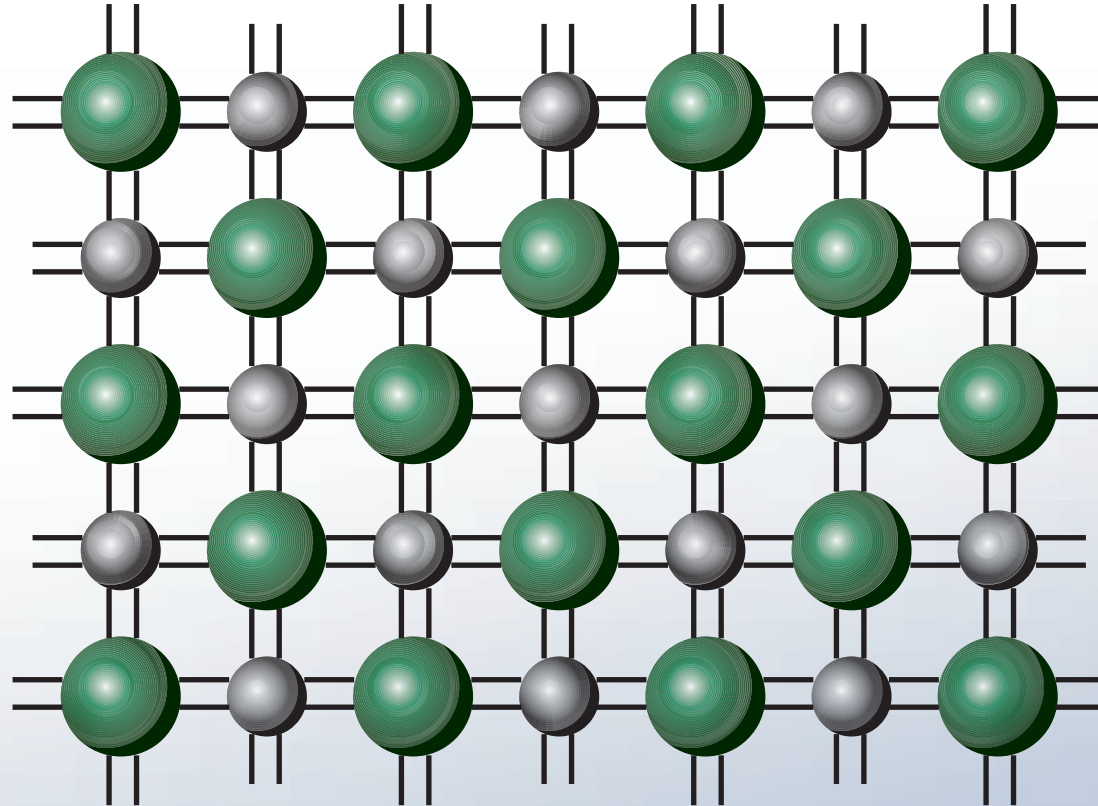


Ultrafast Dynamics of Metallic Thin Films

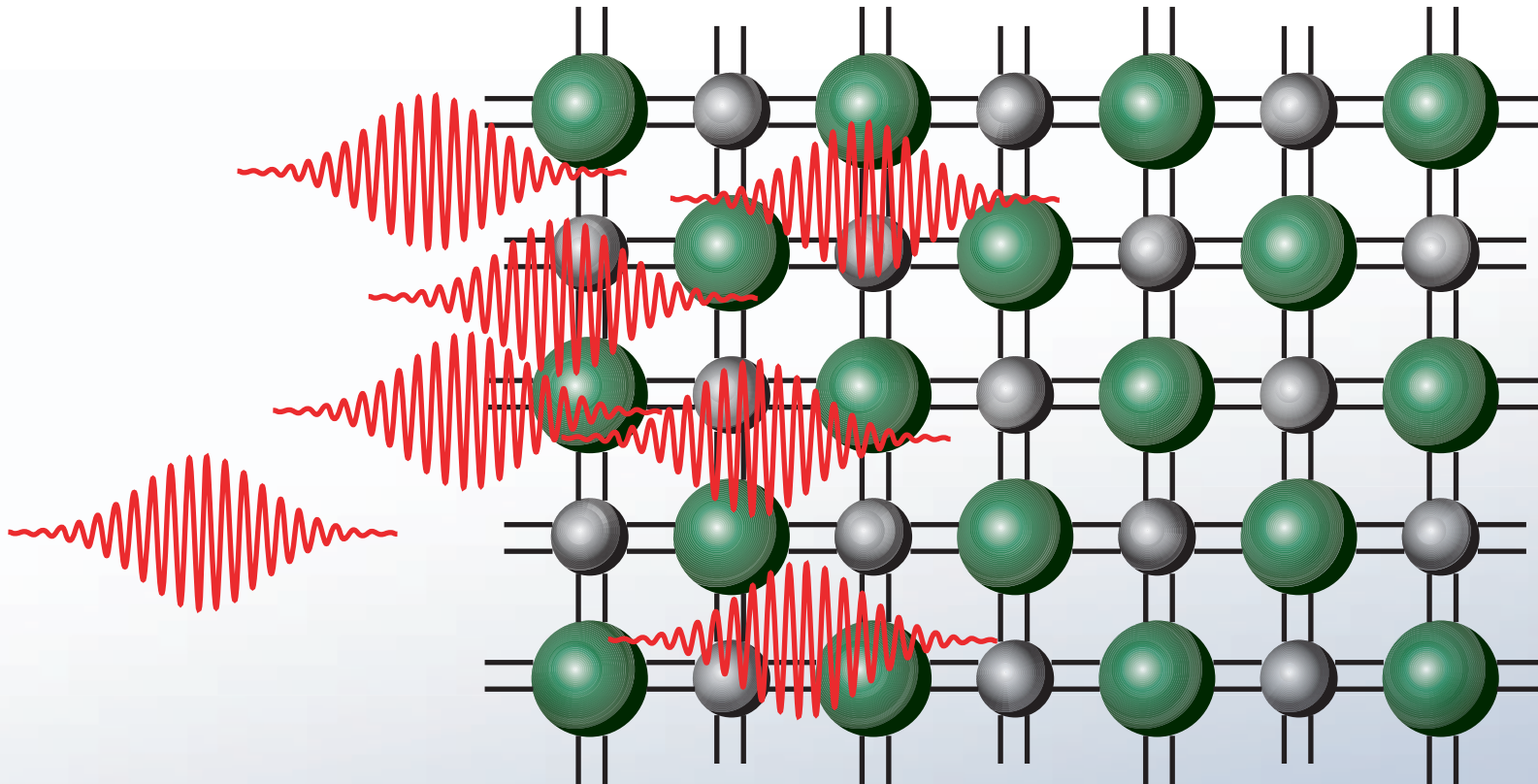
Tina Shih

Maria Kandyla, Eric Mazur

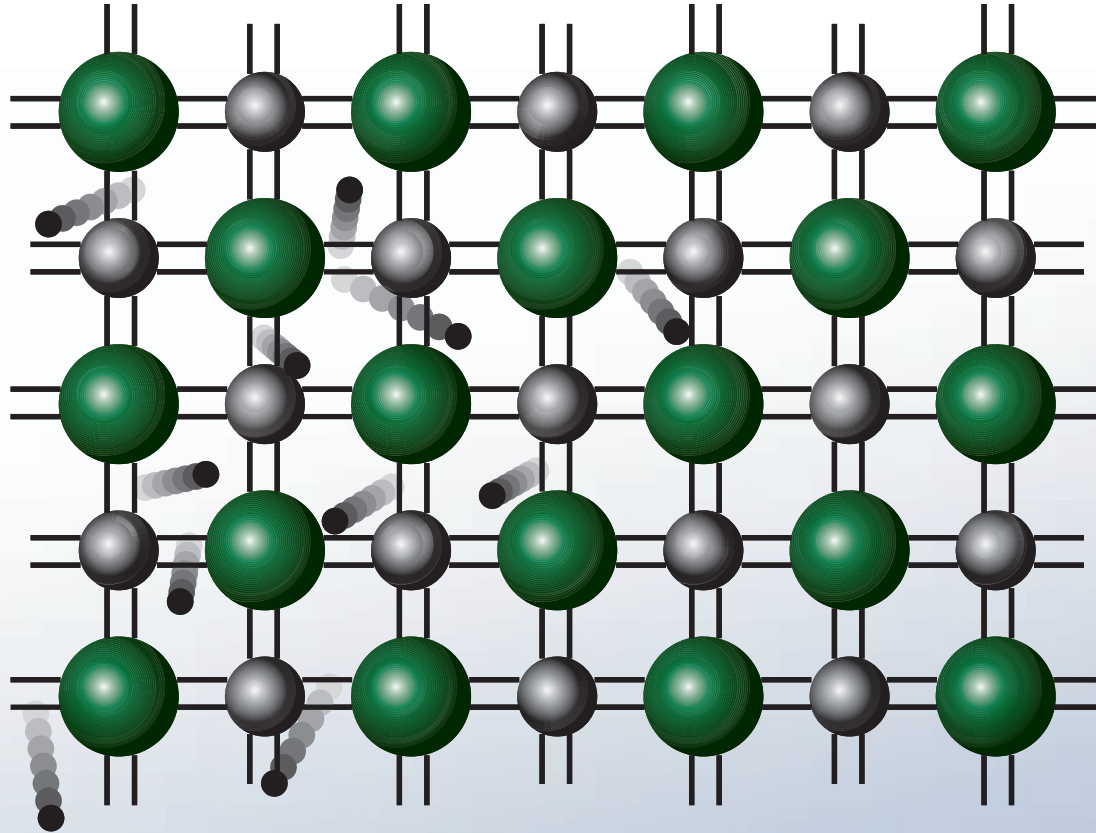
Harvard University



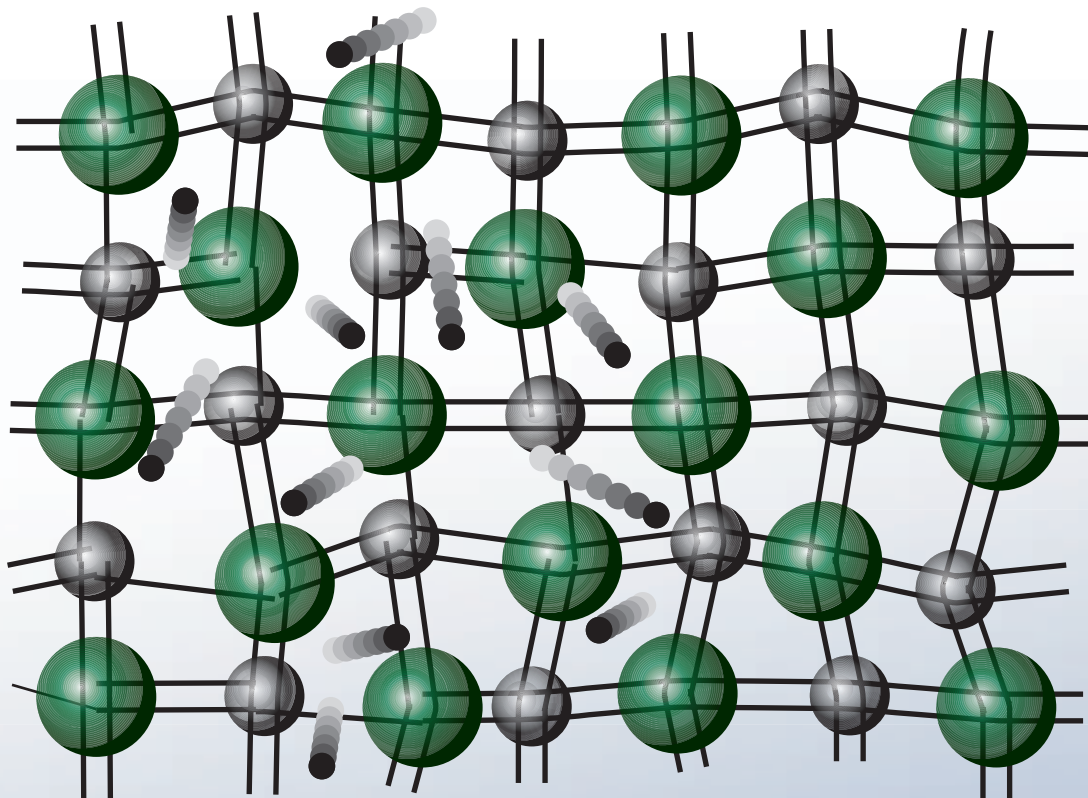
Interaction of femtosecond pulses with solids



