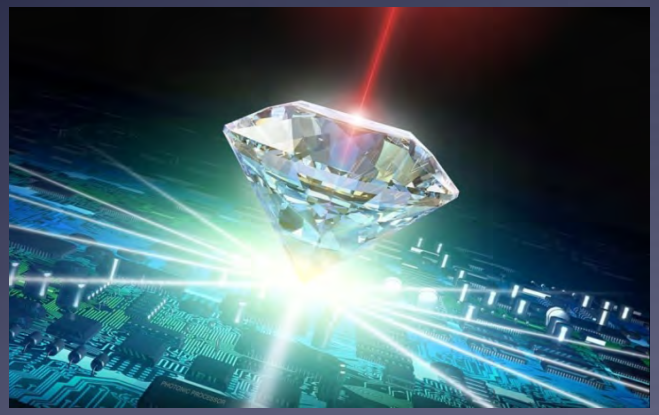
Nanodiamond Surface Effects



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INSET
Internships in Nanosystems, Science, Engineering and Technology

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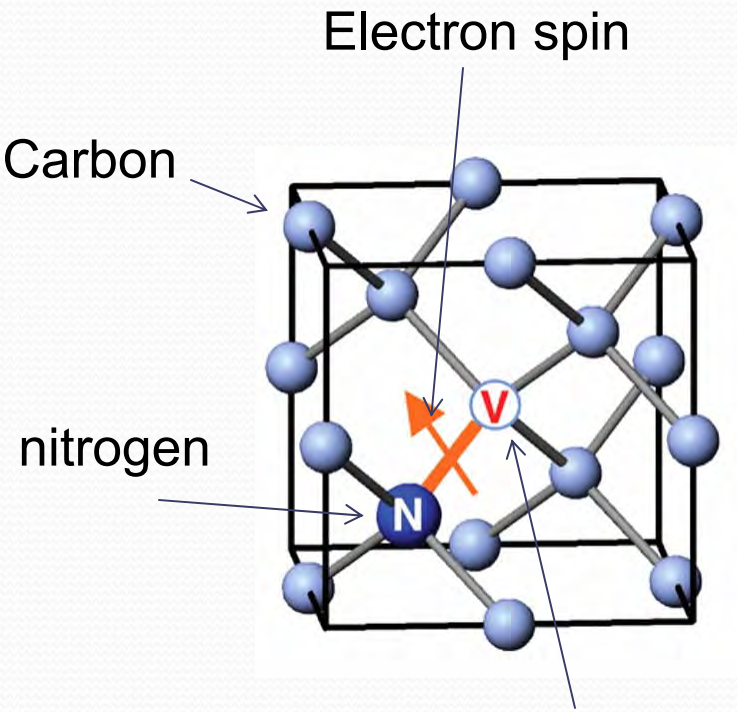
UNITED STATES AIR FORCE

Why nanodiamonds?

Properties

- Biocompatibility & nontoxicity
- Chemical stability
- Fluorescence from its defects



Potential applications

- Single particle tracking
- Cellular biomarkers (tumor targeting and cell imaging)

http://awsch-web.physics.ucsb.edu/research/solid_state/polarization/d2_figure_01.jpg

Problems

- Background noise complicates experiments
- Suspect they come from surface(50nm~100nm diamond has large surface area to volume ratio)

Goals

- Create a method to approximate nanodiamond concentration
- Surface cleaning
- Study of surface charge properties

