

# Nanodiamond for Biomedical Applications

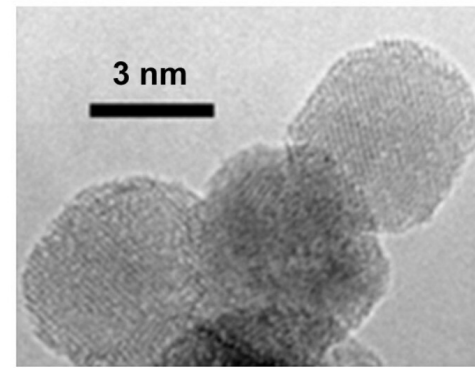
Ivan Rios-Mondragon

Dept. of Physics and Technology, and Dept. of Clinical Dentistry  
University of Bergen

ITAPA 2024



# Introduction to Nanodiamonds



Kaur et. al., Int. J. Nanomedicine 2013

## What are Nanodiamonds (NDs)?

- Carbon-based nanoparticles with unique optical and mechanical properties.
- Small size (2-10 nm) with diamond core structure.
- Nitrogen-vacancy (NV) centers enable optical and magnetic sensitivity.

## Why NDs for Biomedical Applications?

- Biocompatibility, modifiable surfaces, stable fluorescence.
- Ideal for targeted drug delivery, bioimaging, and sensing.



# Properties of Nanodiamonds

## Key Properties

- Biocompatible and non-toxic for in vivo applications.
- Fluorescence without photobleaching due to nitrogen-vacancy (NV) centers.
- Surface functionalization for attaching drugs, proteins, and other biomolecules.

## Advantages in Biomedicine

- High stability in physiological environments.
- Versatility in interacting with various biological molecules.
- Easy to integrate into different biomedical systems.



# Drug Delivery Applications

## NDs as Drug Carriers

- High surface area and functional groups allow effective drug loading.
- Controlled drug release to target specific cells or tissues.

## Example Applications

- Cancer treatment: Delivery of doxorubicin directly to tumors.
- Gene delivery: Transport of nucleic acids with reduced degradation.

## Benefits

- Enhanced bioavailability of drugs.
- Reduced side effects by targeted delivery.



# Bioimaging and Diagnostics

## Fluorescent Nanodiamonds (FNDs)

- NV centers provide bright, stable fluorescence.
- Resistant to photobleaching, ideal for long-term imaging.

## Applications in Imaging

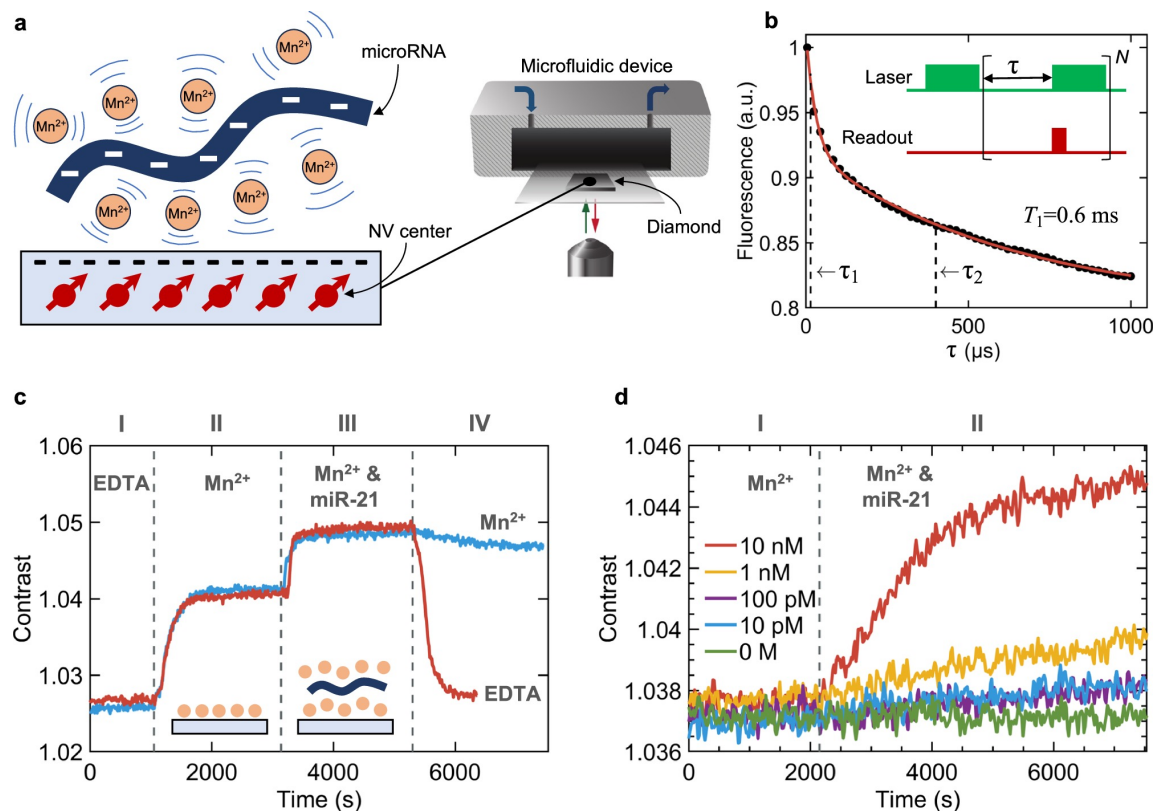
- Cellular imaging to monitor processes at the nanoscale.
- Diagnostic imaging for real-time tracking of biological molecules.