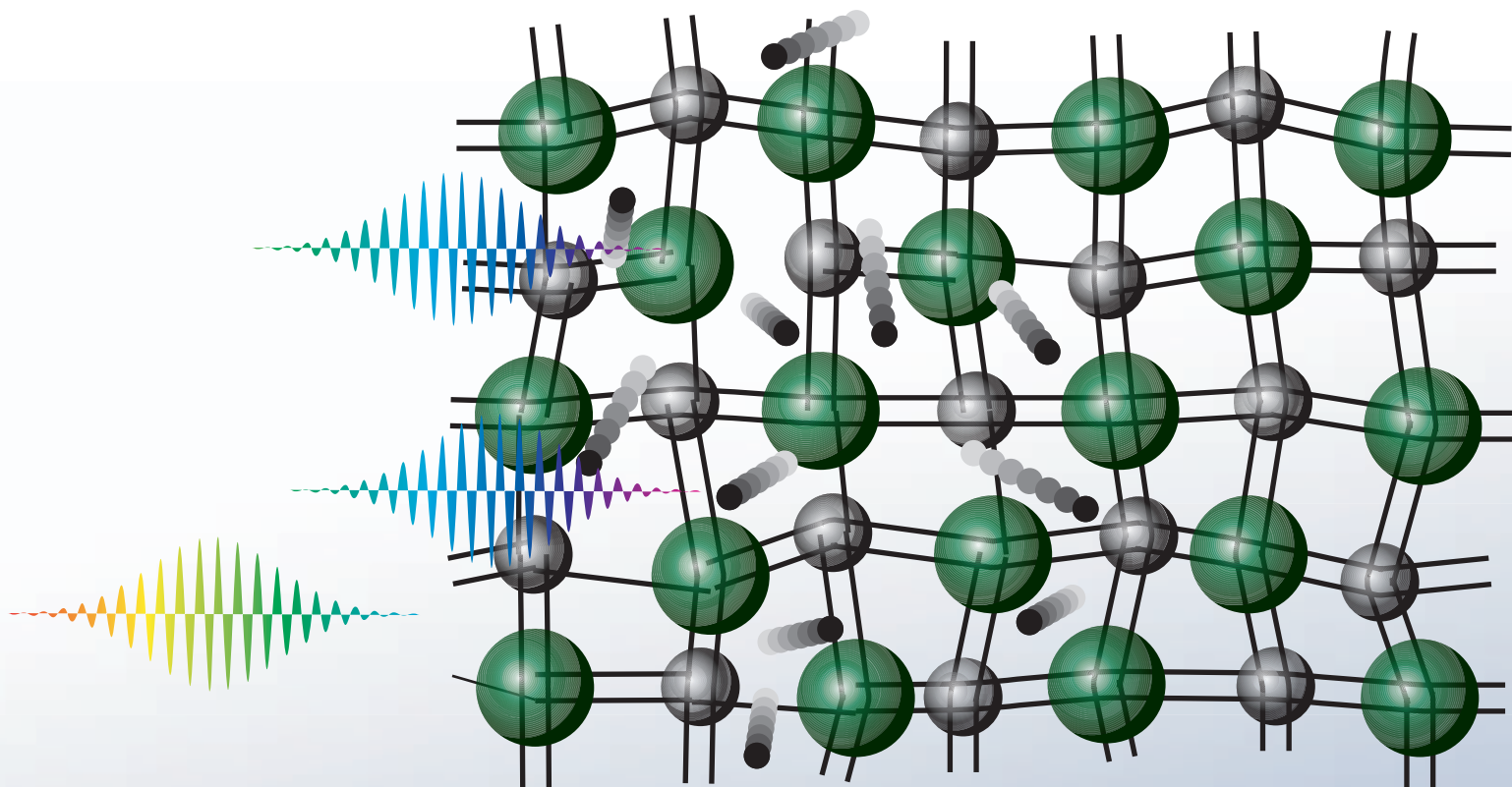
Incident photons from the pump pulse excite valence electrons



Creating free carriers



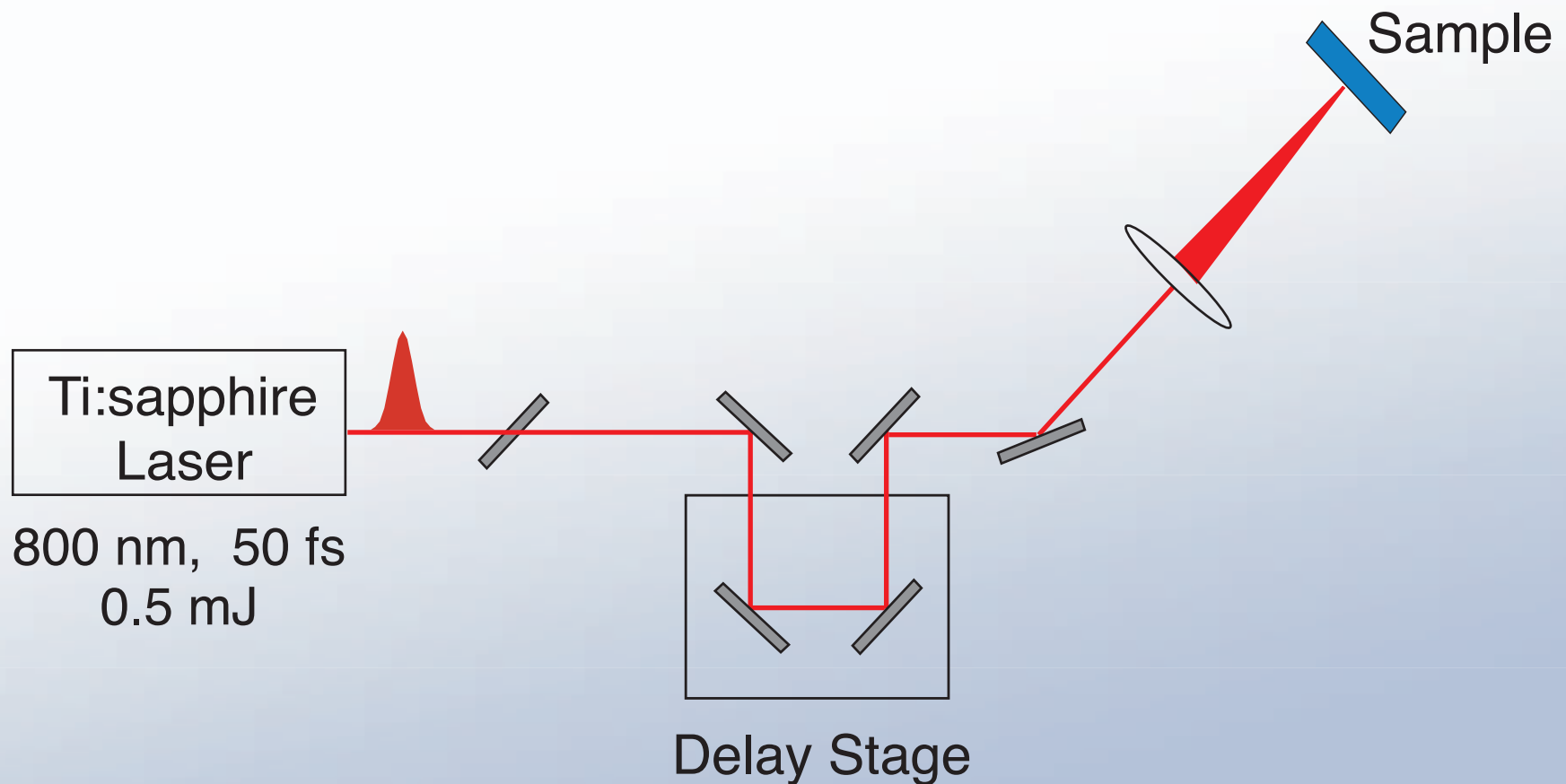
Causing electronic and structural changes