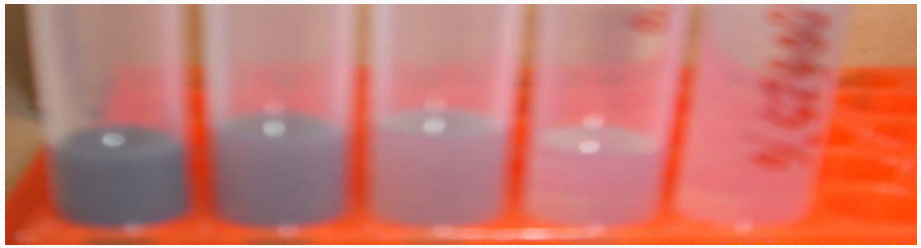
Concentration vs absorption

Dilution

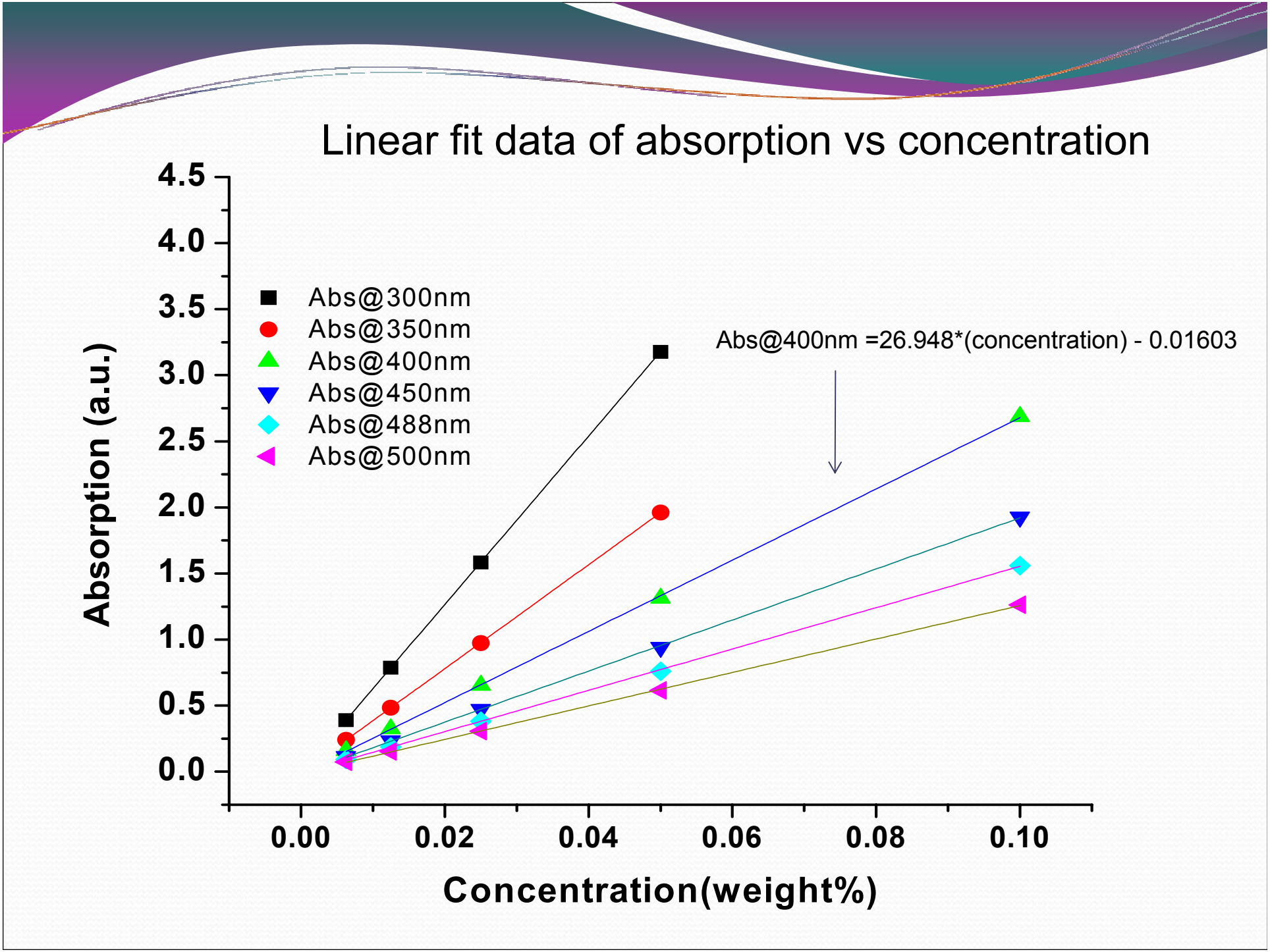
Run absorption scan using UV-vis spectrophotometer

Analyze the absorption as a function of concentration

Develop a method of figuring out the concentration of a nanodiamond solution easily



UV-vis spectrophotometer


Linear fit data of absorption vs concentration
Absorption (a.u.)
Concentration(weight%)
Abs@300nm
Abs@350nm
Abs@400nm
Abs@450nm
Abs@488nm
Abs@500nm
Abs@400nm =26.948*(concentration) - 0.01603
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.00
0.02
0.04
0.06
0.08
0.10

