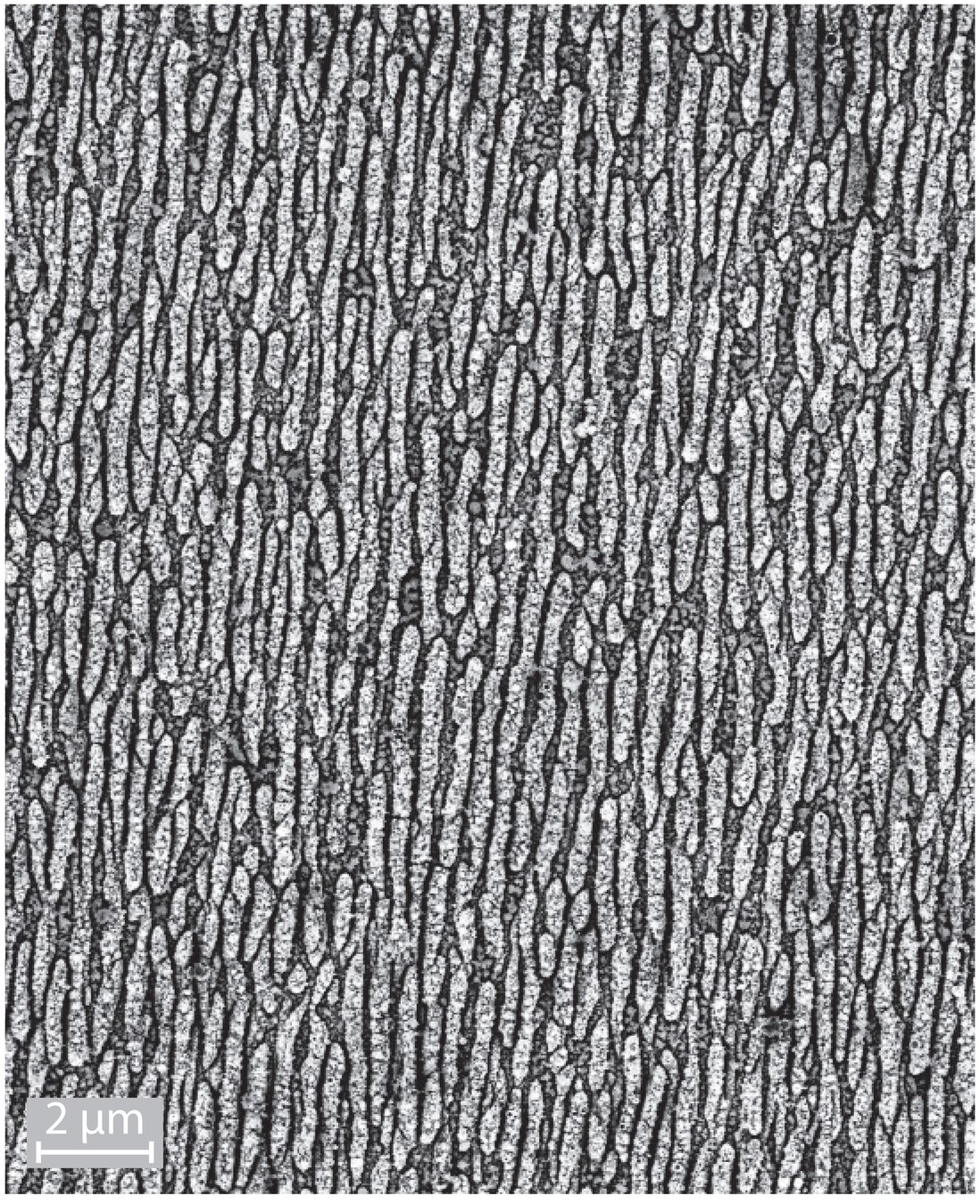


Production of TiO_2

microstructures



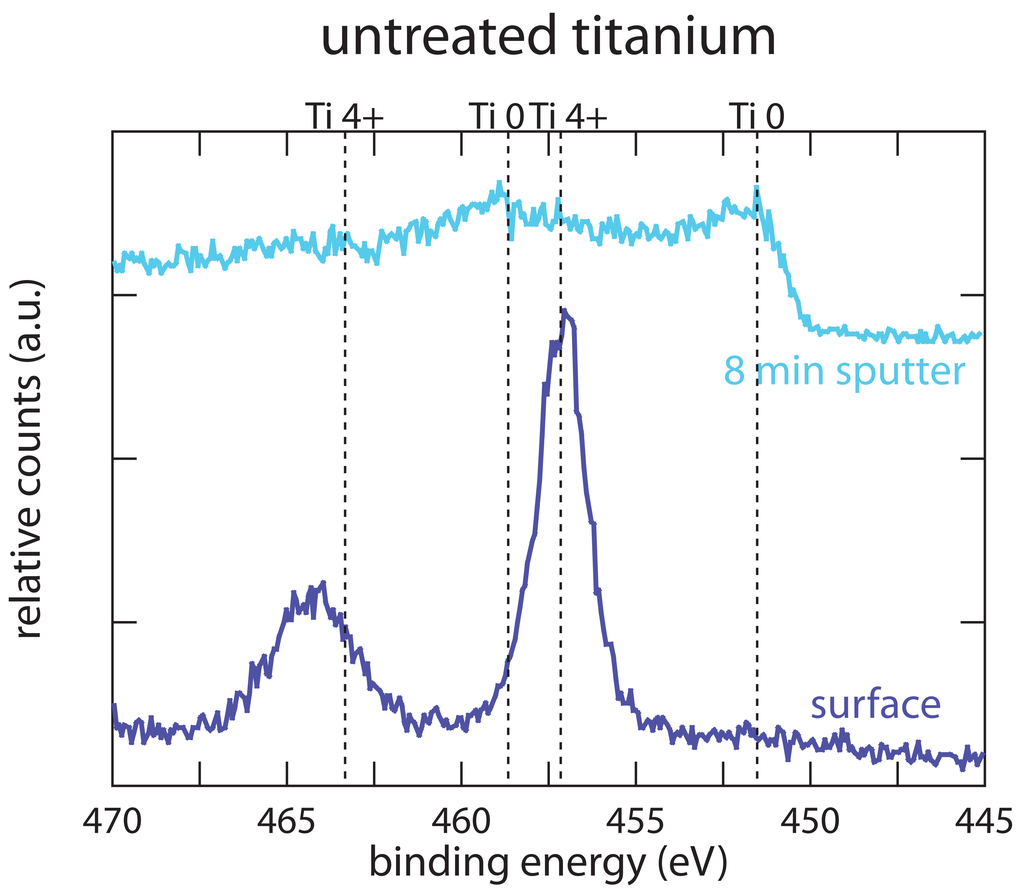
untreated titanium

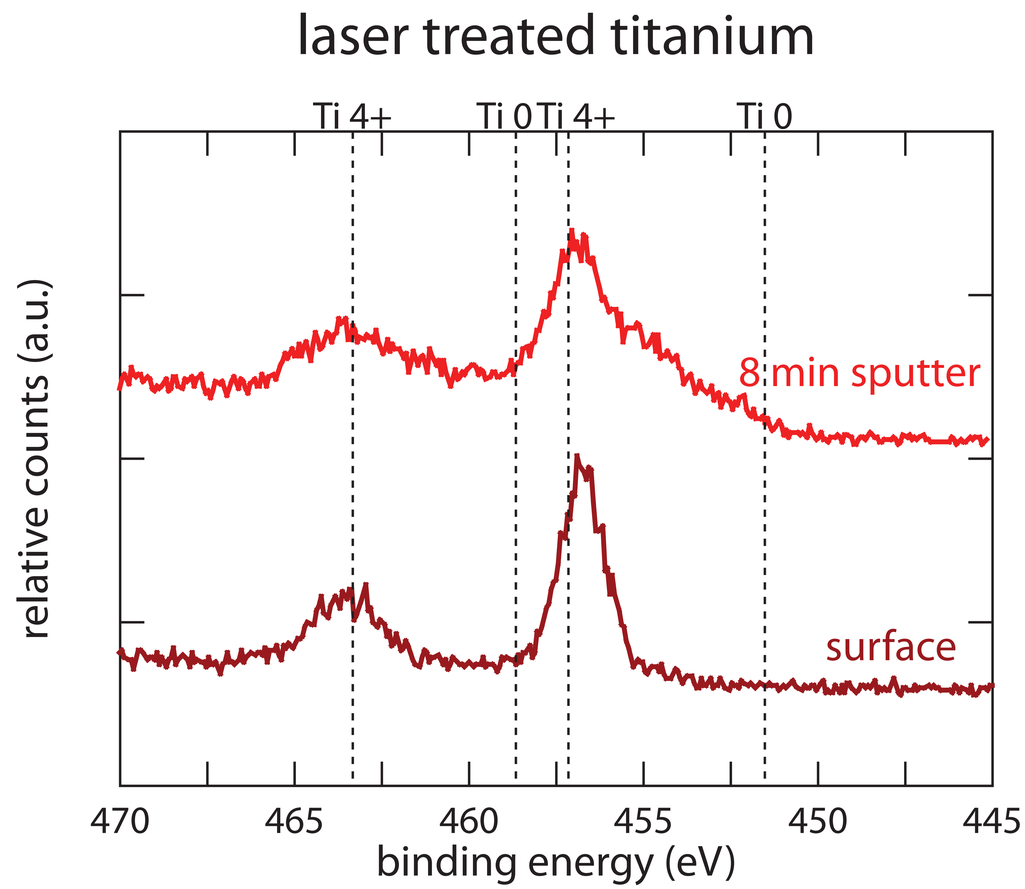


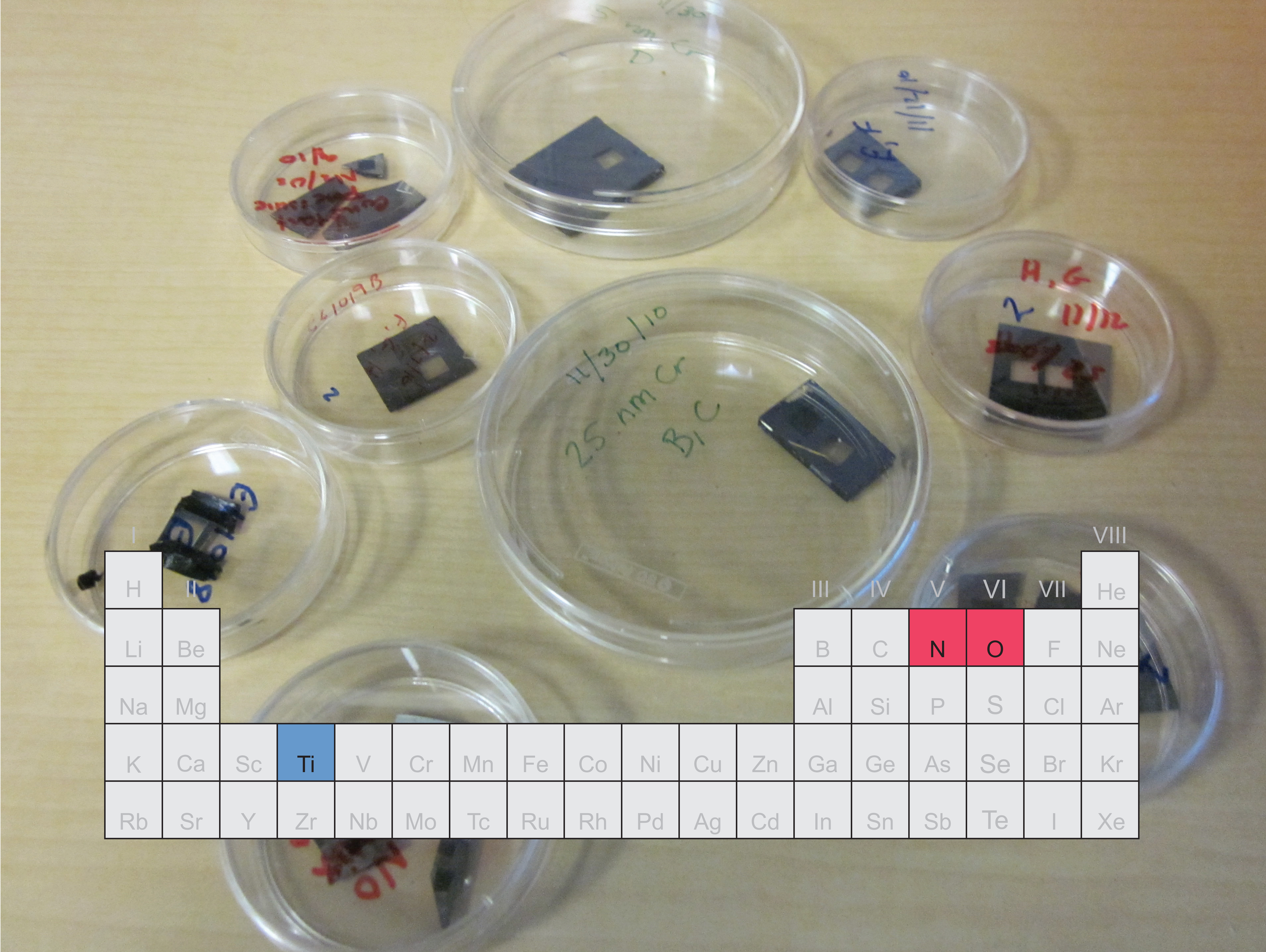
laser treated titanium