which could be detected by a second probe pulse

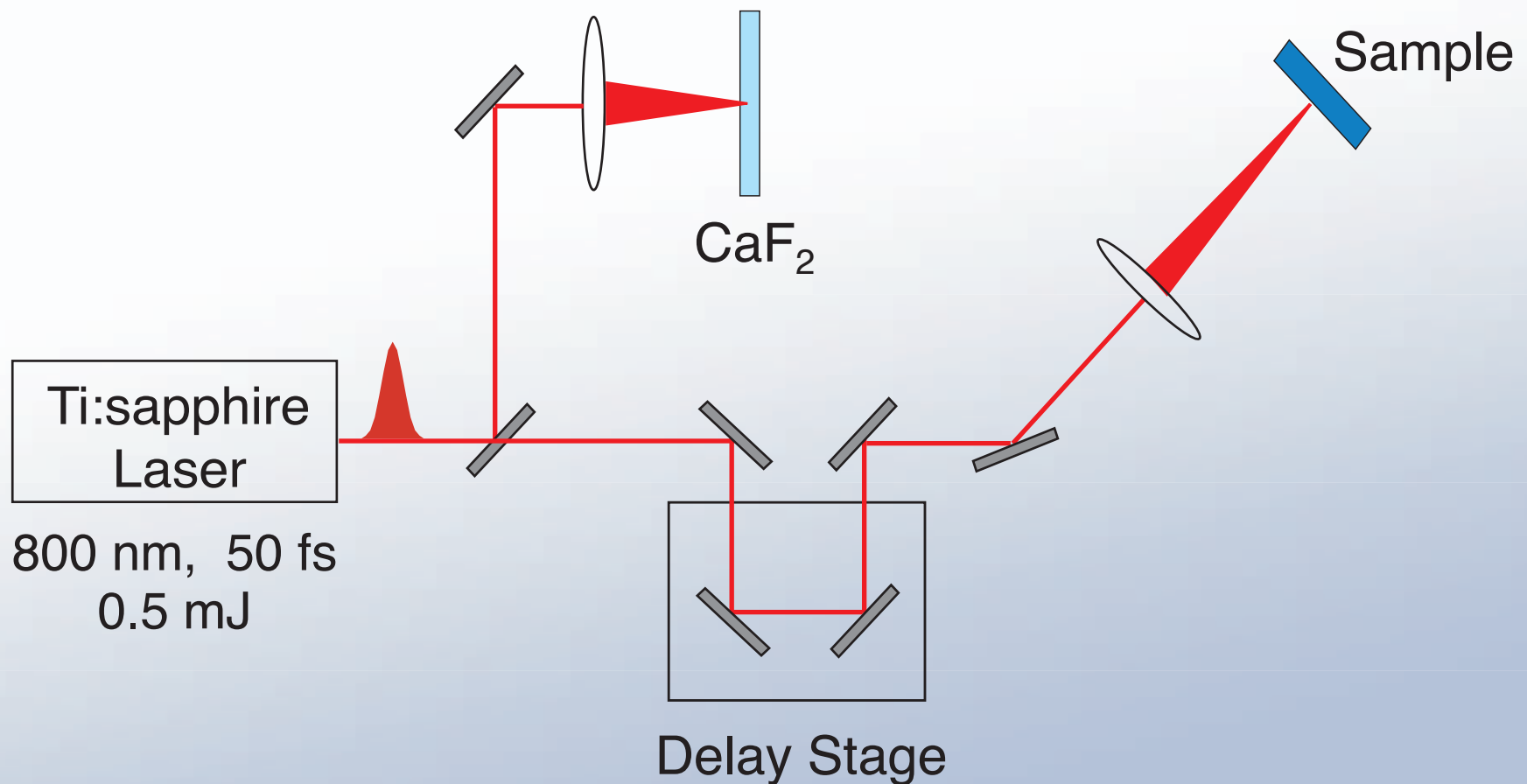
Pump Probe Spectroscopy

Broadband dual-angle reflectometry



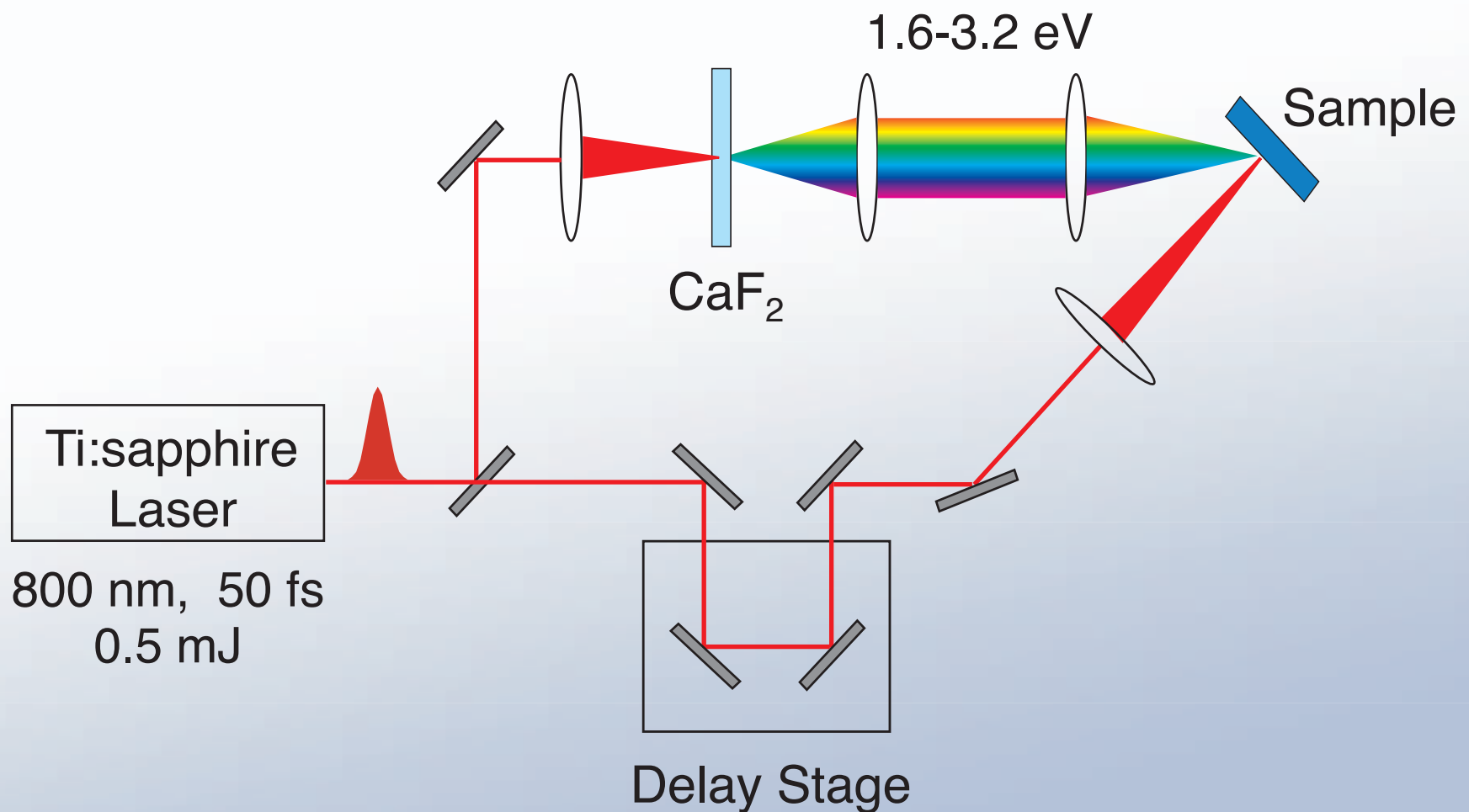
Pump Probe Spectroscopy

Broadband dual-angle reflectometry



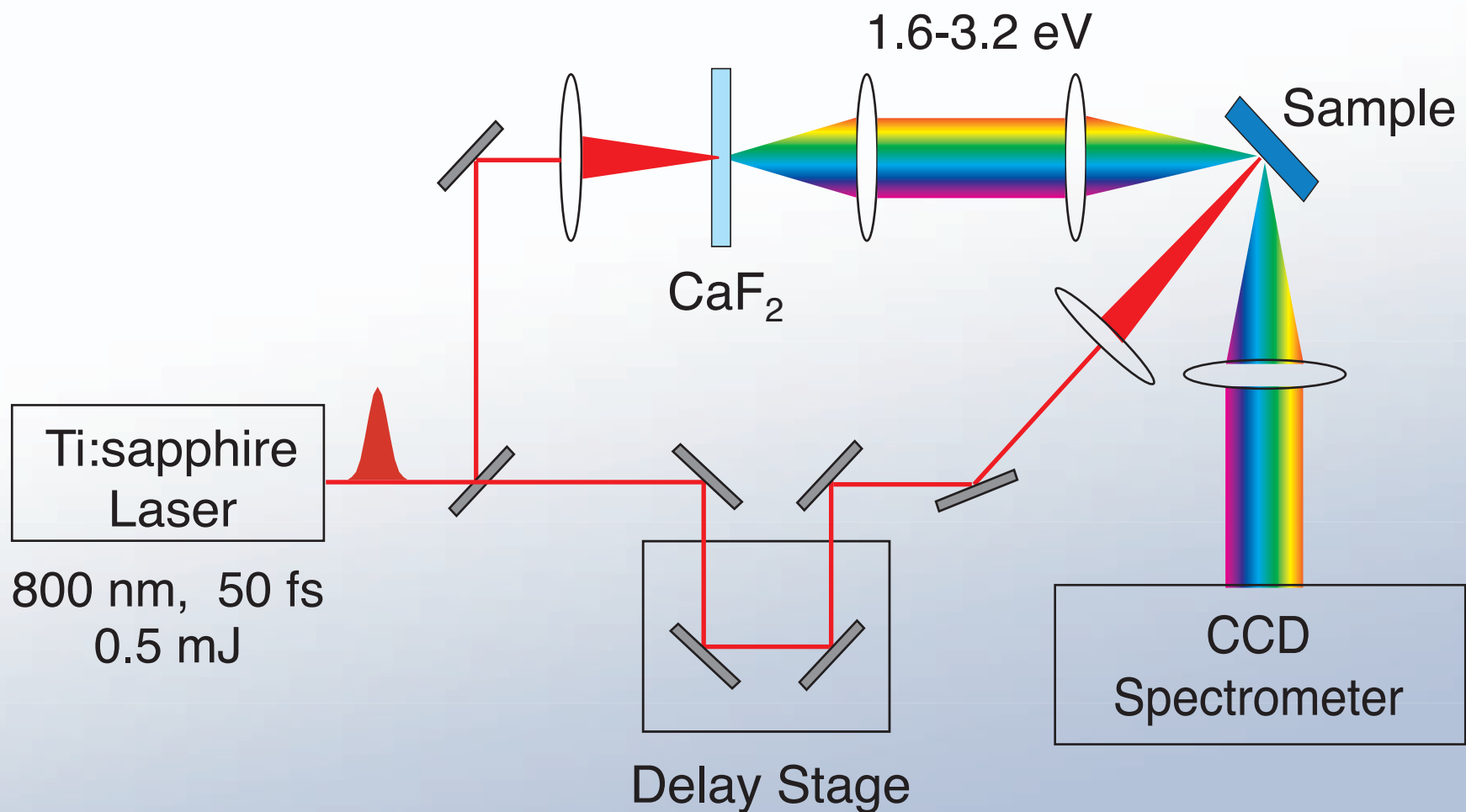
Pump Probe Spectroscopy

Broadband dual-angle reflectometry

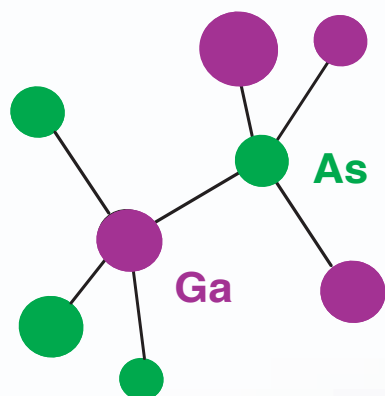


Pump Probe Spectroscopy

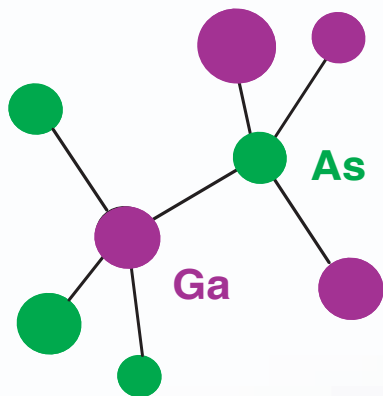
Broadband dual-angle reflectometry



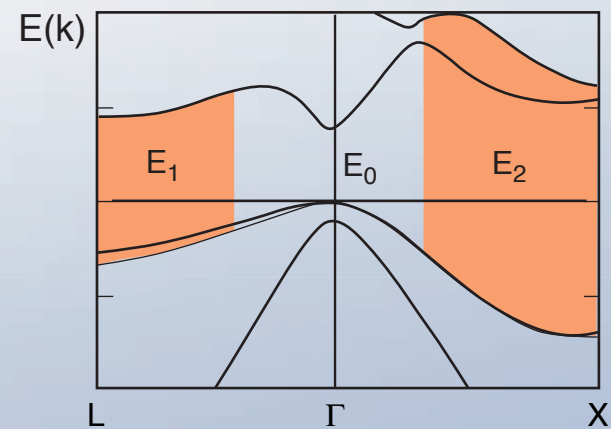
Structure and Electronic Configuration