Surface cleaning

Centrifuge nanodiamond → Acetone treatment

↓

Rinse with millipore water and centrifuge the sample. Repeat 3 -4 times

↓

Resuspend treated nanodiamond in water for experiments

After surface treatment

- Excitation at 532nm
- Emission scan with fluorimeter
- Fluorescence comparison

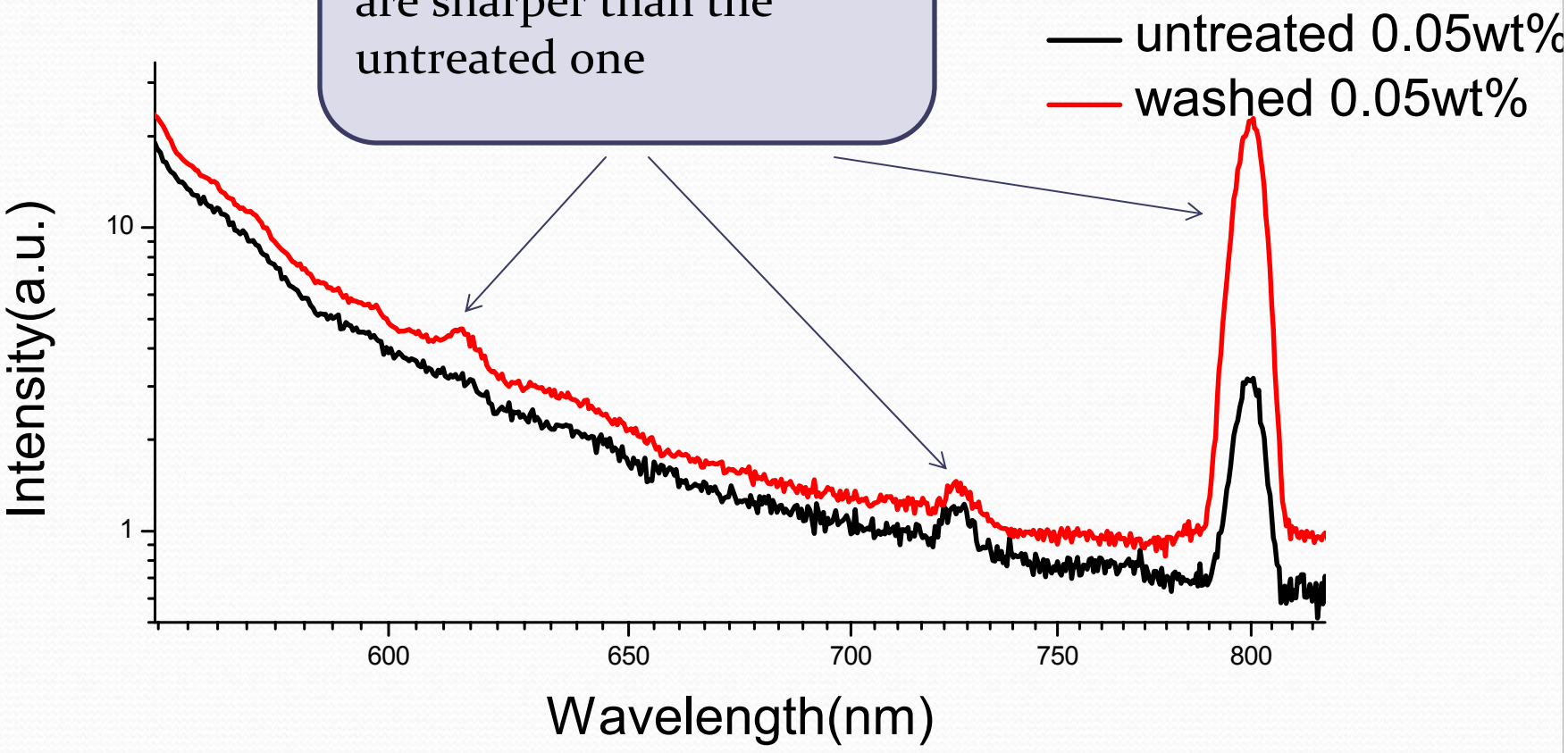
Cary Eclipse Fluorimeter