Production of TiO_2

structural data: XPS







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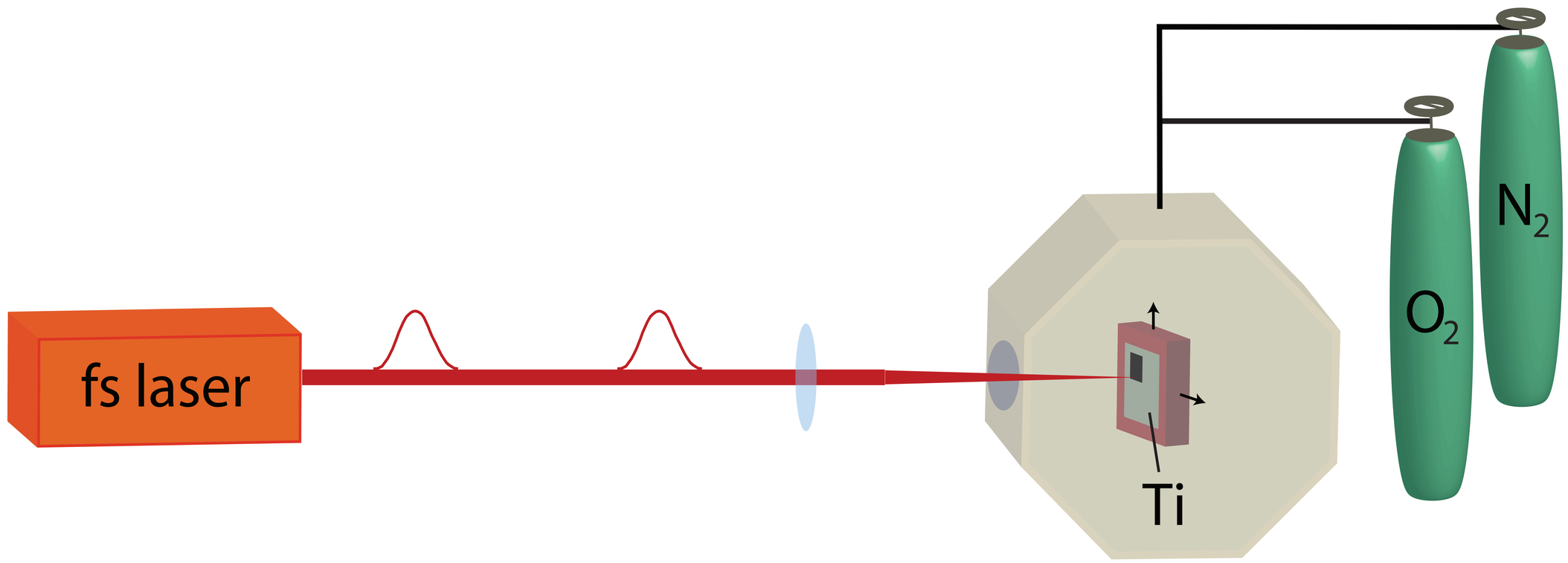
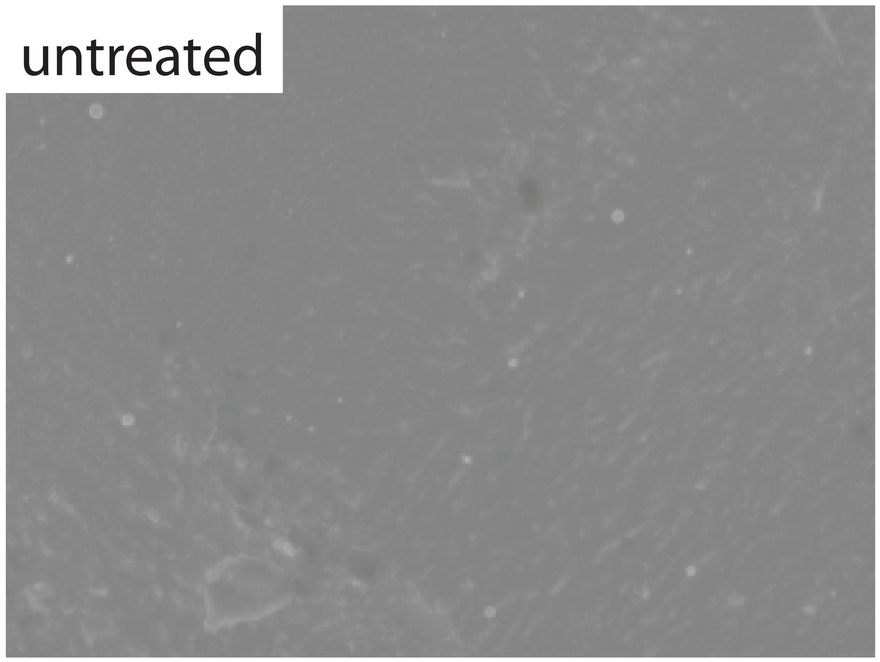
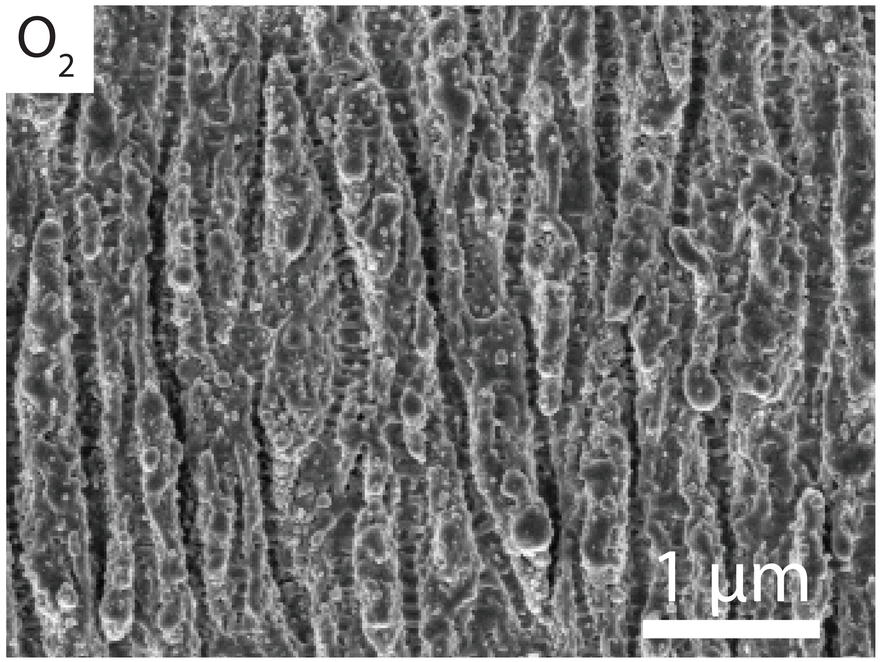
Chemical Selectivity