Structure and Electronic Configuration

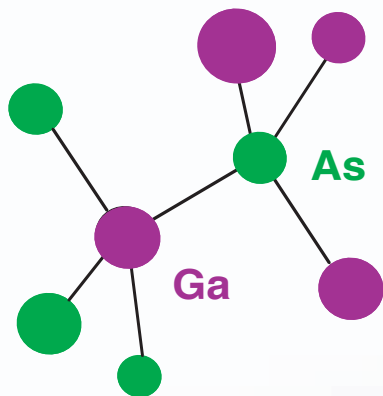


Band Structure and Occupation

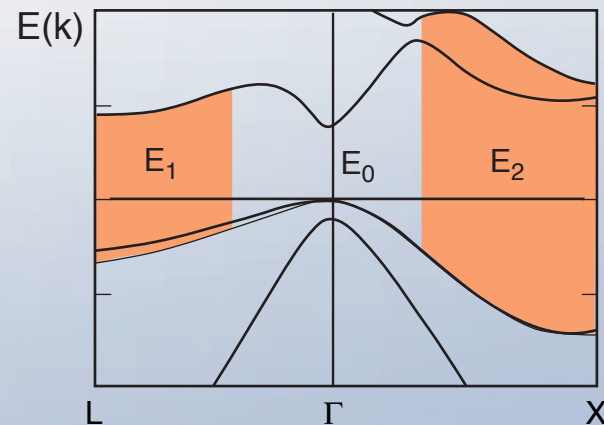


Interpretation

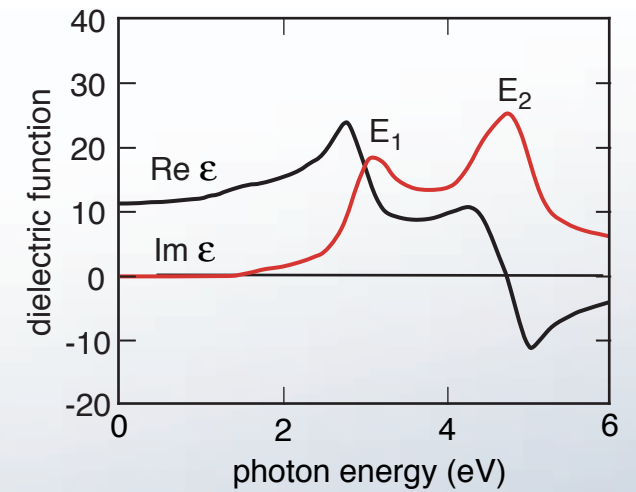
Structure and Electronic Configuration



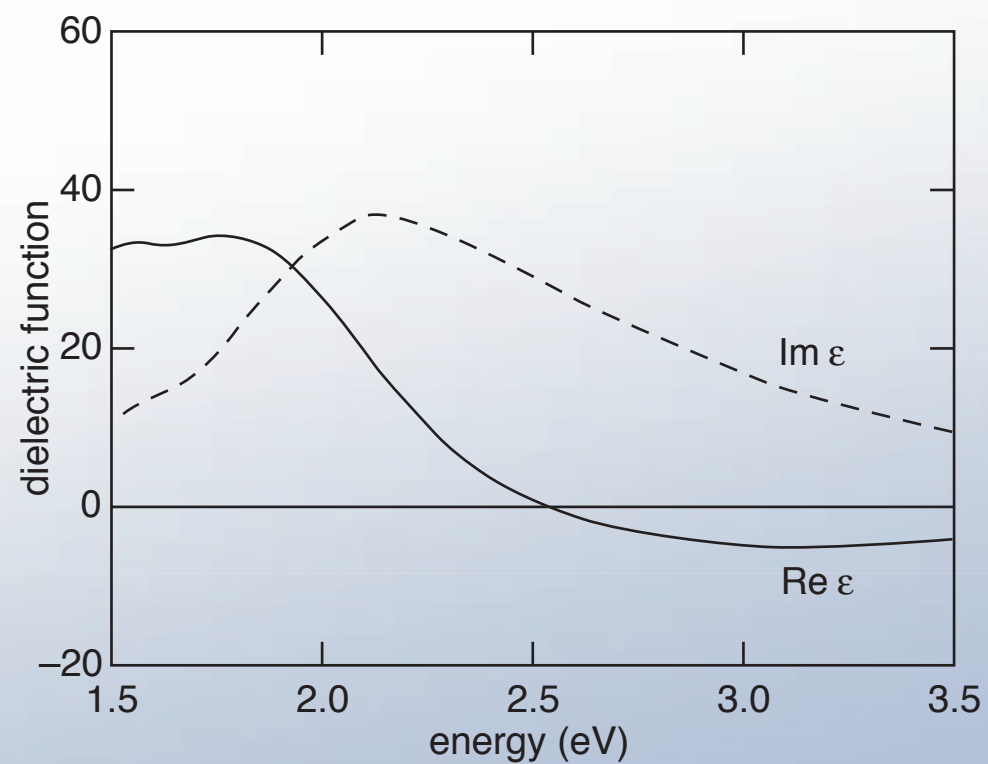
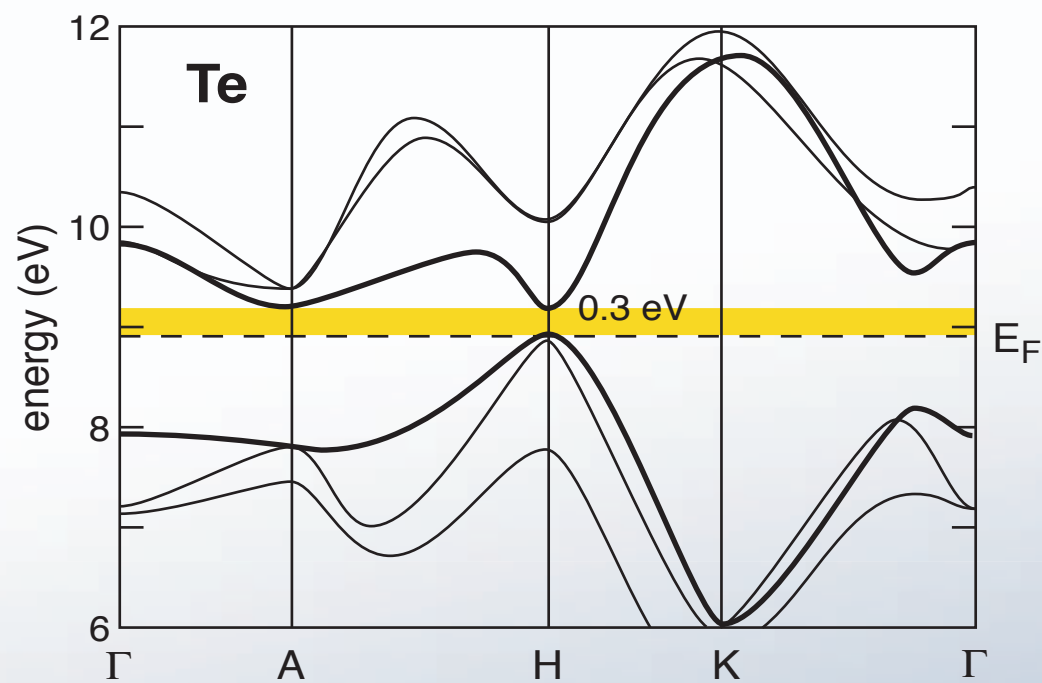
Band Structure and Occupation



Dielectric Function

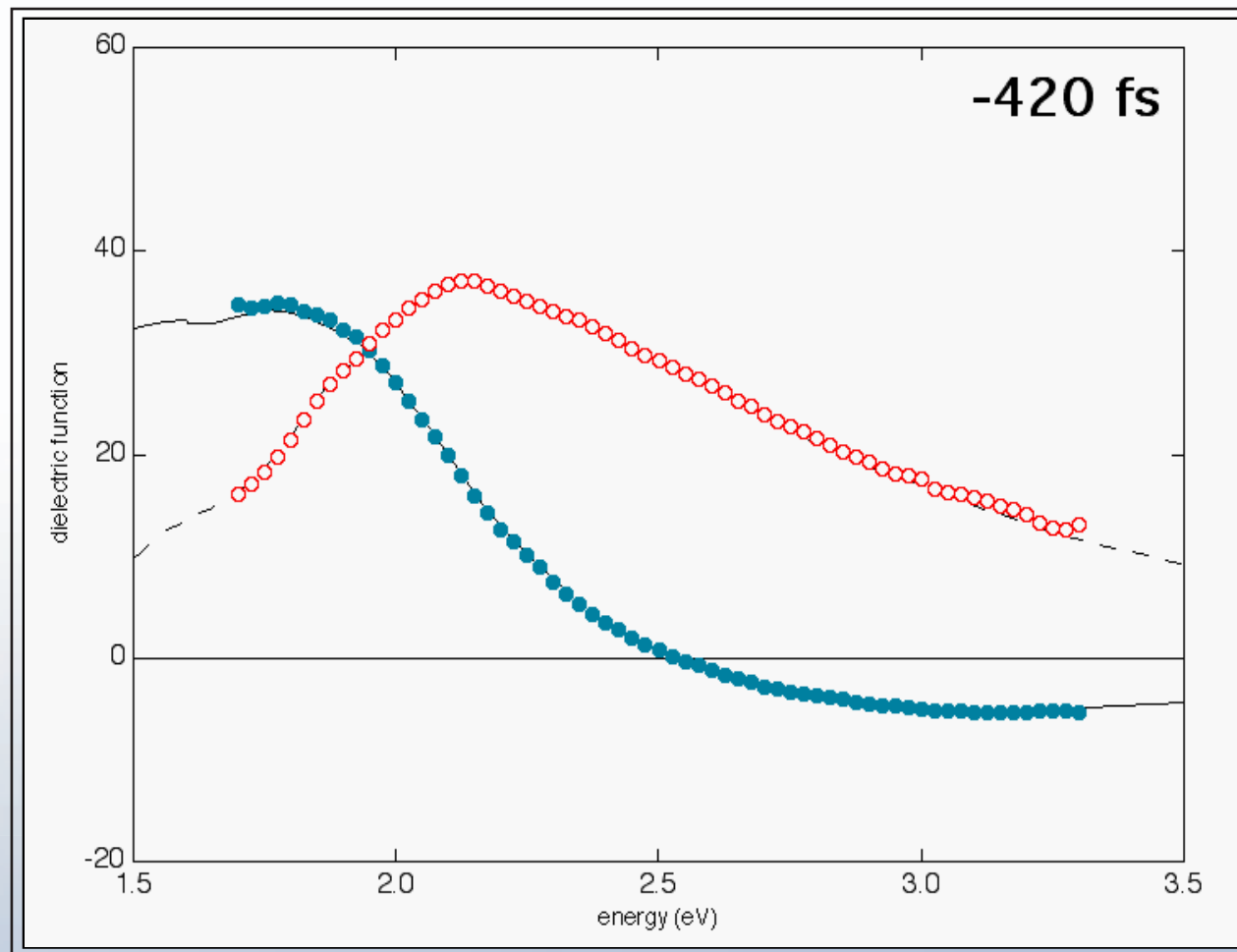


Te bandstructure and dielectric function

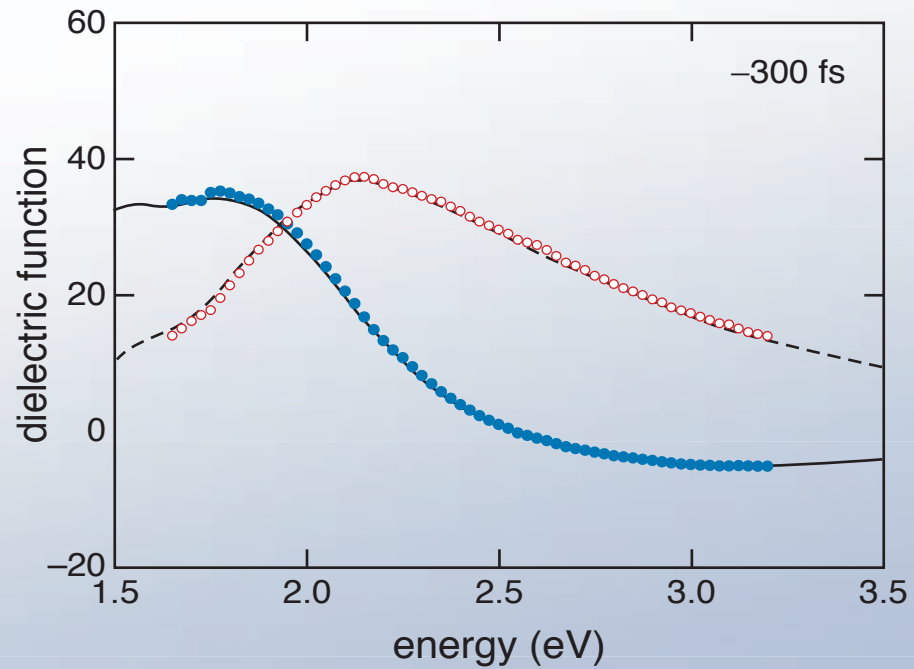
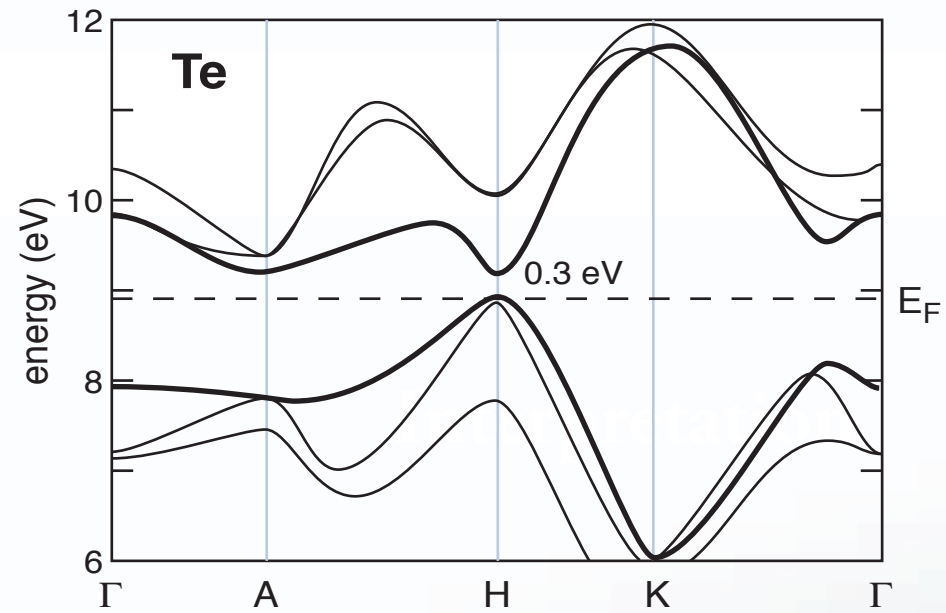