- Fluorimeter vs UV-vis spectrophotometer

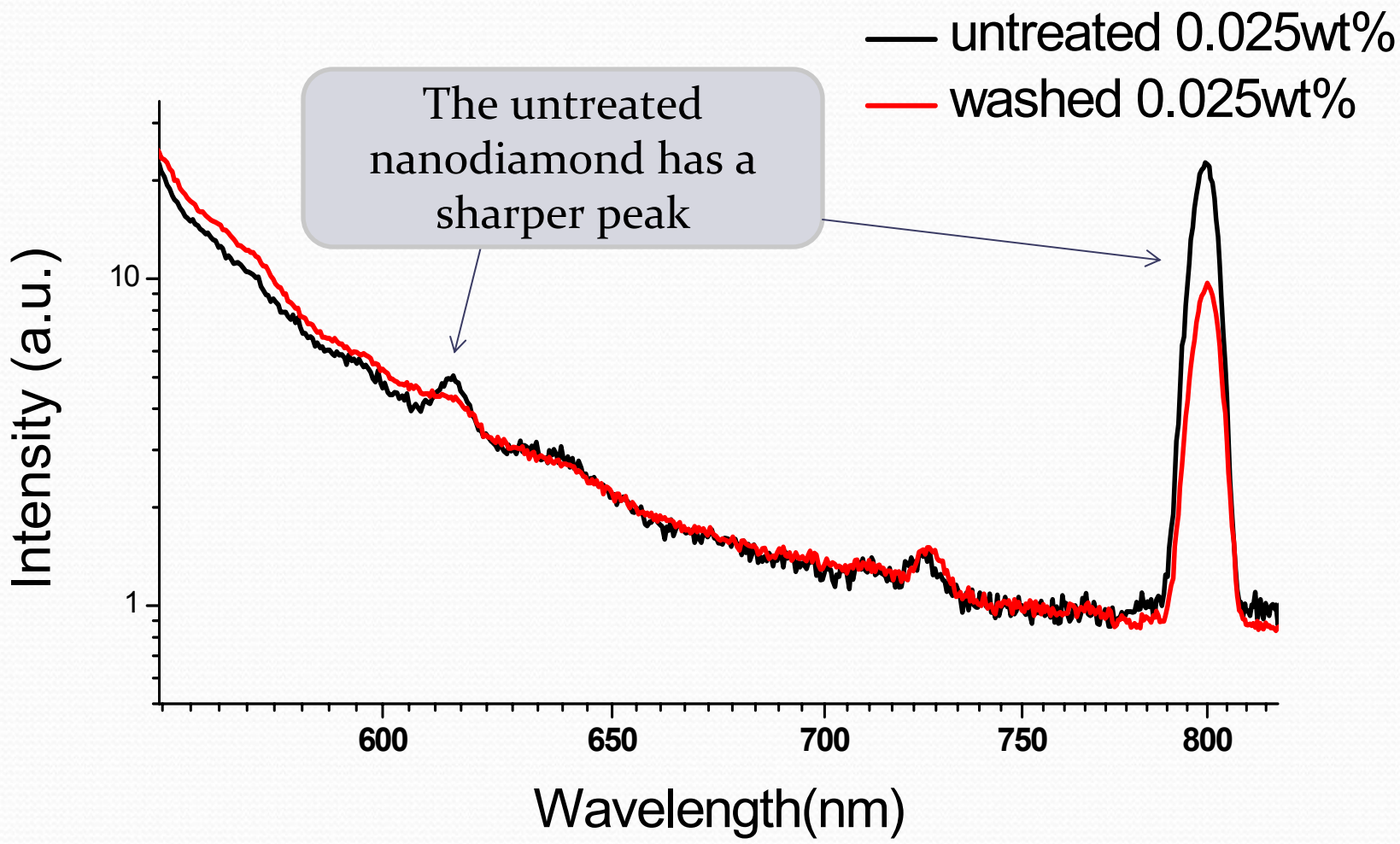
Fluorimeter	UV-vis spectrophotometer
Measures the light that is emitted from the sample, which is called fluorescence	Measures how much light being absorbed by the sample

Emission scan at 532nm

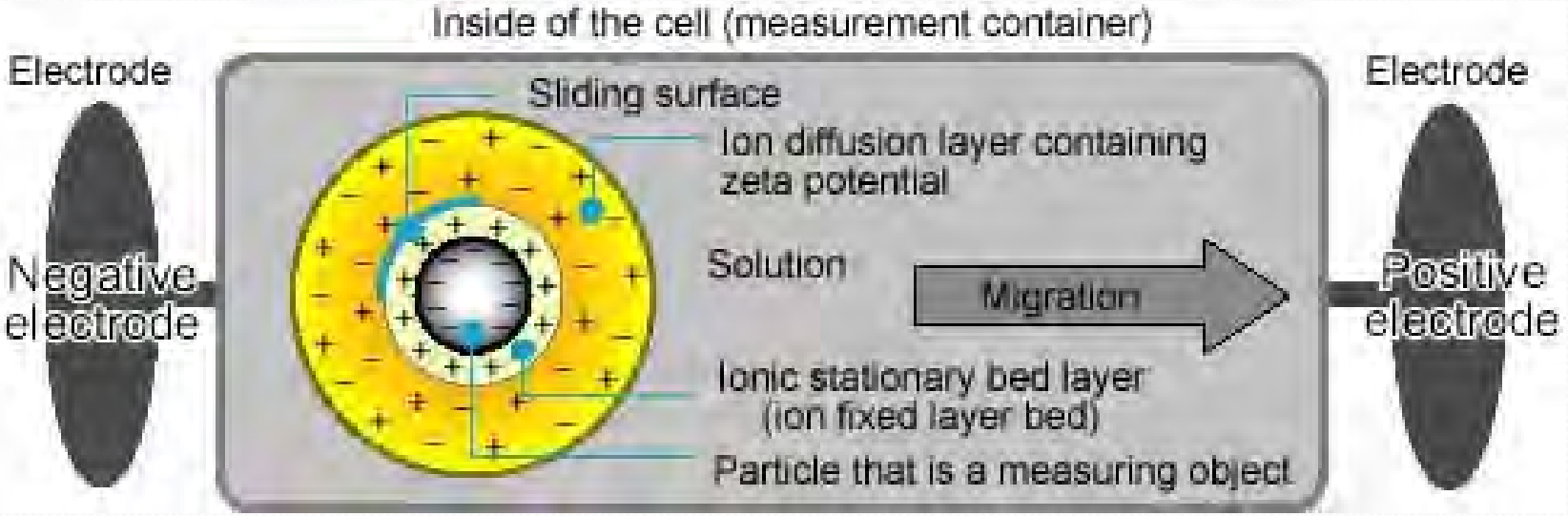
The fluorescent peaks of the washed nanodiamond are sharper than the untreated one