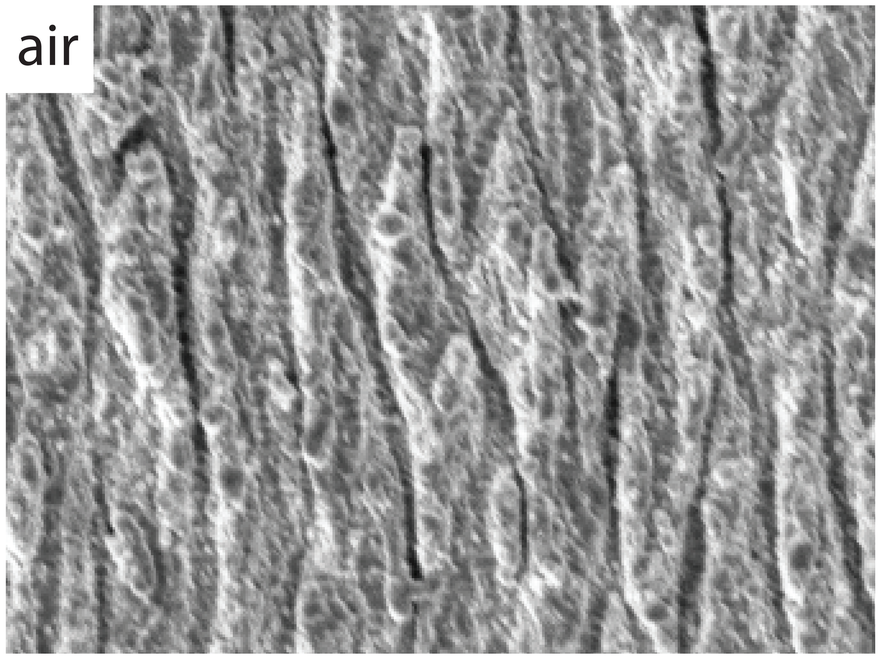


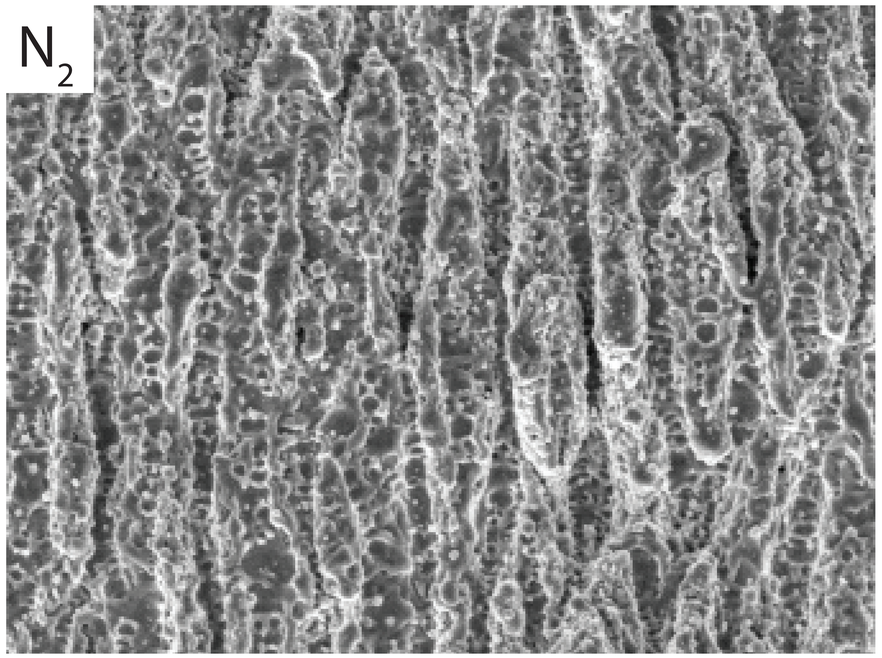
Chemical Selectivity

microstructures









Chemical Selectivity

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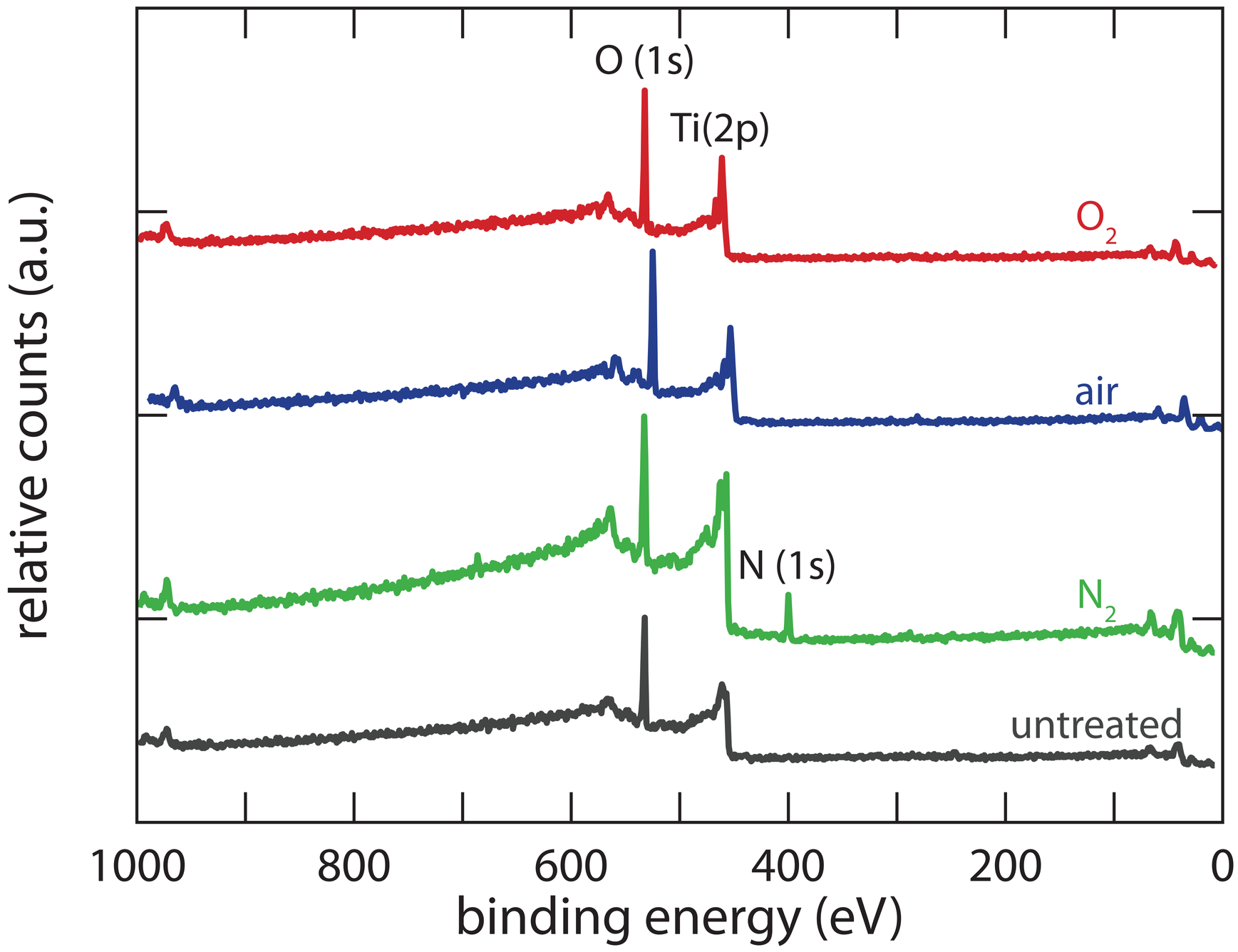

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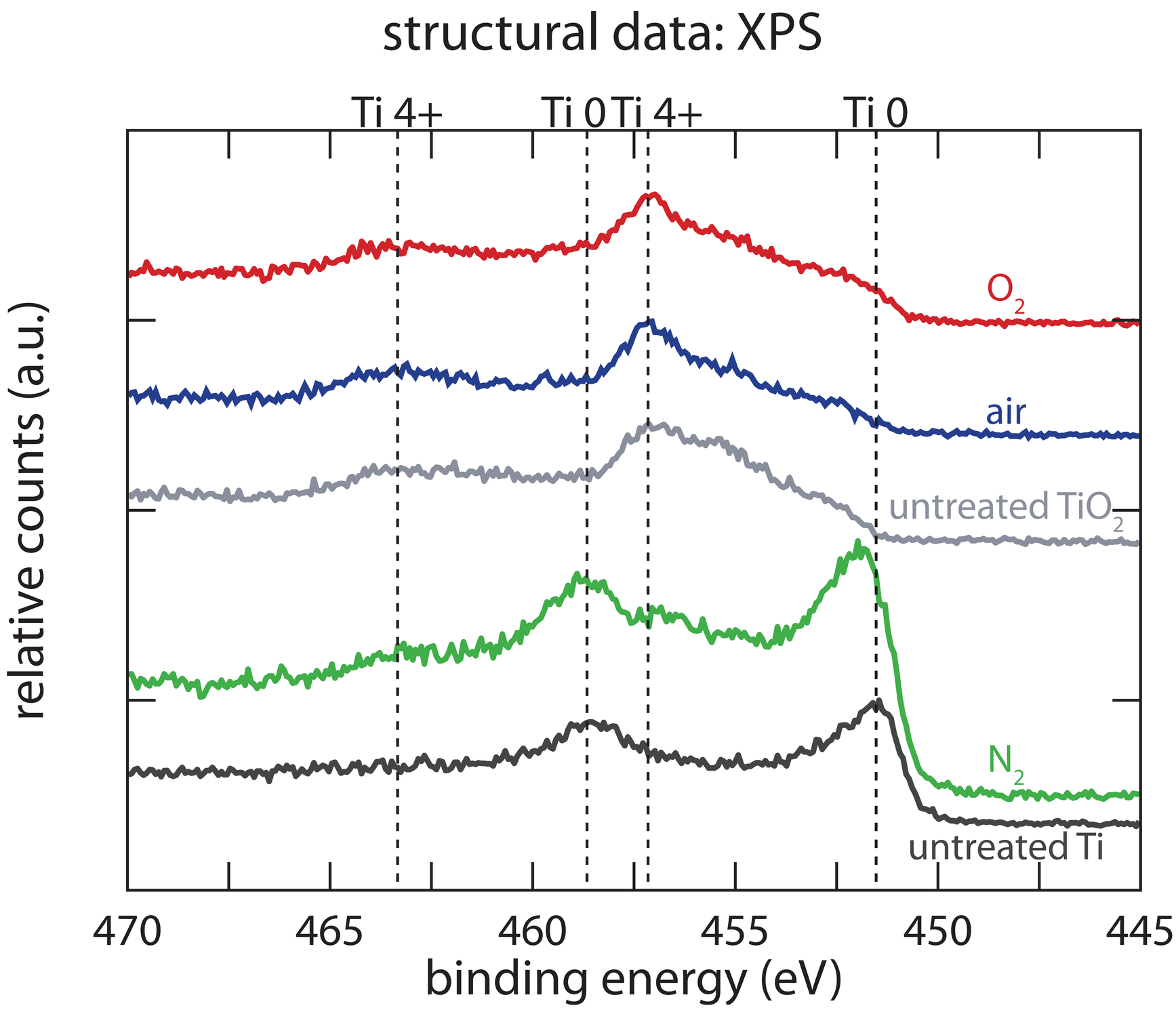