Time Resolved Material Response

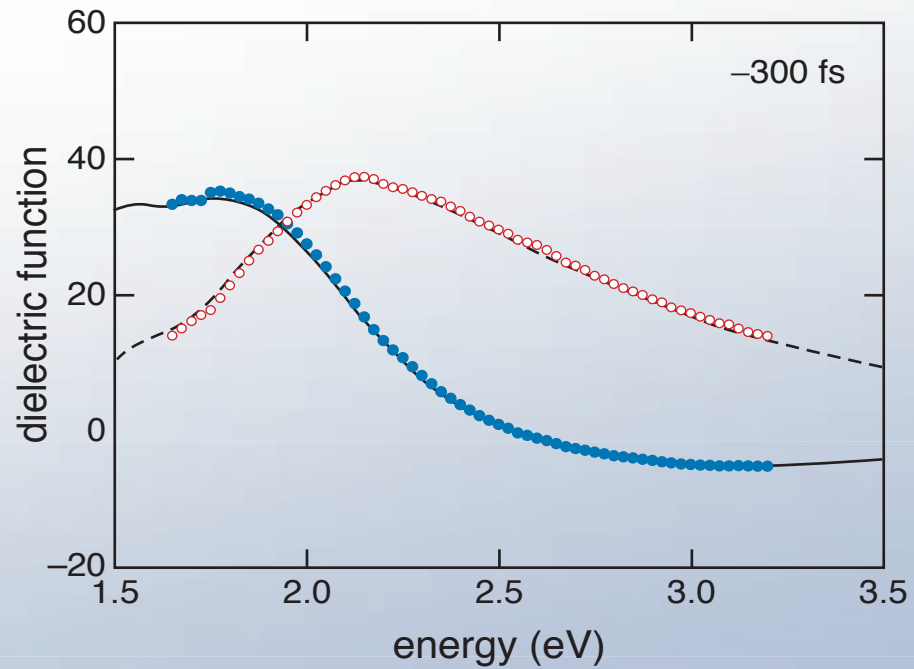
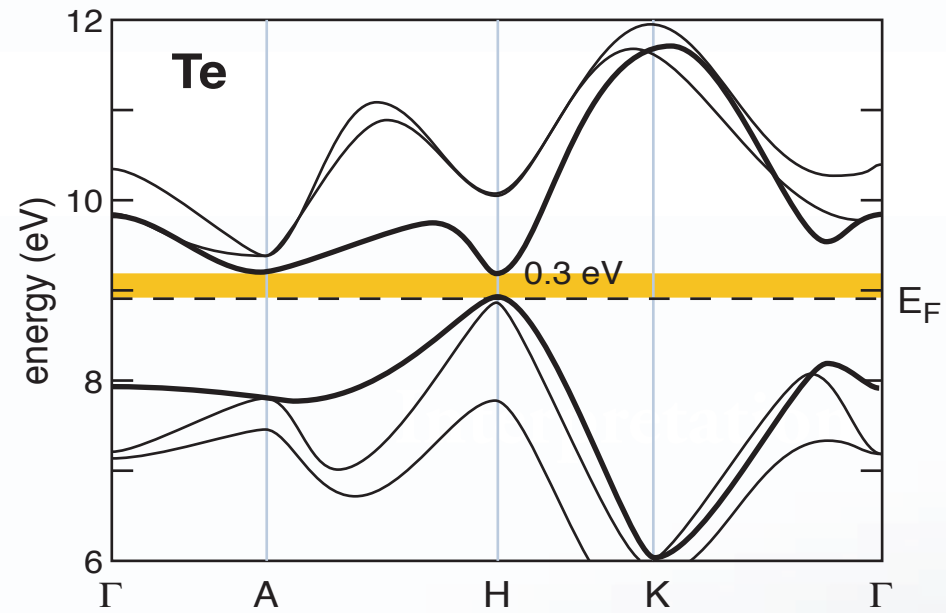
Te under $0.71 F_{th}$ excitation



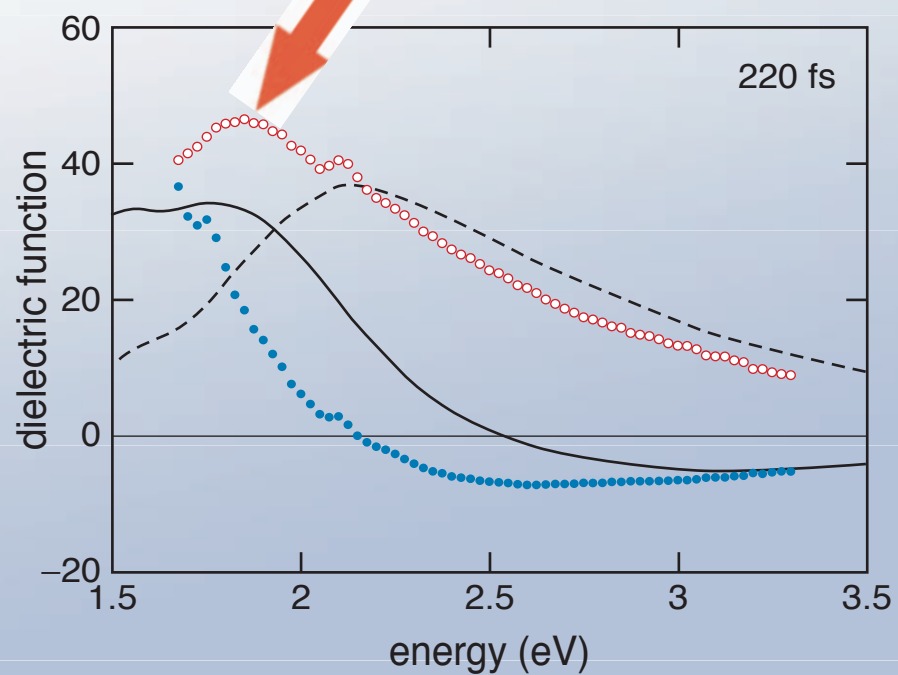
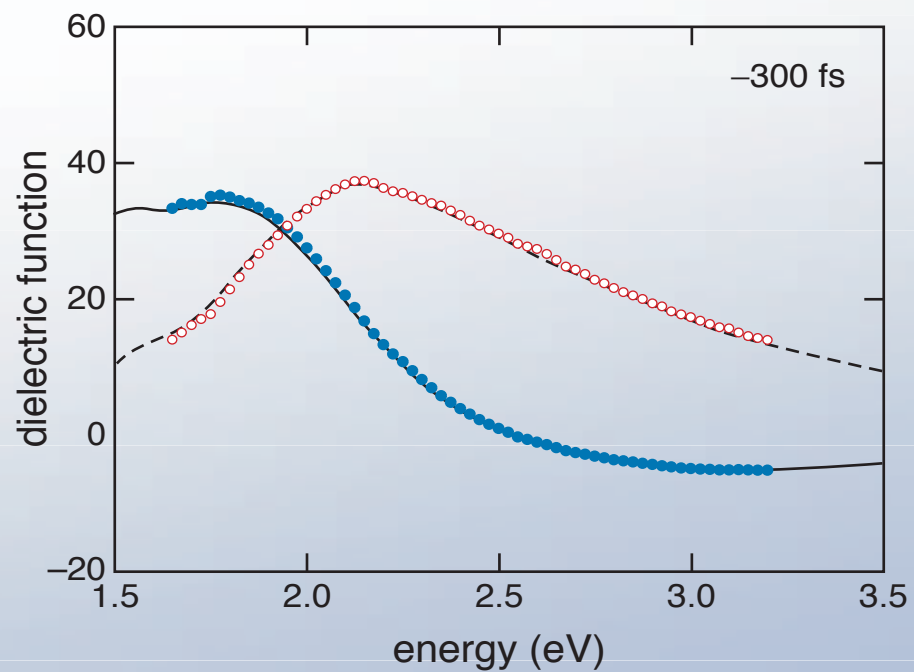
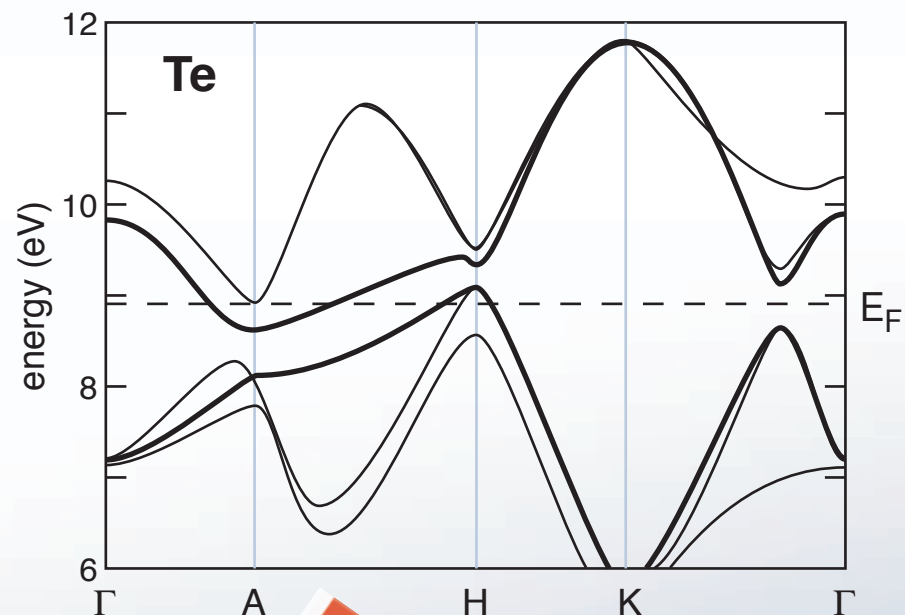
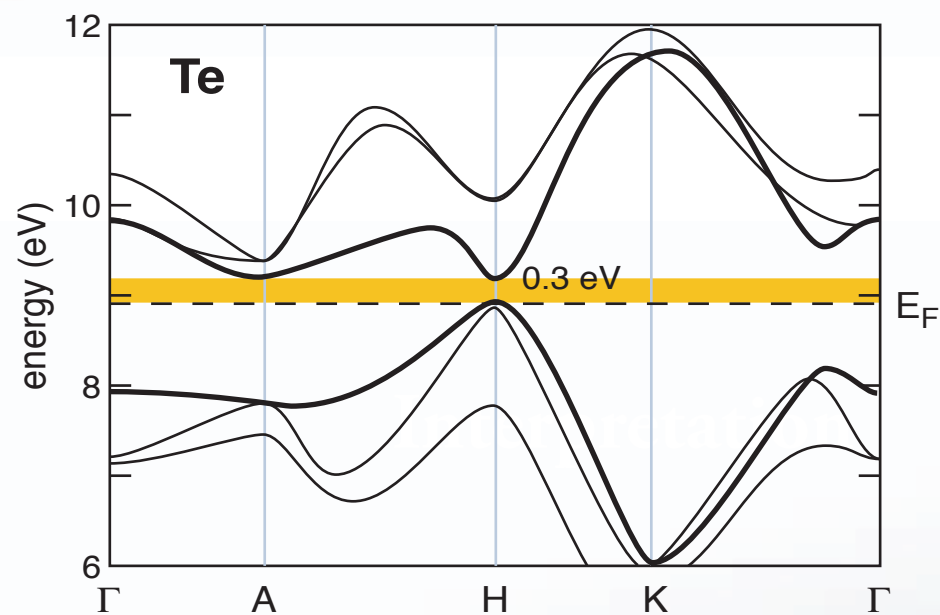
Highlights



