

# X-Ray Photoelectron Spectroscopy of TM:Ga<sub>2</sub>Se<sub>3</sub>

# Silicon Nanotechnology

Spintronic devices require a system that can generate a current of spin-polarized electrons. This is most easily accomplished with ferromagnetic materials.

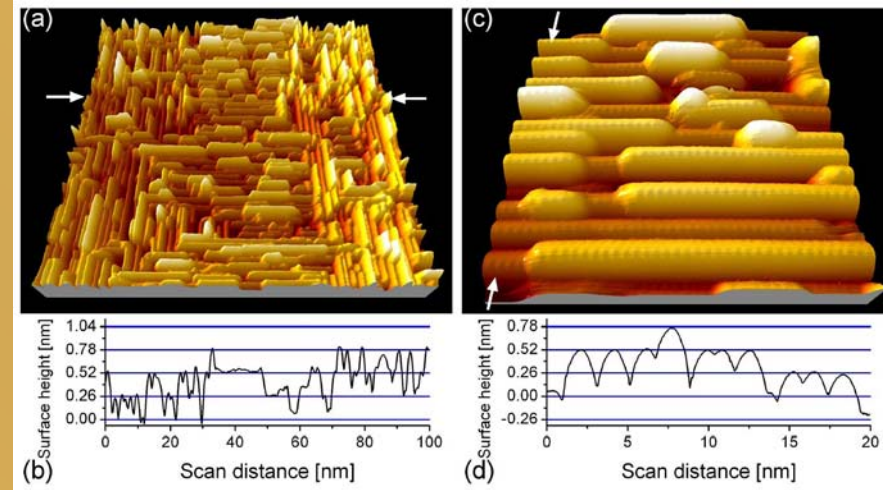
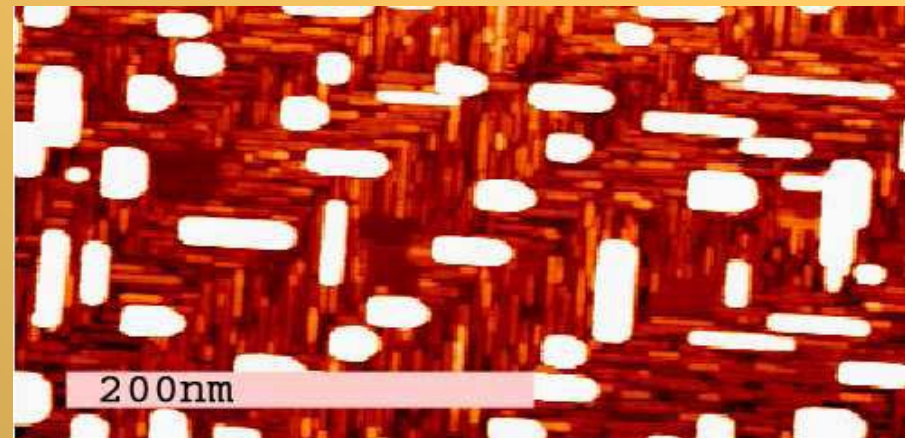
The incorporation of spintronics in silicon-based nanoelectrics requires a room temperature ferromagnet with spin-preserving transport through a silicon interface. Such a material has yet to be observed.

The Chalcogenides group at UW is looking at TM: Ga<sub>2</sub>Se<sub>3</sub> as a potential candidate material.

Previous work has shown that during growth on Si(001):As, the intrinsic vacancies in Ga<sub>2</sub>Se<sub>3</sub> spontaneously order to form nanoscale ridges.

Like similar Dilute Magnetic Semiconductors GaAs and GaN, TM:Ga<sub>2</sub>Se<sub>3</sub> will likely prove ferromagnetic at low TM concentrations

We wish to characterize the surface composition and bonding chemistry of thin films of TM:Ga<sub>2</sub>Se<sub>3</sub> via X-ray Photoelectron Spectroscopy.