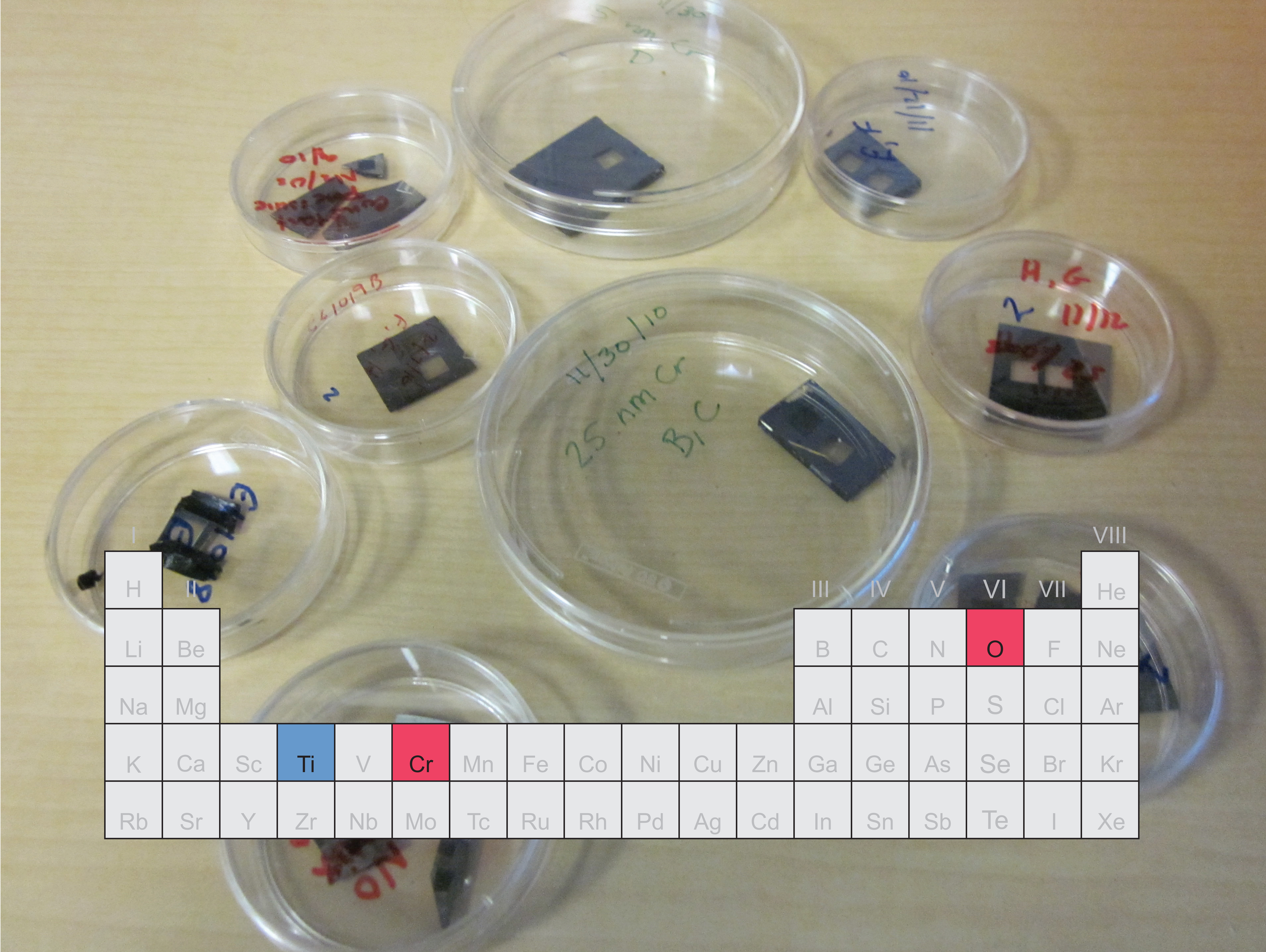

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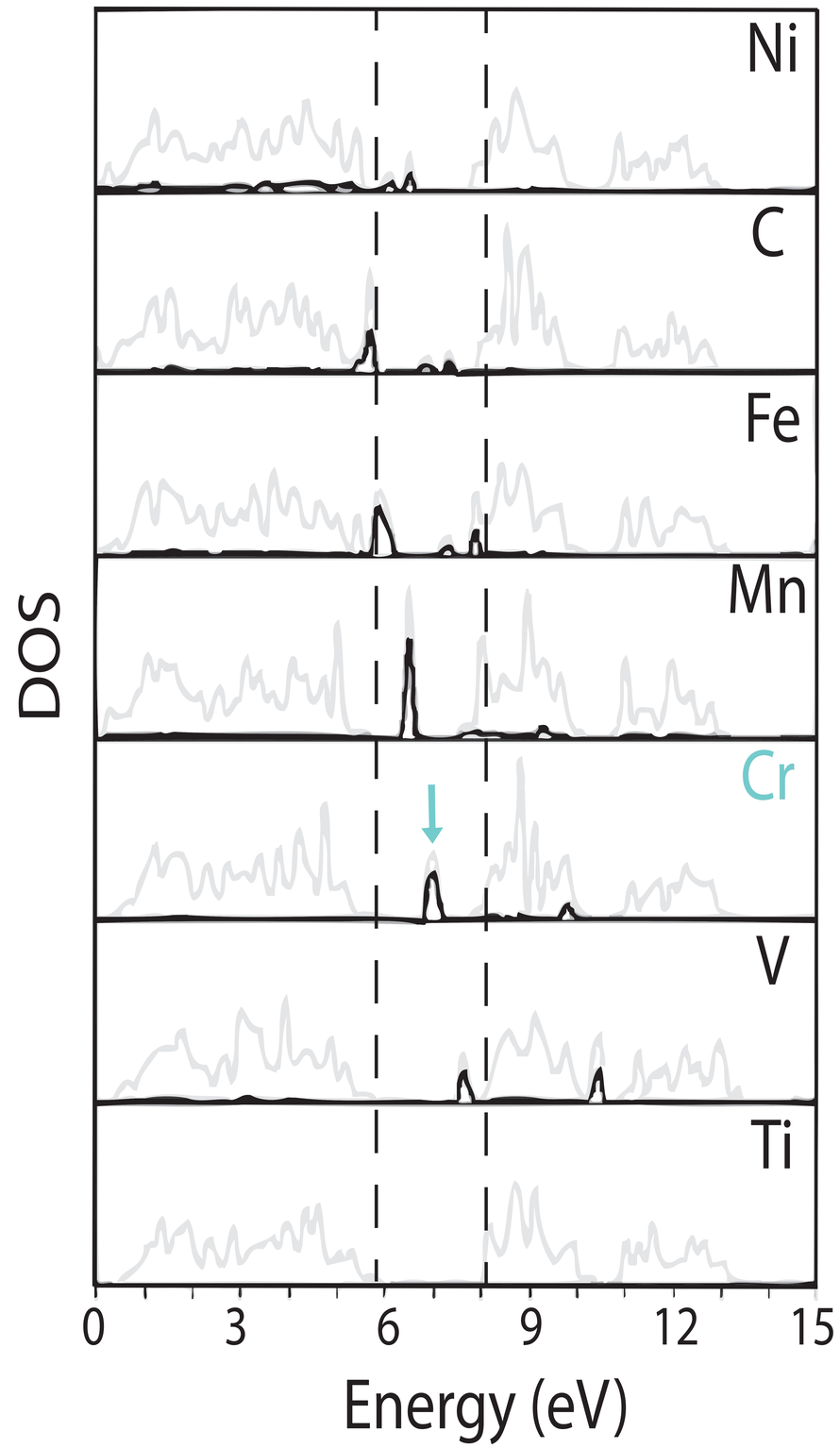
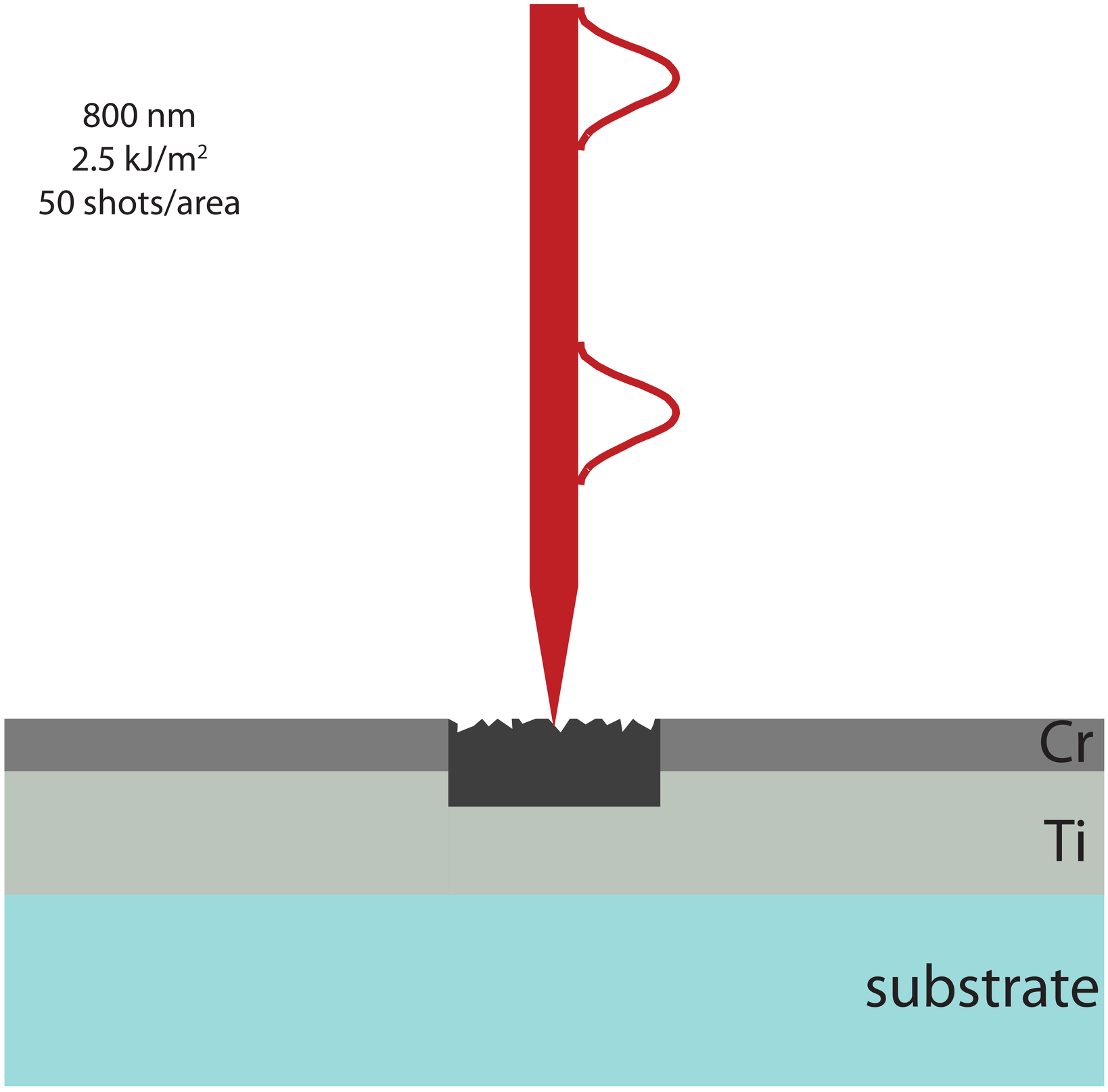
Laser fabricated doped TiO_2



Umebayashi, J. Phys. Chem. Solids, 2002.