Emission scan at 532nm



What is zeta potential?



❖Measures the amount of surface charge

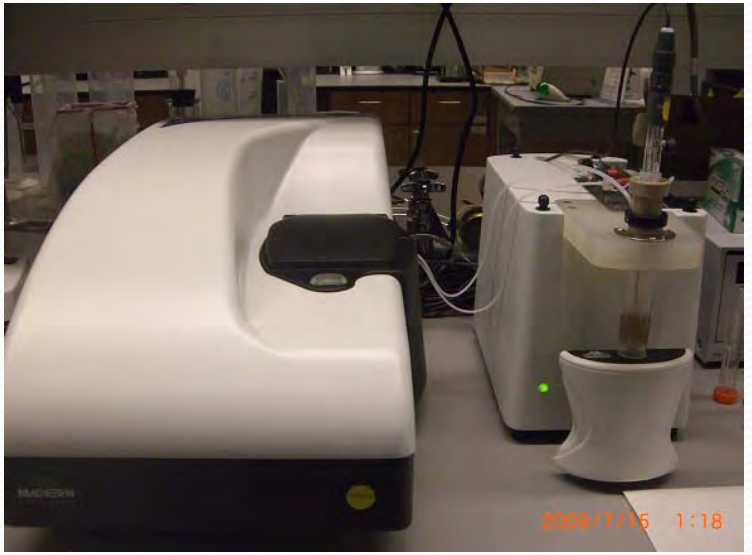
❖Potential between the diffuse layer and fixed layer is zeta potential