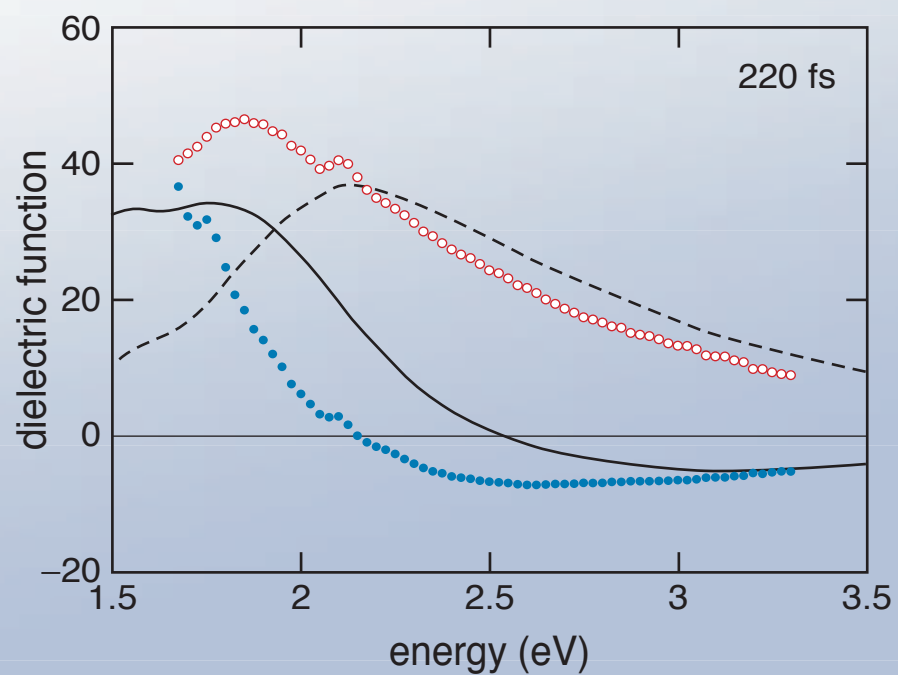
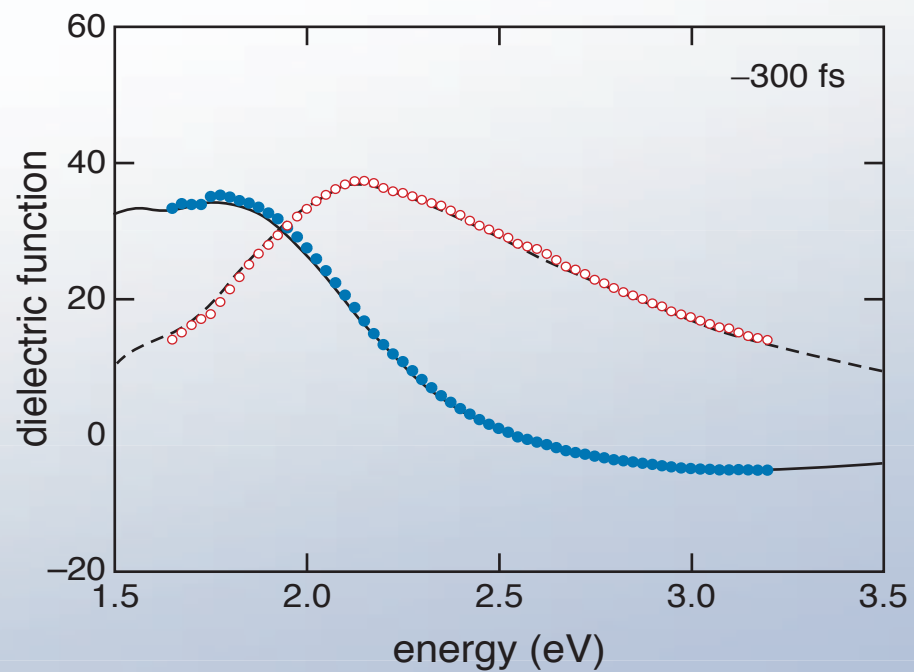
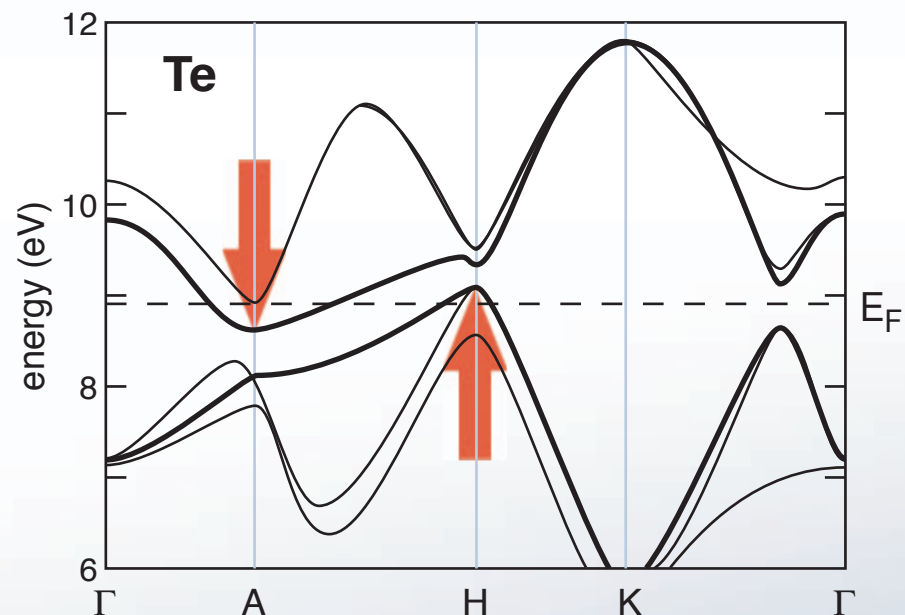
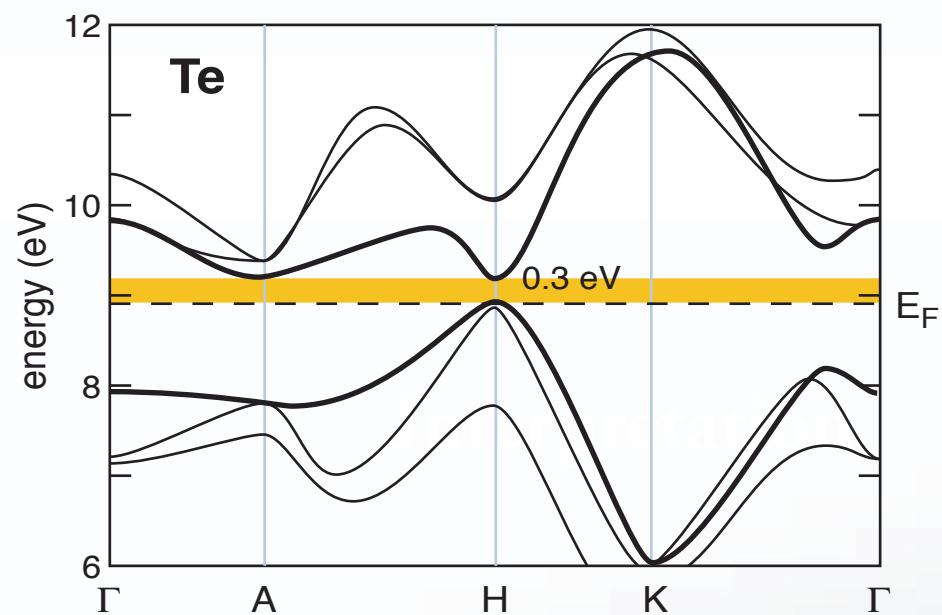
Highlights



Highlights



Highlights



Why Metals?

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Applications in electronics

Widespread use

Interesting ultrafast dynamics

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Why Thin Films?

Why Metals?

Applications in electronics

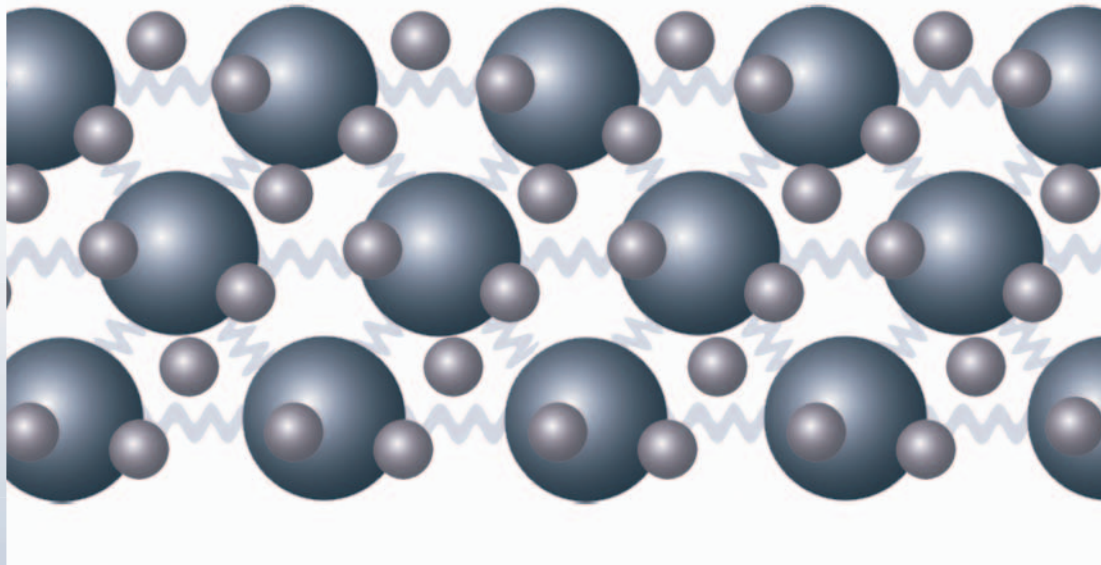
Widespread use

Interesting ultrafast dynamics

Why Thin Films?