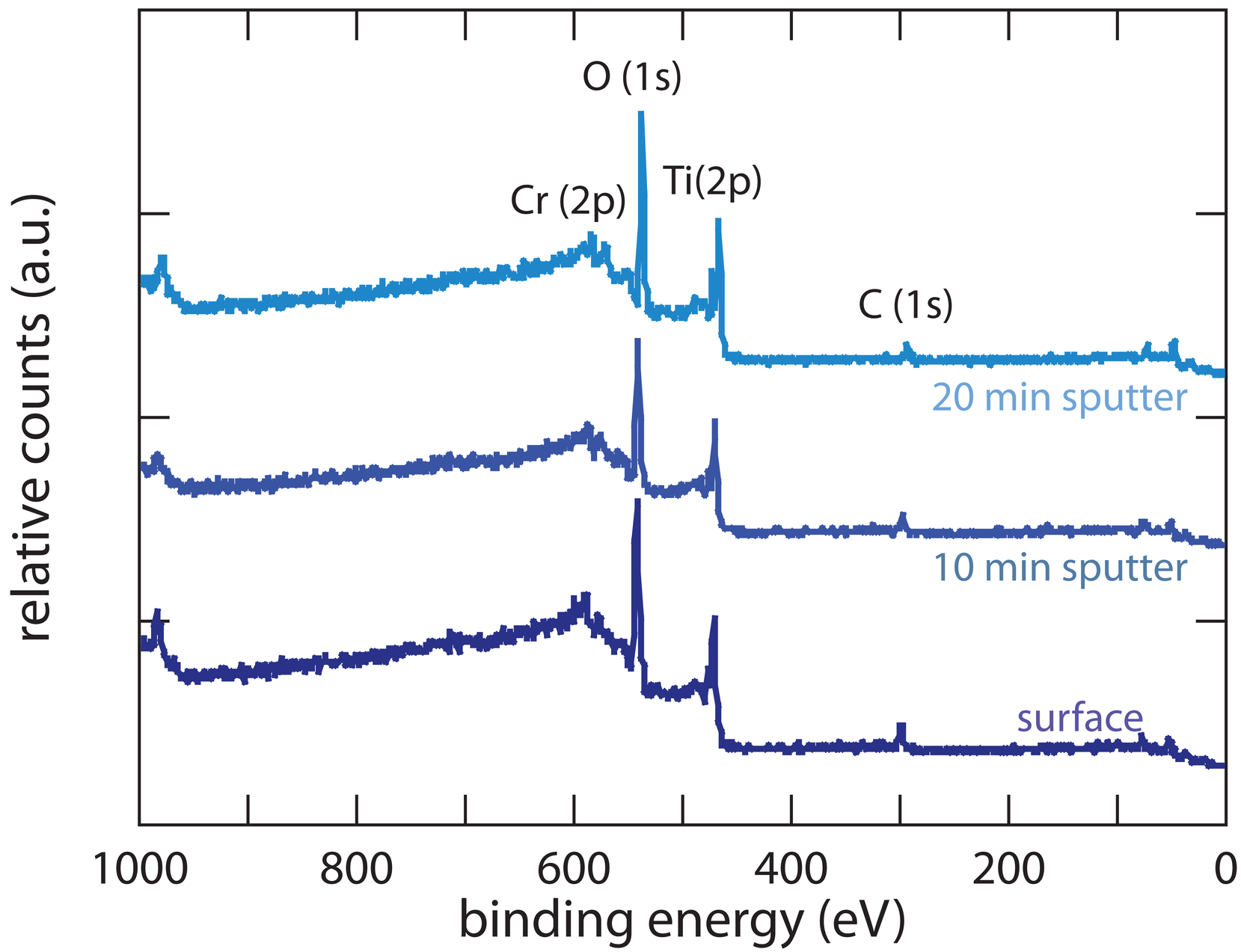
Laser fabricated doped TiO_2

800 nm
2.5 kJ/m^2
50 shots/area



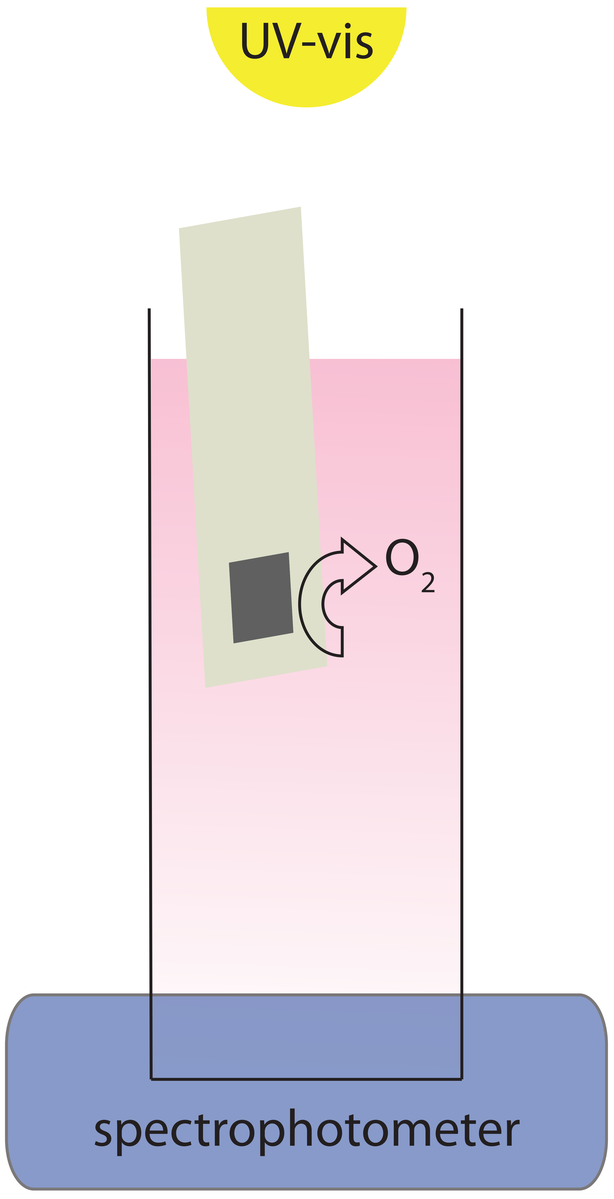
Laser fabricated doped TiO_2

structural data: XPS



Laser fabricated doped TiO_2

photocatalysis



Laser fabricated doped TiO_2

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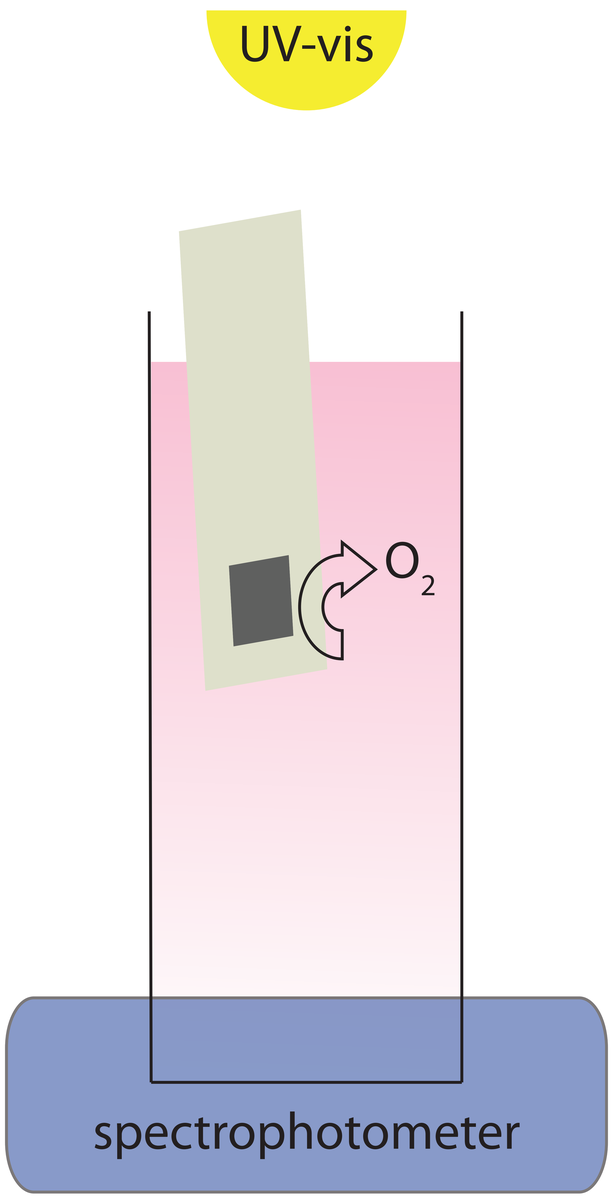
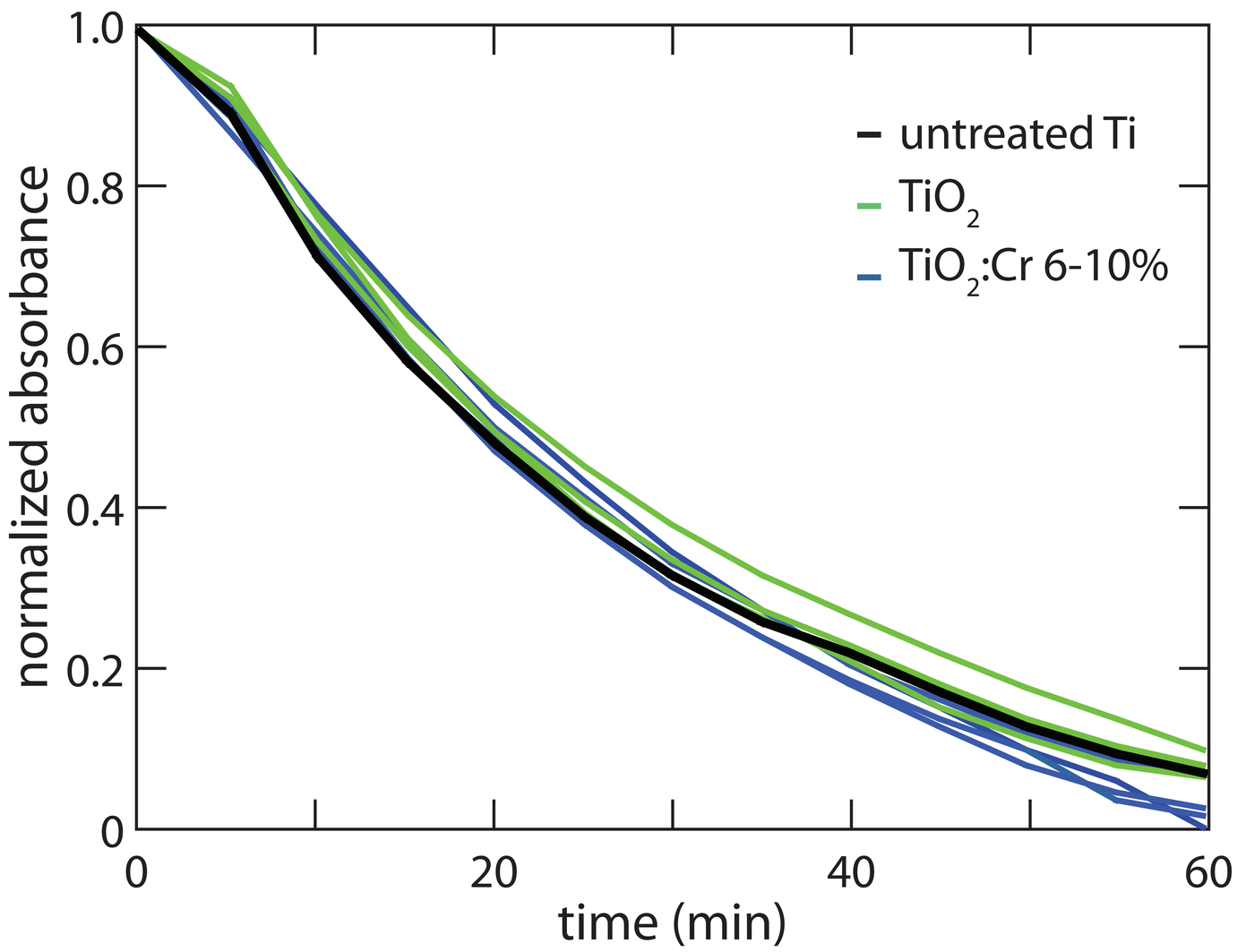