❖Factors

•Speed of particle

•Strength of E field

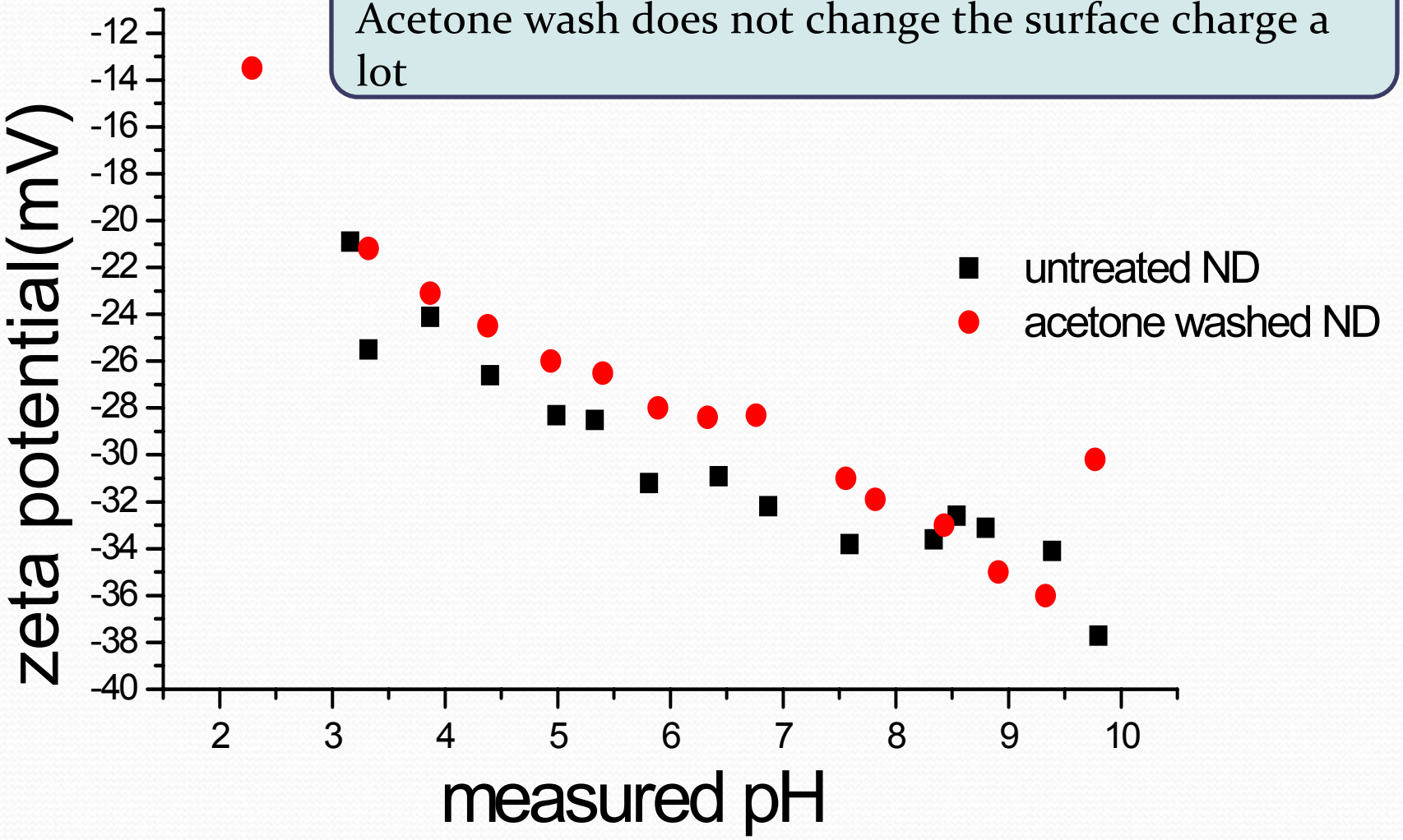
•Distance between the electrodes



http://nition.com/en/products/zeecom_s.htm

Zeta potential vs pH

Surface charge varies with pH
Acetone wash does not change the surface charge a lot



Future studies

- Clean the nanodiamonds with strong acid at high temperature

- Study if the surface charge properties affects the fluorescence of nanodiamonds through the emission scan with different pH in solution