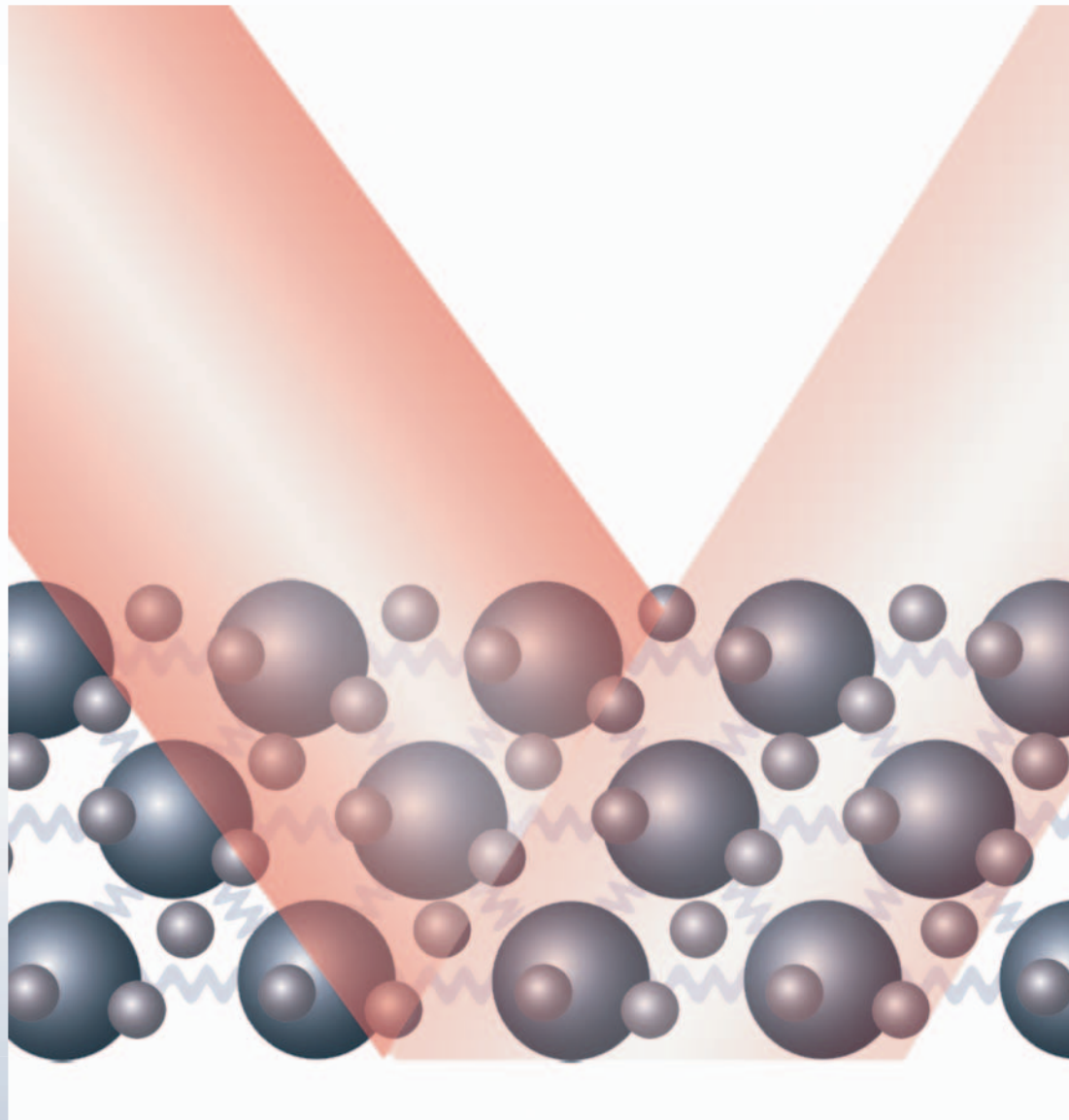
Confinement of electronic behavior

Electron Thermalization



unperturbed material

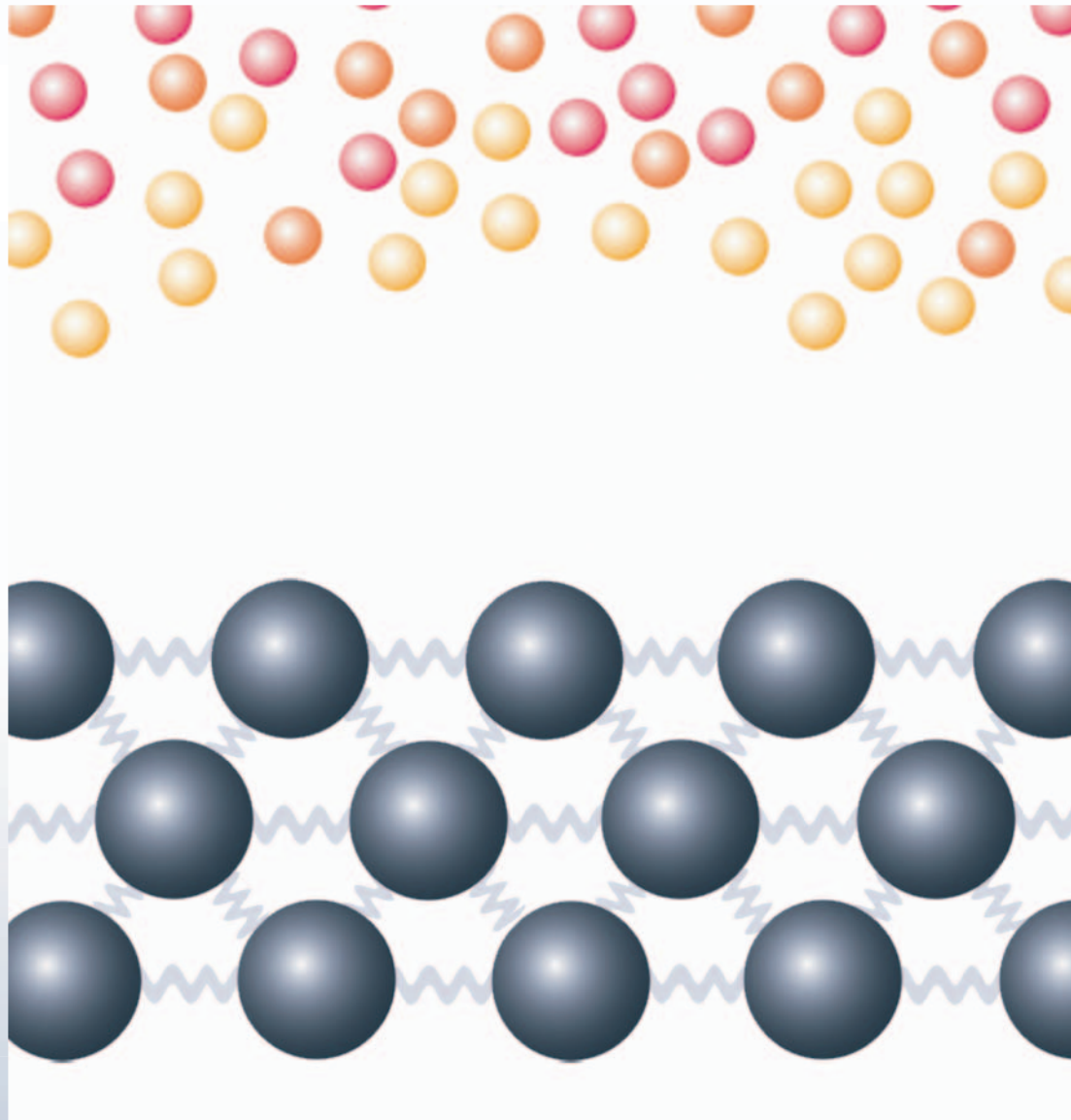
Electron Thermalization



$t = 0 \text{ fs}$

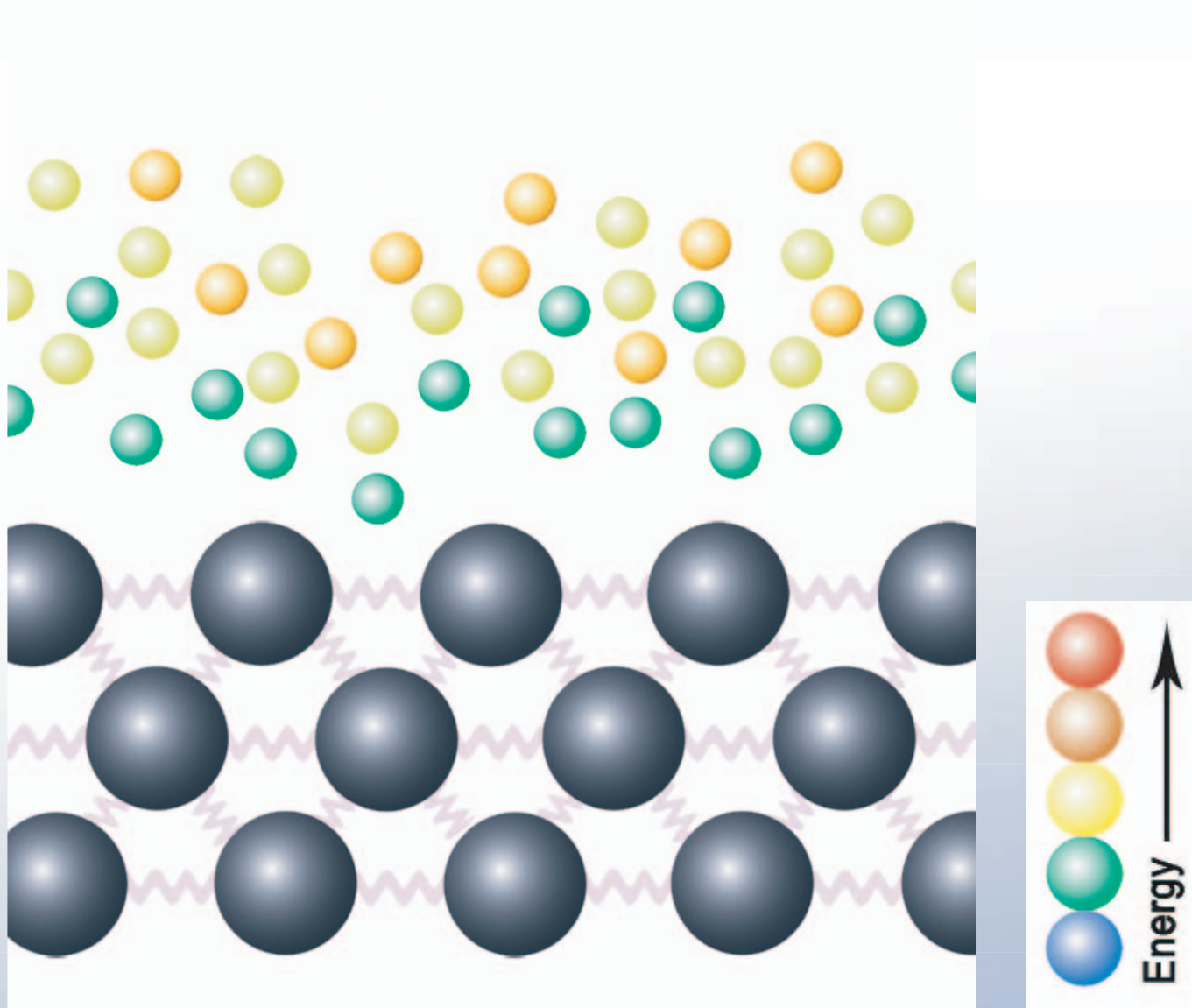
excite material with femtosecond pump pulse

Electron Thermalization



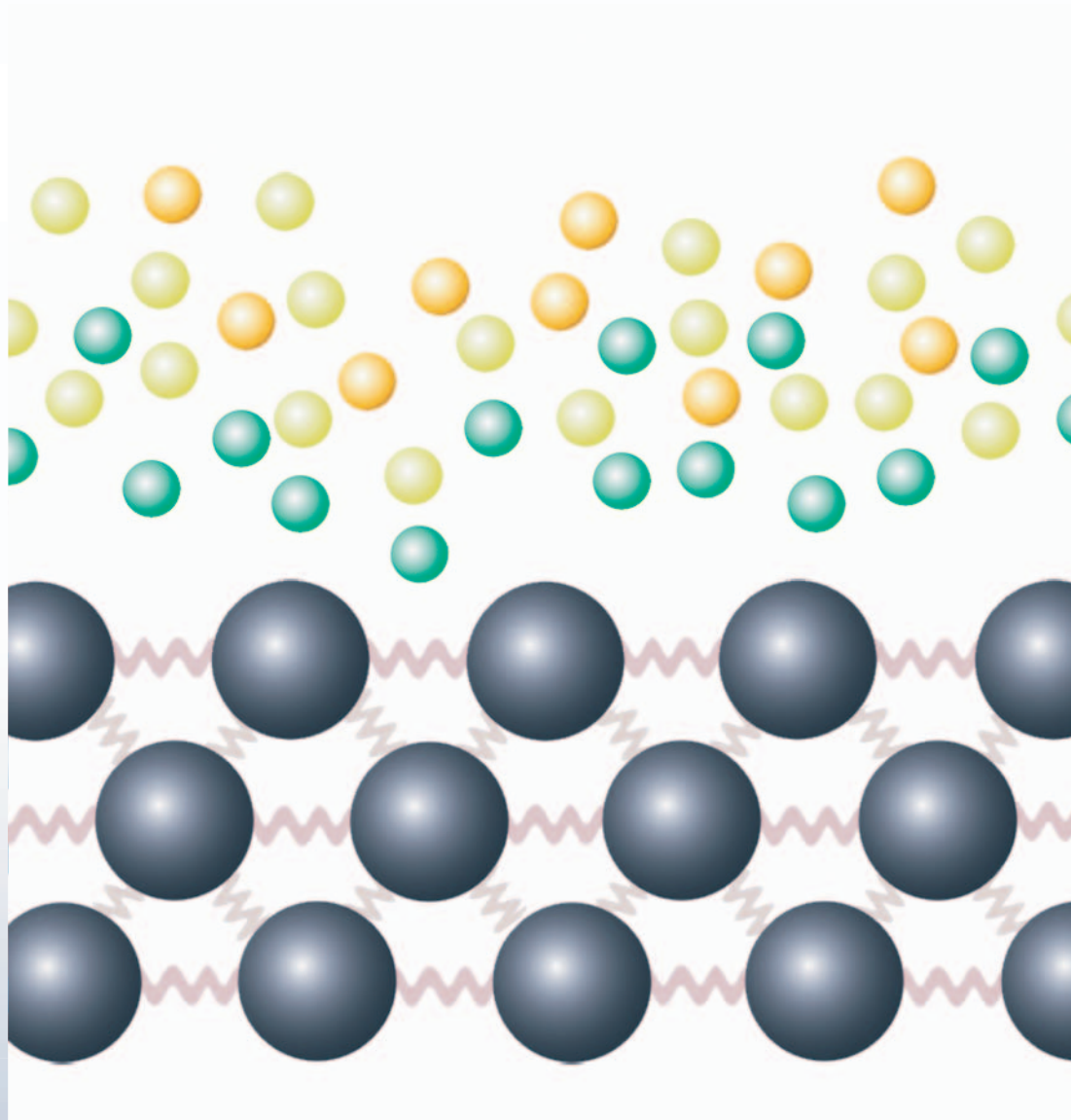
valence electrons are excited instantaneously