Summary

Form nanostructured TiO_2 with laser processing

Cannot introduce N_2 into TiO_2 because of chemical selectivity

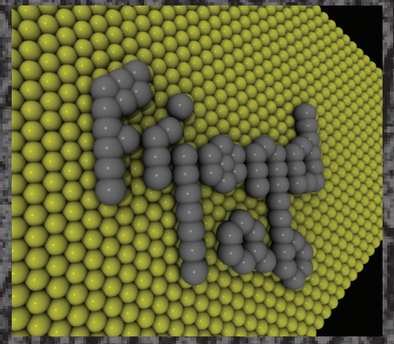
Control chromium doping but catalysis is not enhanced

Annealling could increase photocatalysis for laser doped TiO_2

Thank you!

HARVARD
School of Engineering
and Applied Sciences

MAZUR GROUP

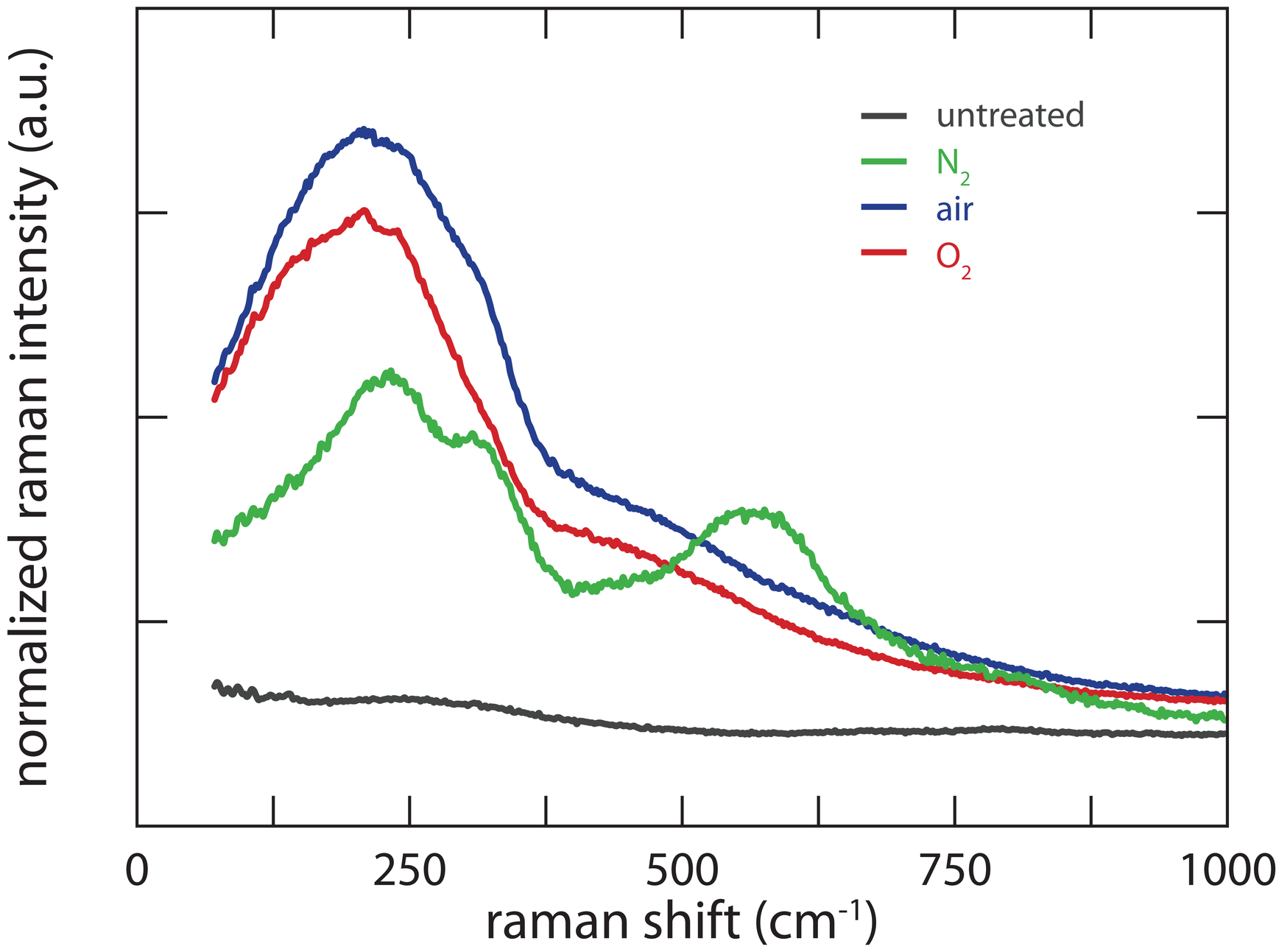


Support provided by NSF Graduate Research Fellowship
and Harvard Center for the Environment

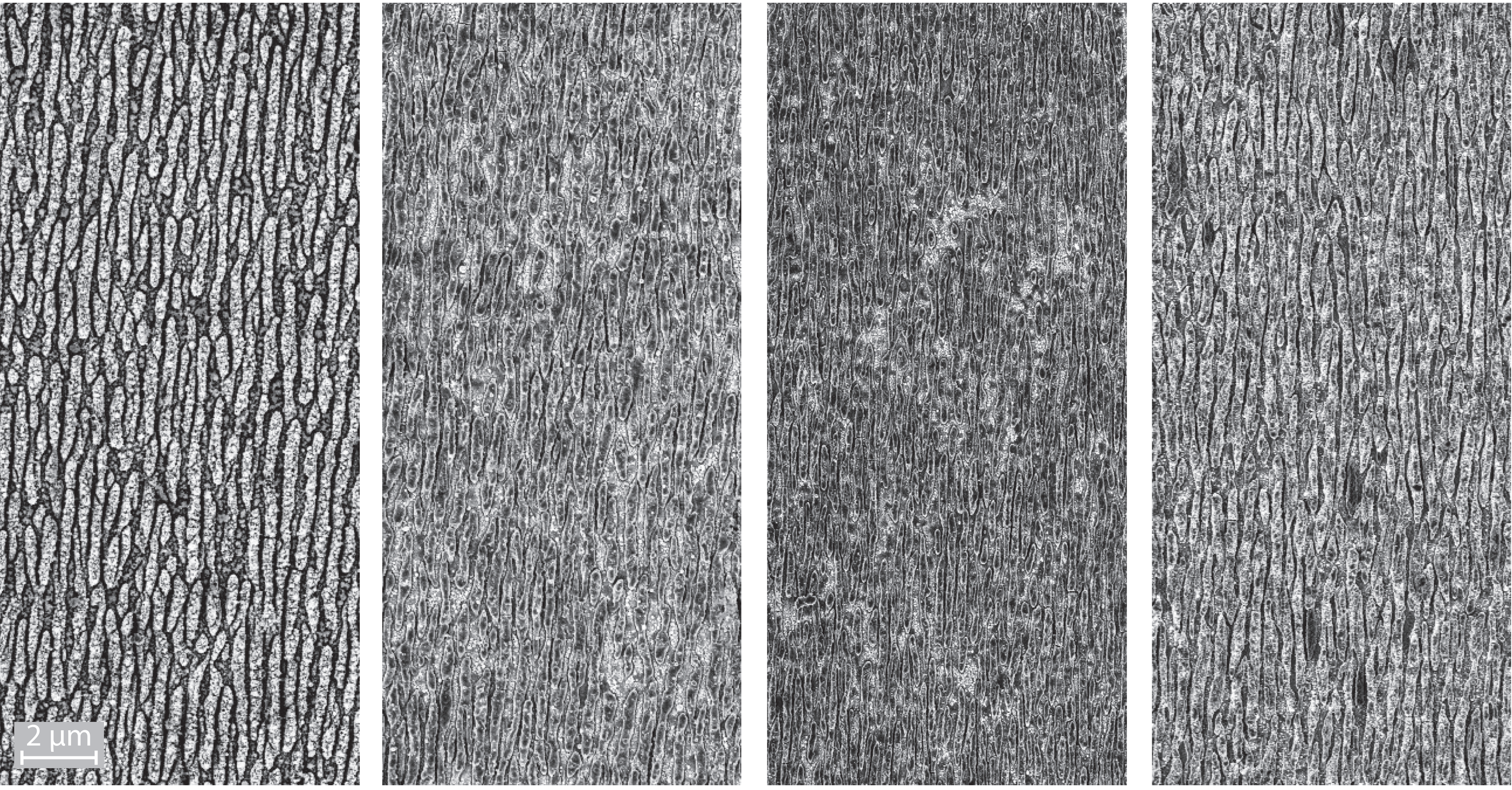
Goal:

To transform semiconductor band structure to harvest solar energy

Chemical Selectivity



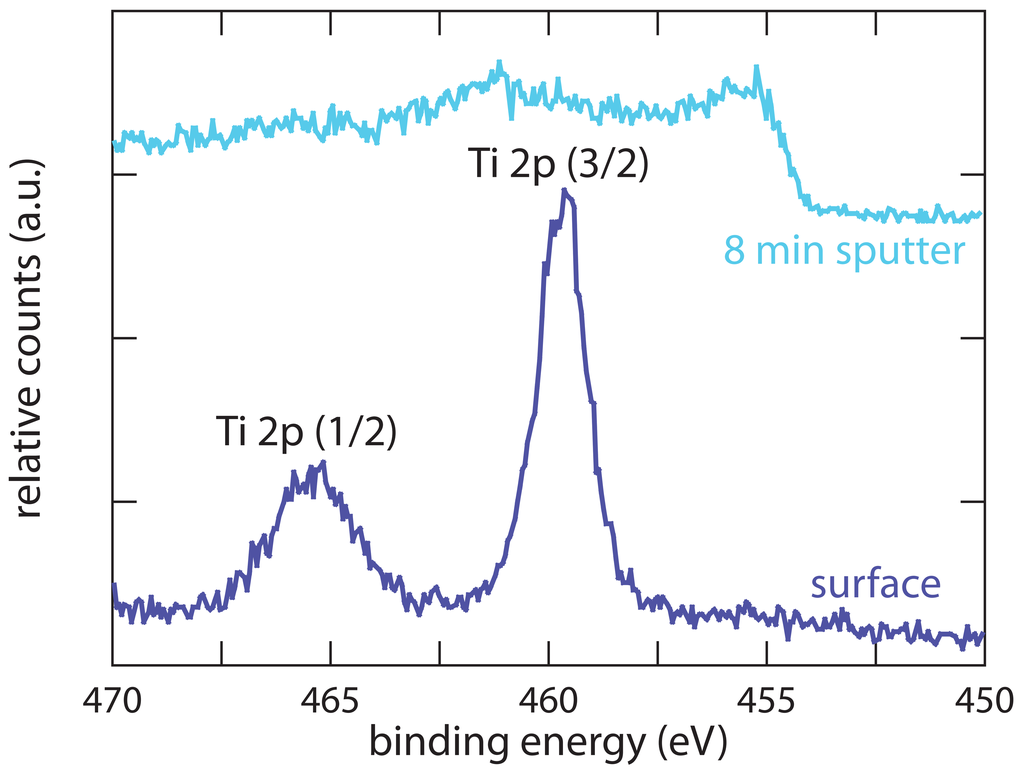
Laser fabricated doped TiO_2



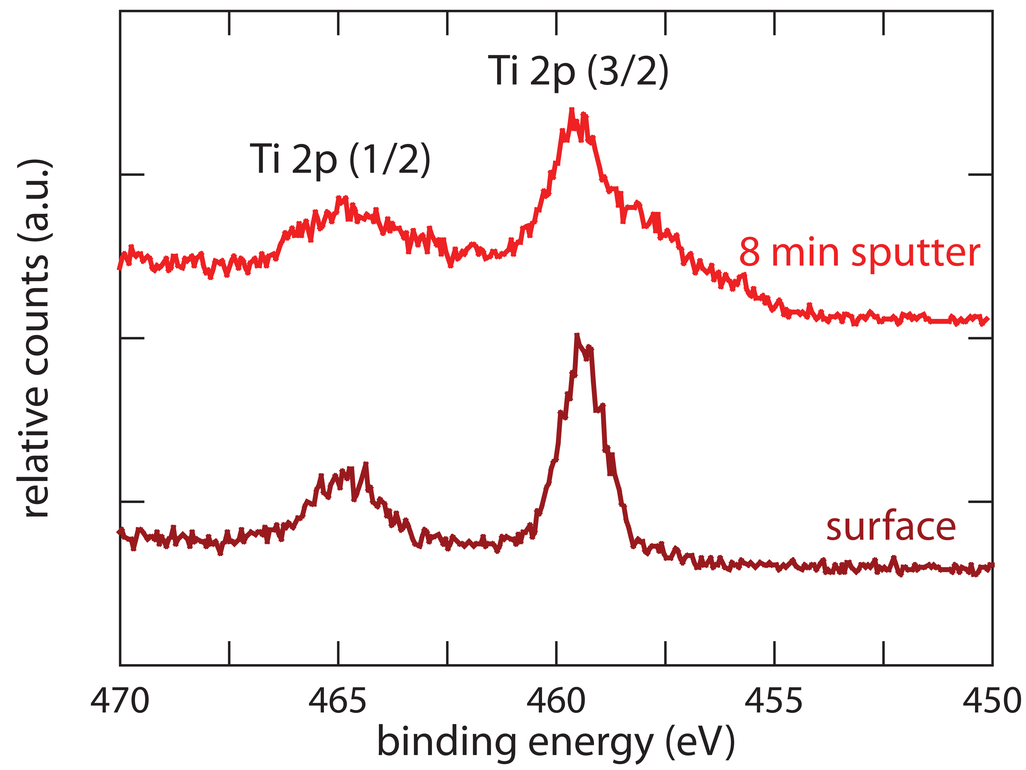
Production of TiO_2

structural data: XPS

bare titanium plate



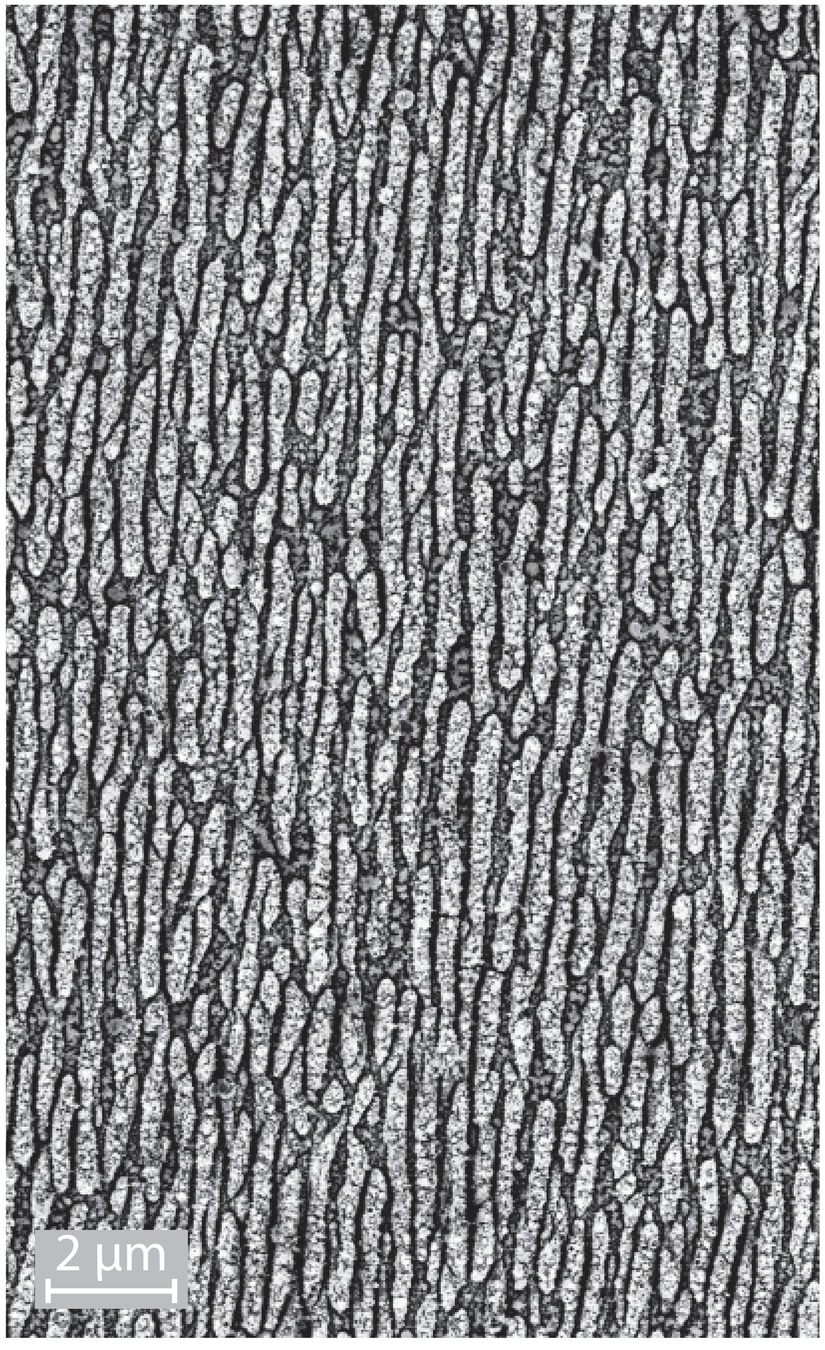
laser treated titanium



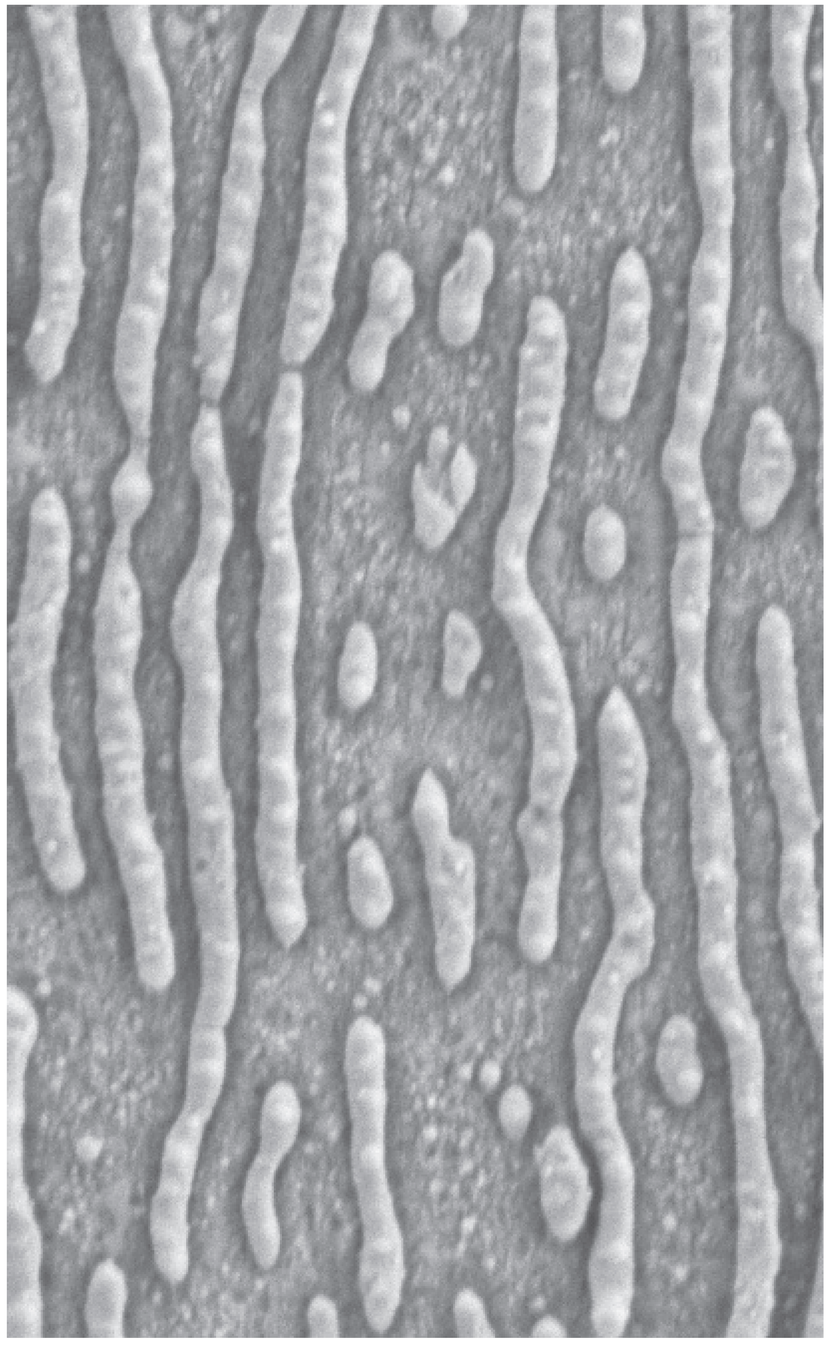
We have produced TiO_2 with laser processing