Acknowledgements

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- Advisor: David Awschalom
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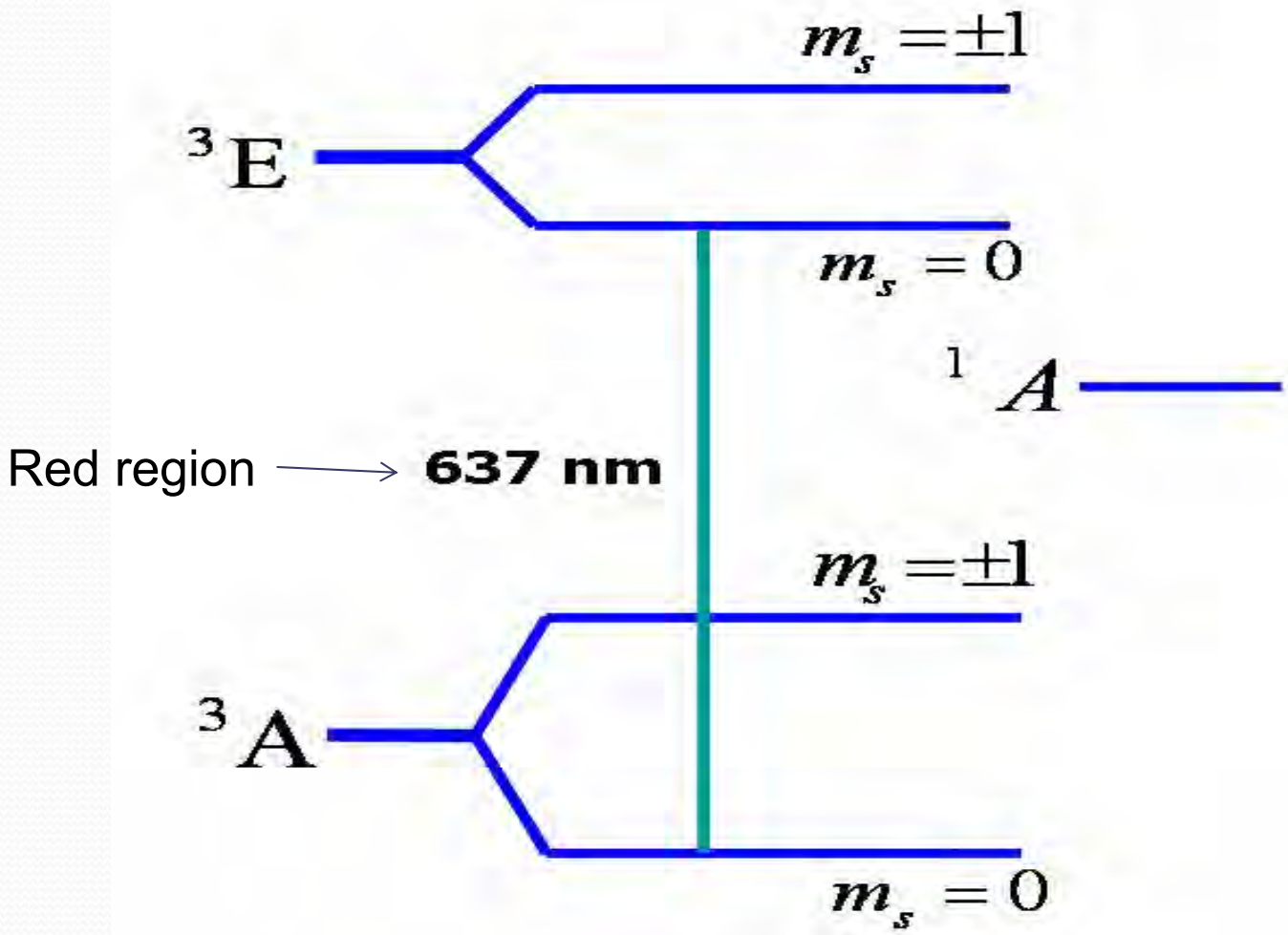
- Funding source: U.S. Air Force
- Reference: “Detonation nanodiamonds as UV radiation filter”
  “The particle size-dependent photoluminescence of nanodiamonds”

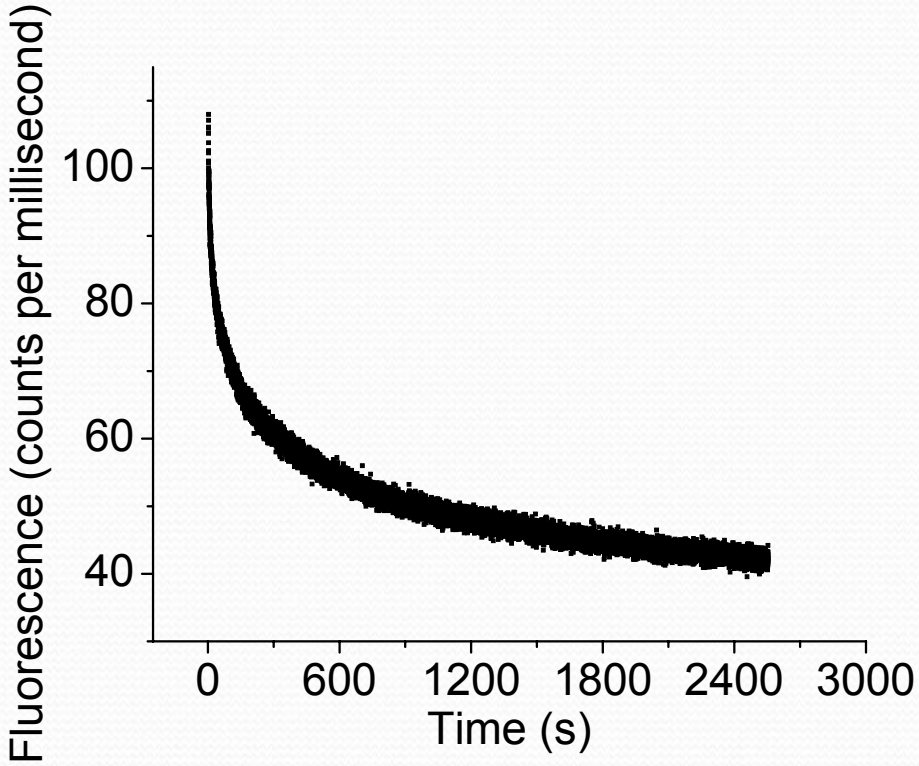
Thank you!

