Designing nanodiamonds for sensing applications

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Introduction and motivations

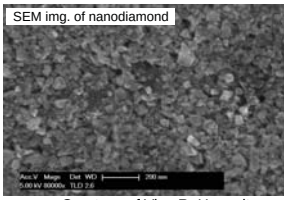
Nanodiamond is known for its biocompatibility, nontoxicity and chemical stability. It is a new and exciting material that holds promises for many biomedical applications.

Nitrogen vacancy center

- Consists of a substitutional nitrogen atom with a neighboring vacancy
- Defect spin is sensitive to surrounding magnetic field
- The electronic spin state is related to the intensity of the fluorescence
- Act as a single photon emitter
- Never photobleaches

Applications

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



Courtesy of Viva R. Horowitz

Problems

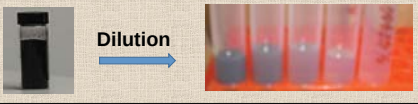
- Unknown photobleaching fluorophores result in background noise during laser scanning
- Suspected to come from surface due to large surface area to volume ratio
- Using laser to eliminate photobleaching fluorophores is a time consuming process

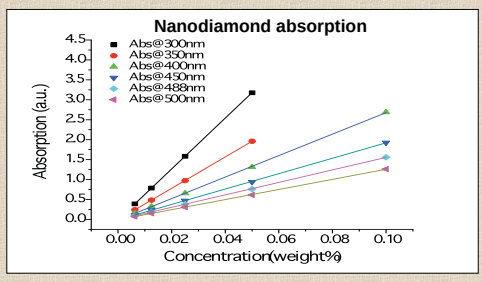
Goals

- Develop a method to estimate concentrations of nanodiamond solutions
- Surface cleaning
- Characterize surface charge properties

Sample background

❖Detonation nanodiamond, formed by detonation of explosive mixture of TNT/RDX

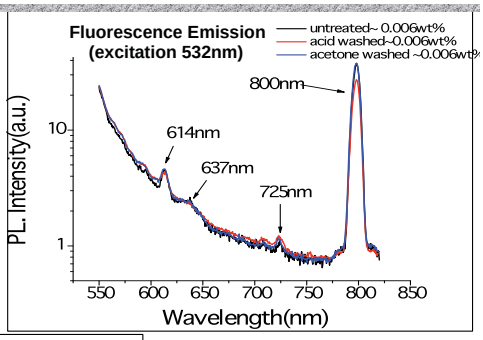




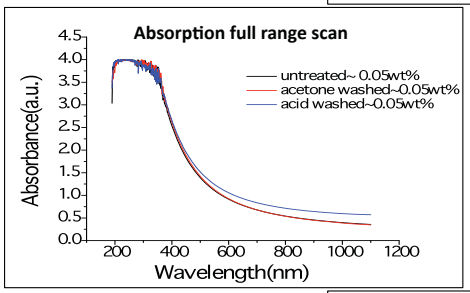
❖Linear fit data of absorption vs. concentration

Surface cleaning

❖Acetone wash
❖H_2SO_4/HNO_3(3:2)

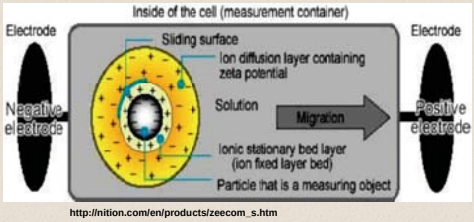


- The fluorescence peaks are consistent
- Unknown fluorescent peaks appear before and after surface treatment
- NV content in nanodiamond is very low



- The absorption of the nanodiamond solution does not change much after surface treatment
- Absorbs mostly ultra violet light (Due to SP2 structure)

Zeta potential

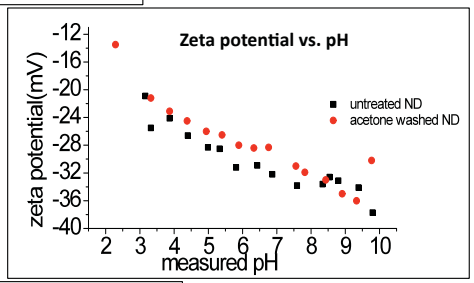


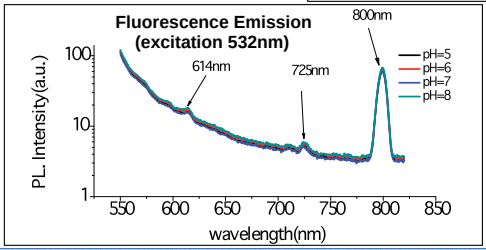
http://nition.com/en/products/zeecom_s.htm

Factors:
- Speed of particle
- Strength of electric field
- Distance between electrodes

Zeta potential measures of the amount of charge on the surface of the particle

- Zeta potential decreases as pH increases
- Surface becomes more negatively charged as pH increases
- Acetone washed and untreated ND have similar charge distribution





- Different pH provides different surface charge.
- The fluorescence is independent of surface charge

Conclusions

- Both the acetone cleaning and acid treatment don't change the fluorescent and absorption results much.
- The zeta potential further supports that the acetone wash does not change the surface properties much.
- The fluorescence of nanodiamonds is independent of surface charge

Future plans

- Longer and more intensive acid treatment
- AFM/ TEM measurements
- Zeta potential measurement of the acid washed nanodiamond

Acknowledgments
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References
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- *Surface Science* 601 (2007) 3866-3870

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