Electron Thermalization



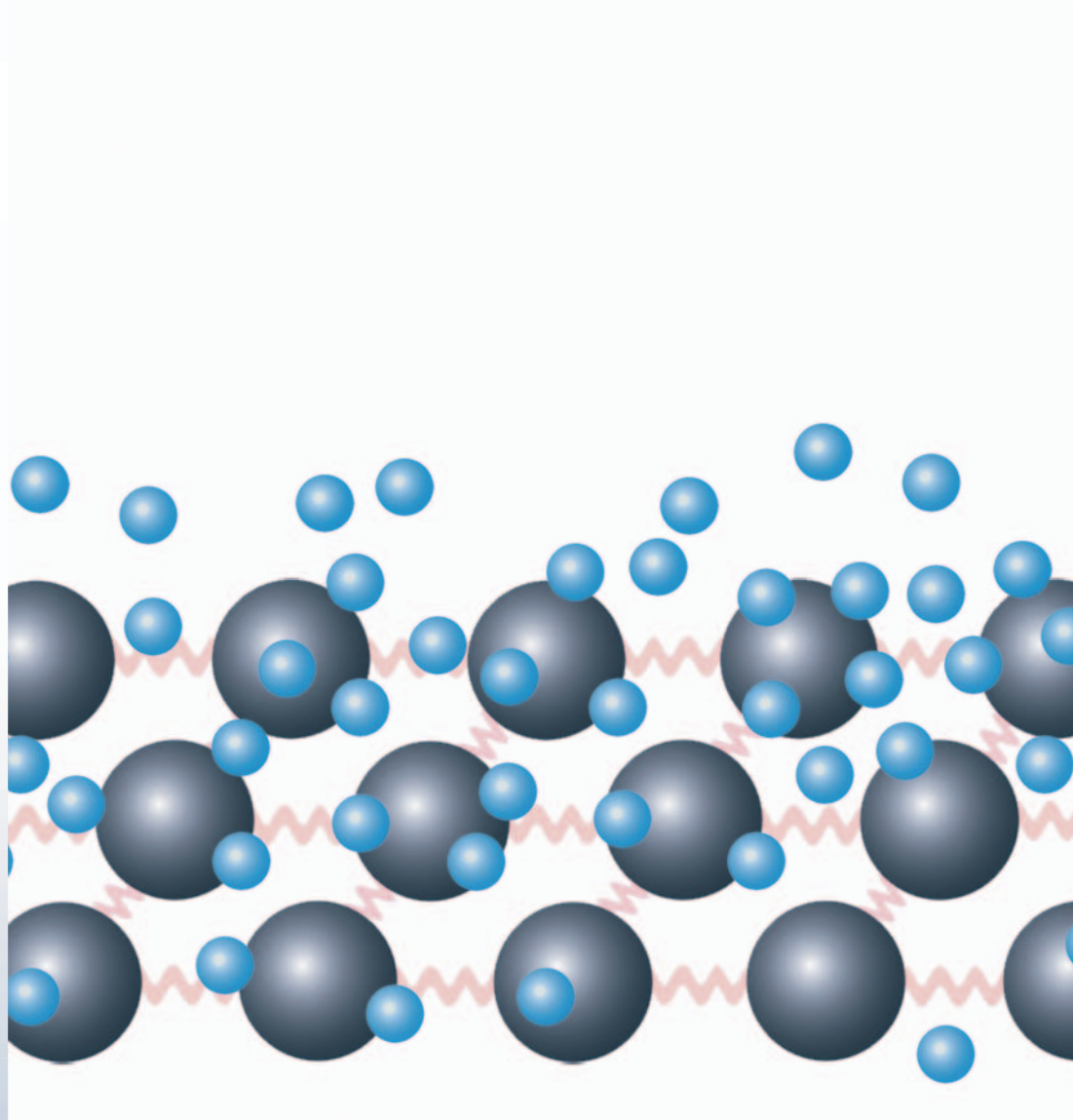
electrons interact with each other and with phonons

Electron Thermalization



electrons interact with each other and with phonons

Electron Thermalization

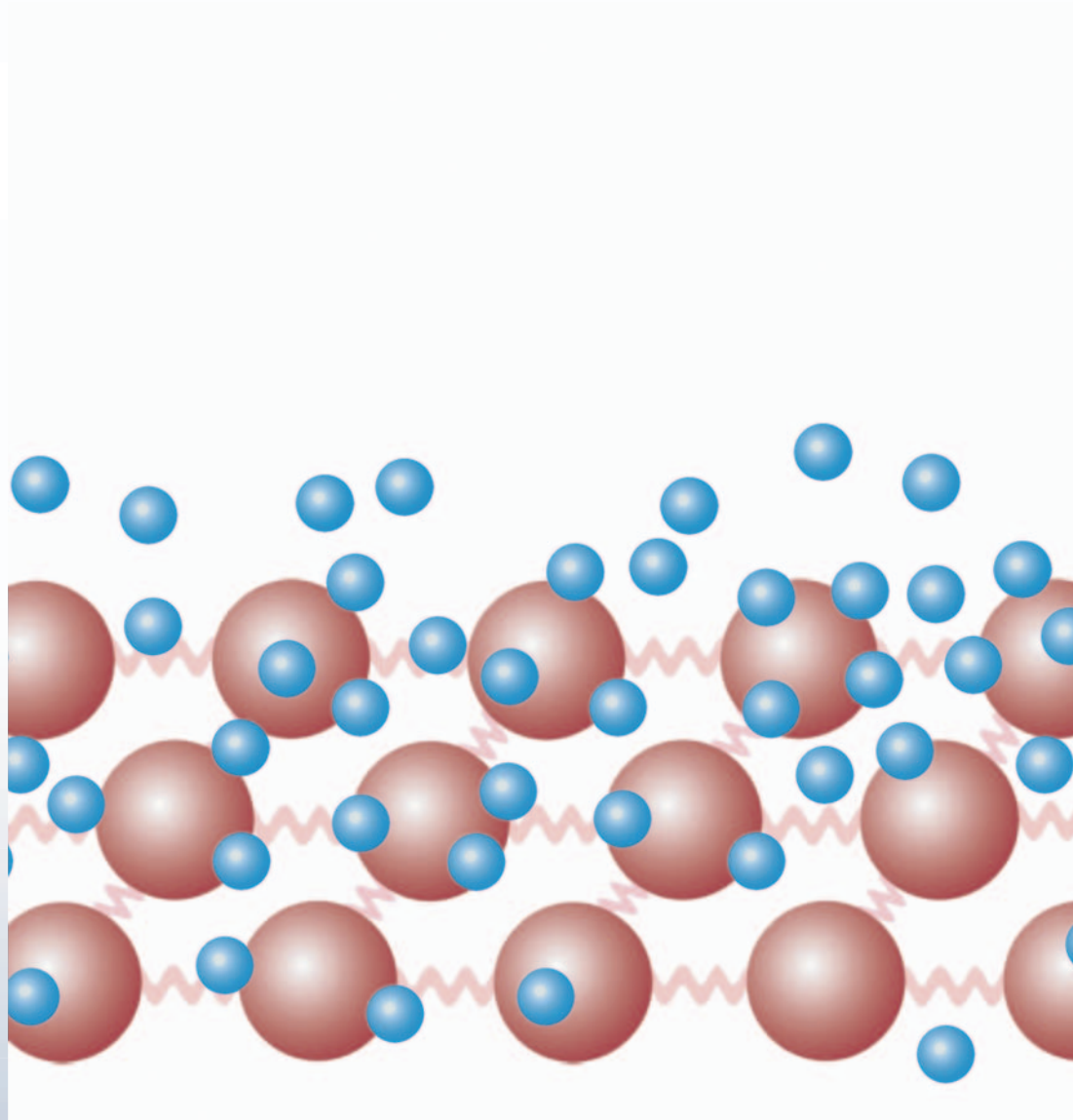


$t = 500 \text{ fs}$



electrons thermalize

Electron Thermalization

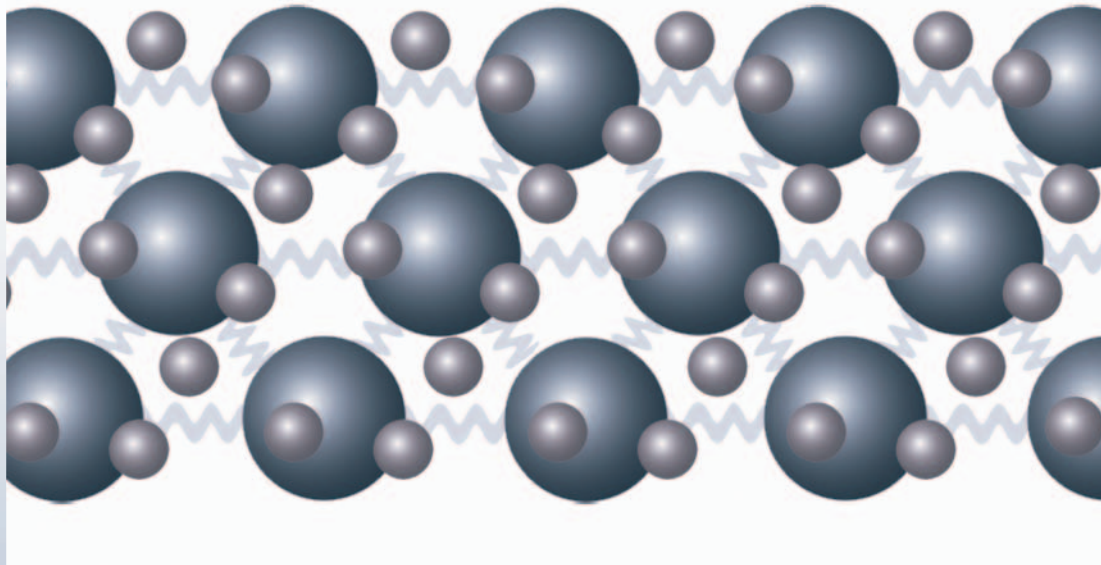


$t \sim 1 \text{ ps}$

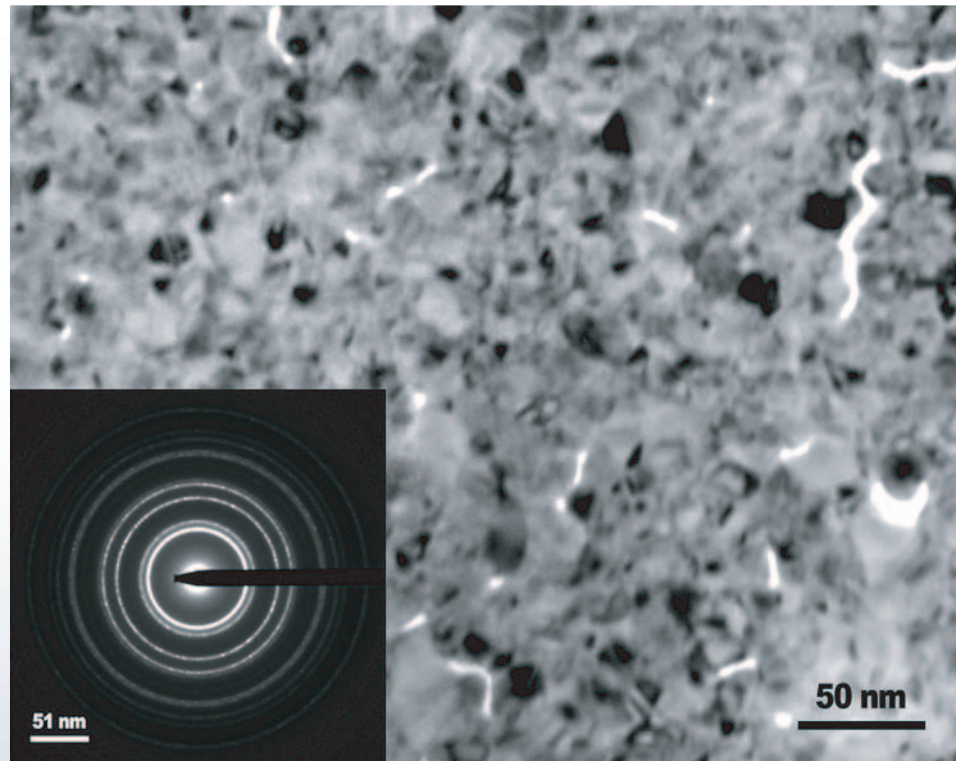


lattice thermalizes

Electron Thermalization



return to initial state



TEM image of 20-nm thick Gold Thin Film

Questions?

Thanks to the Mazur group

This research is supported by NSF funding