Energy band diagram



Nanodiamond in solution

Nanodiamonds photobleaching



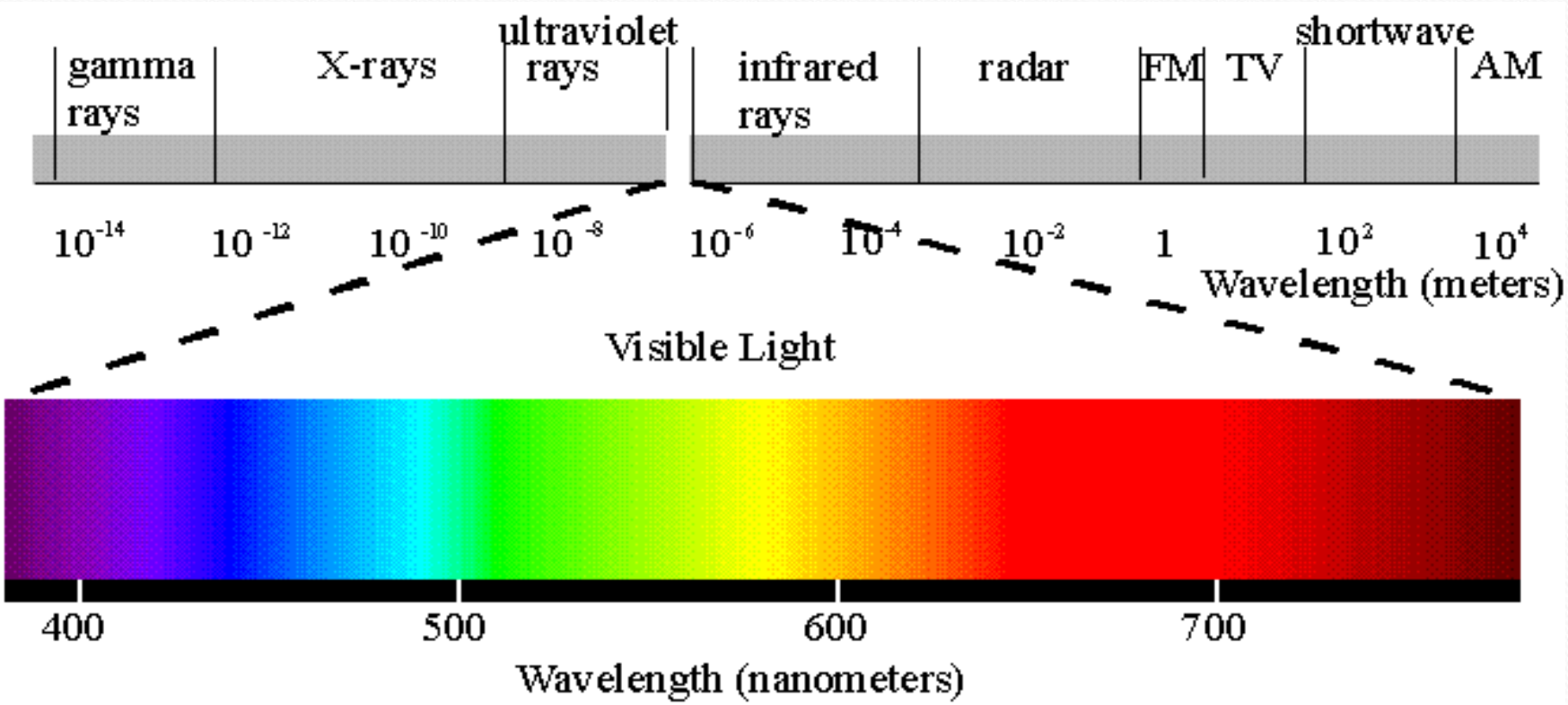
- Laser: 160mW, 532 nm
- **Photobleaching** is the photochemical destruction of a fluorophore. In microscope, photobleaching may complicate the observation of fluorescent molecules, since they will eventually be destroyed by the light exposure necessary to stimulate them into fluorescing. This is especially problematic in time-lapse microscopy.

Equation of zeta potential

$\mu e = 2 \varepsilon \boldsymbol{\zeta}\, \mathbf{f(Ka)}/3\eta$

- μe=the electrophoretic mobility $(\mu/s)/(V/cm)$
- ζ= zeta Potential (mV)
- ε= dielectric constant of the medium
- η= viscosity of the medium
- F(ka)=Function of particle radius

Light spectrum



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Visual Stimulus

http://www.dnr.sc.gov/ael/personals/pjpb/lecture/spectrum.gif

Questions

- How is the orientation of spin relate to intensity of fluorescence? Does it relate to the energy band?
- Why single photon emission results in high resolution imaging in application