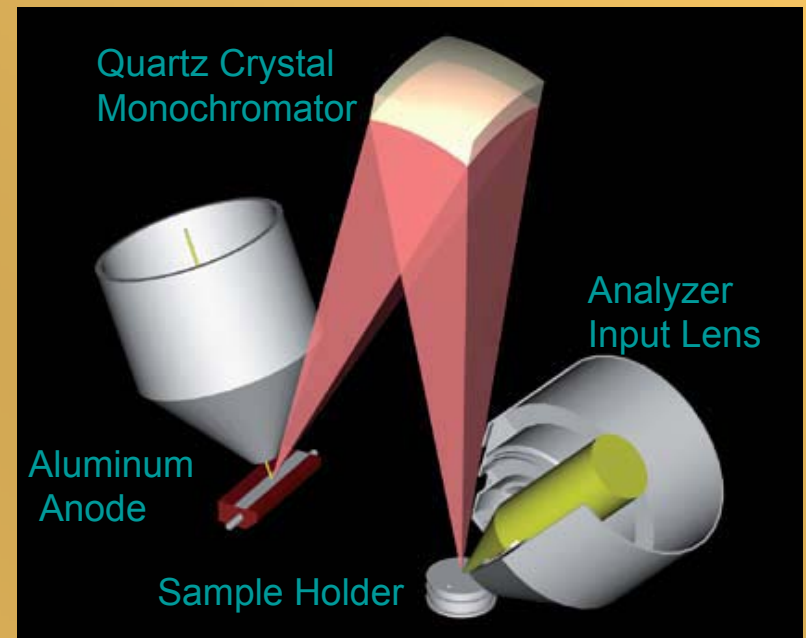
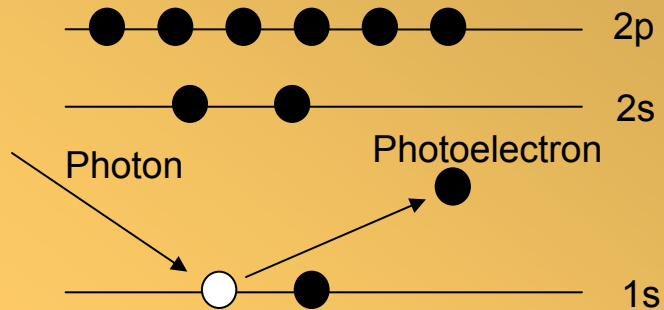


# Principles of XPS

X-ray Photoelectron Spectroscopy (XPS) is a surface analysis technique in which a sample is irradiated with monochromatized x-rays. Photons of energy  $h\nu$  cause the emission of electrons from core levels of the solid. The kinetic energy of the resulting photoelectrons is given by  $KE = h\nu - BE - \Phi$ . Electrons escaping the surface are collected and sorted by an energy analyzer.

## Hemispherical analyzer

- a  $1/r^2$  electric field between two concentric spherical surfaces
- the radius of the electrons' paths are proportional to their energy
- electrons with different energies are dispersed spatially
- the number of electrons at each energy is recorded, and an energy spectrum is constructed



# Features of the energy Spectrum

## Background

Background signal is comprised of electrons that undergo inelastic collisions before exiting the sample. Thus the background increases the as we probe deeper into the sample.

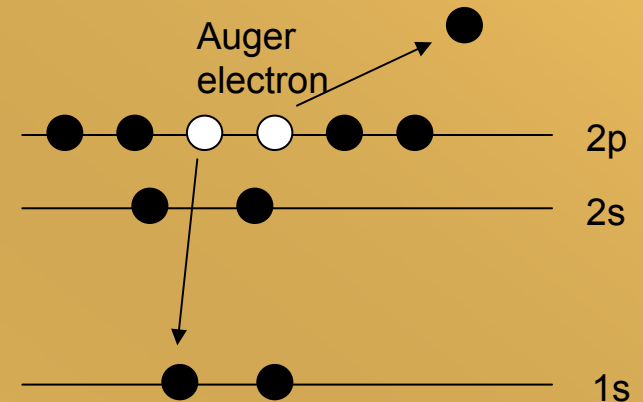
## Peak Types

- Photoelectron Lines

The “main peaks”: sharp lines due to core-level photoelectrons that reach the analyzer without undergoing inelastic loss.

- Auger Lines

Secondary electrons emitted after photoemission occurs as excited ions relax.



- Plasmon Lines

Energy loss to conduction electrons occurs in well-defined amounts. Photoelectron lines are mirrored at successive intervals of higher binding energy.

- Shake-Up Lines

Sattelites resulting from ions left in an excited state after photoemission

## What we can learn from XPS:

### Elemental Identification

Each element has a characteristic set of binding energies, producing a “signature” set of peaks in the spectrum.

### Concentration

Peak areas can be converted to atomic concentrations with the use of appropriate photoionization cross sections for various peaks.

### Chemical State Identification

Bonding with other elements changes the local electronic environment of an atom, thus altering the original binding energy of the electrons. This manifests as a shift in the photoelectron peak on the energy spectrum.