Laser fabricated doped TiO_2

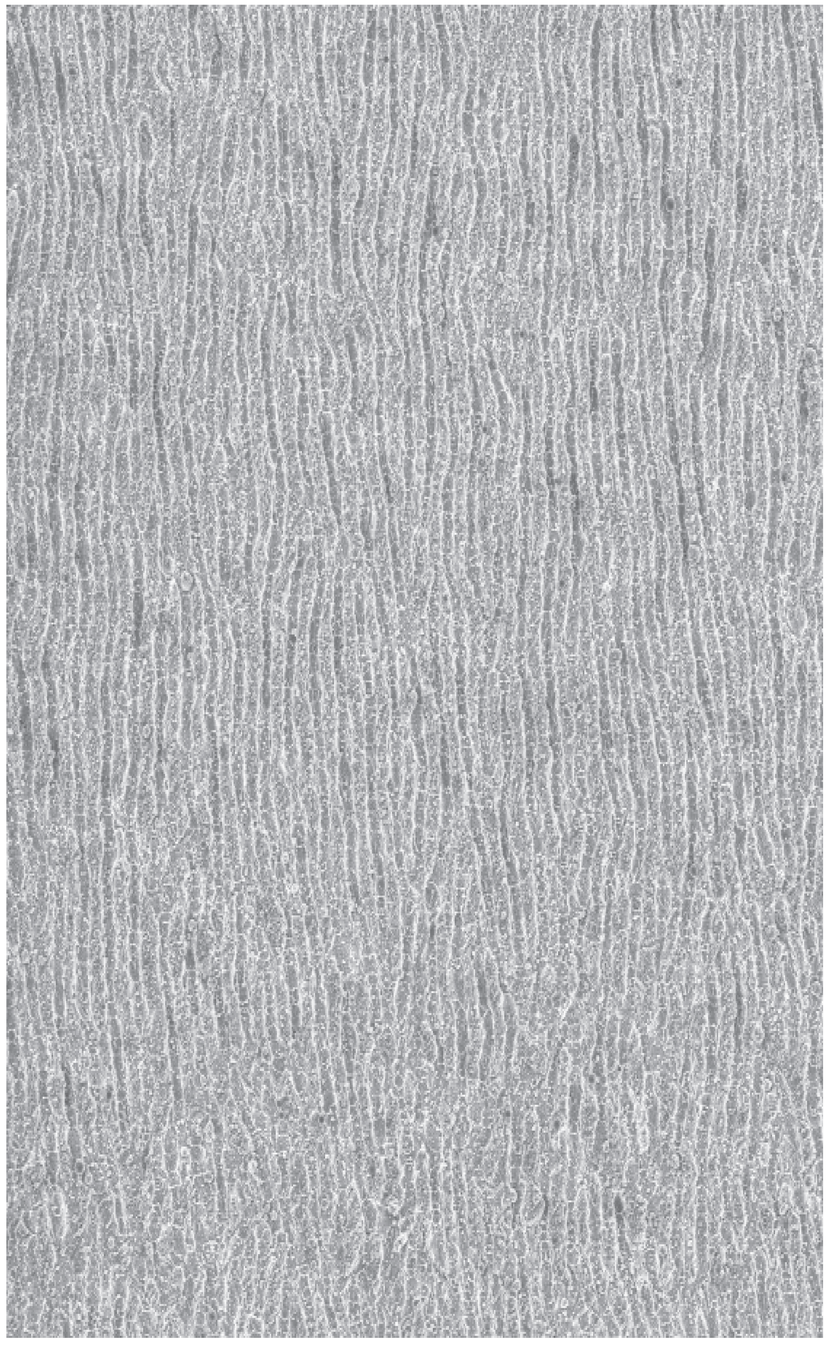
microstructures



0 nm Cr
no doping

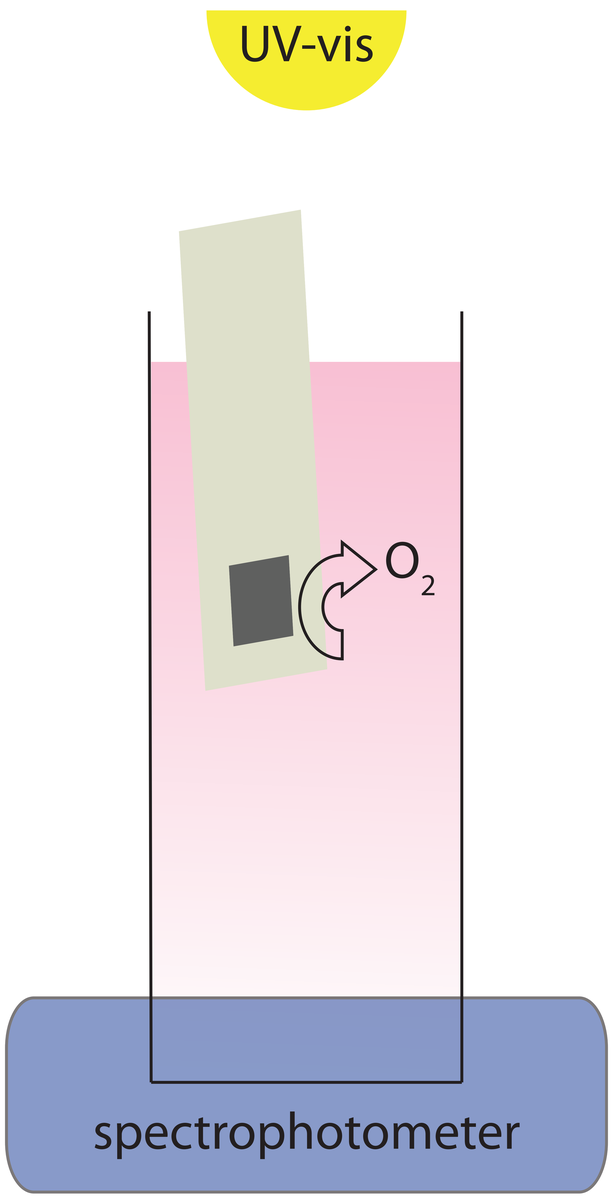
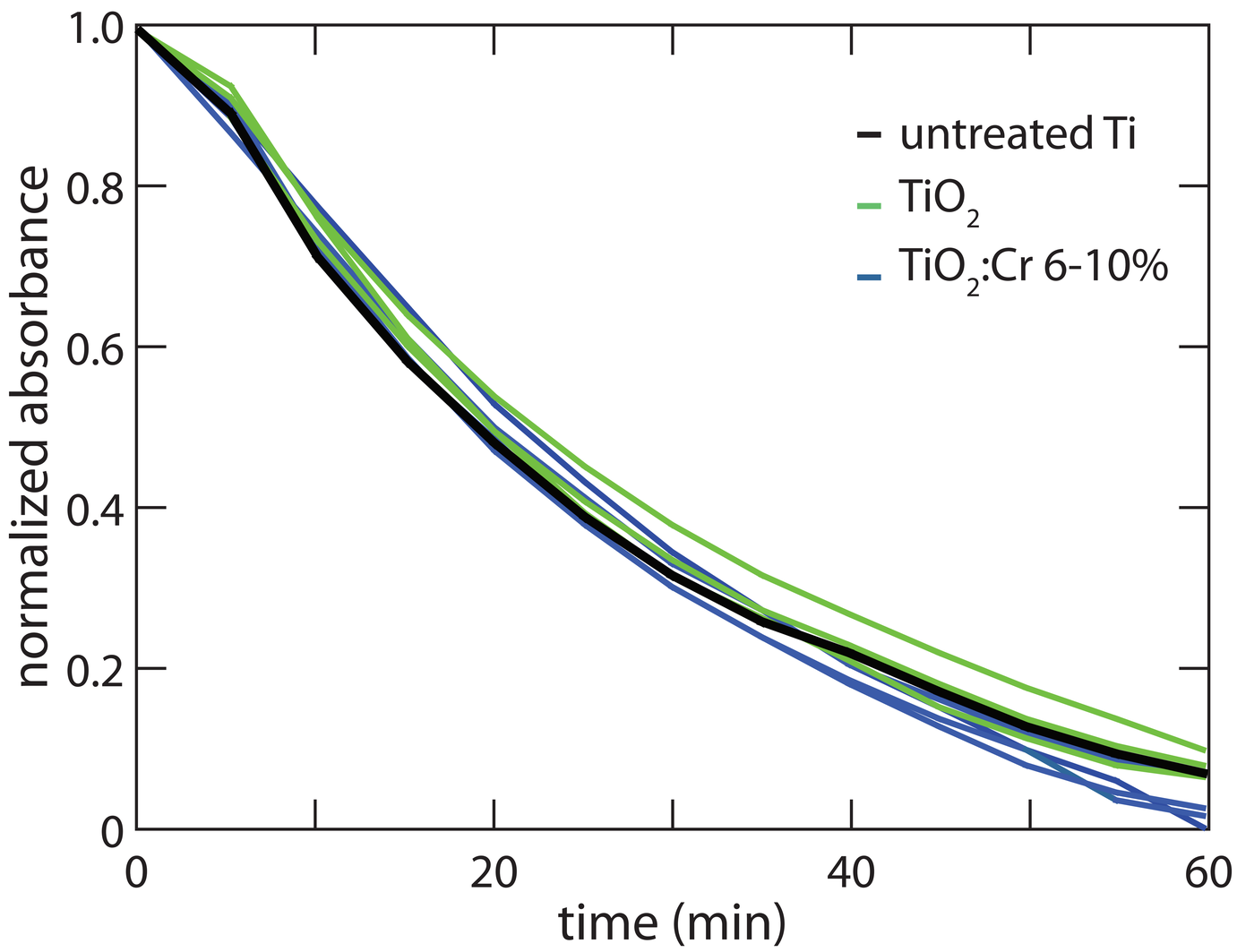


10 nm Cr
7% Cr-doped



70 nm Cr
30% Cr-alloy

Chemical Selectivity

Laser fabricated TiO_2

photocatalysis