## Quantum Sensing Potential

- Detect temperature, pH, magnetic and electric fields, and pressure at cellular levels.



# Quantum sensing of miRNAs



# Tissue Engineering and Implant Coatings

## NDs in Tissue Scaffolds

- Enhances scaffold strength and supports cell adhesion and growth.
- Encourages differentiation in bone and cartilage regeneration.

## Coatings on Medical Implants

- Antimicrobial properties to reduce infection risk.
- Improves durability and biocompatibility for long-term implants.

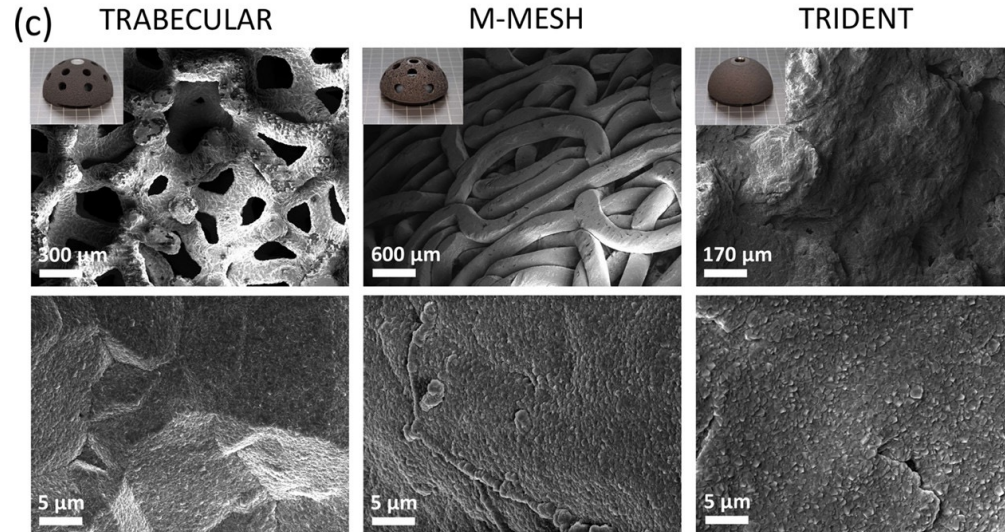
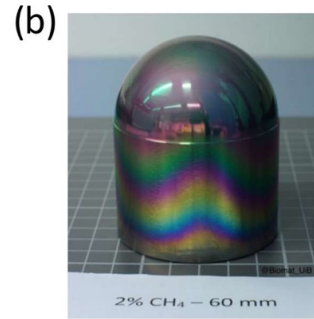
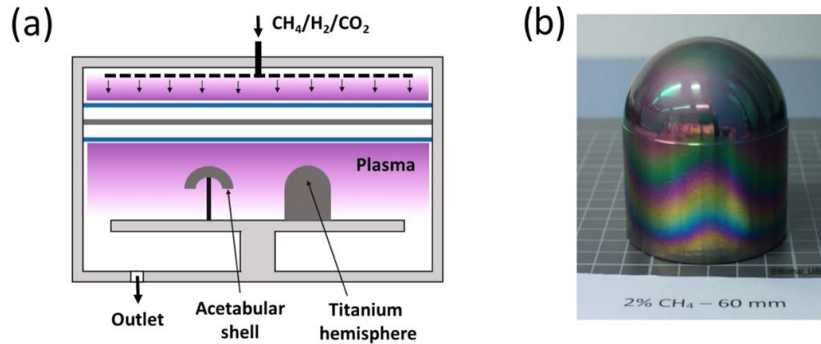
## Benefits for Tissue Engineering

- Promotes healing and reduces inflammation in implantable devices.



# Coating of implants with nanodiamond films

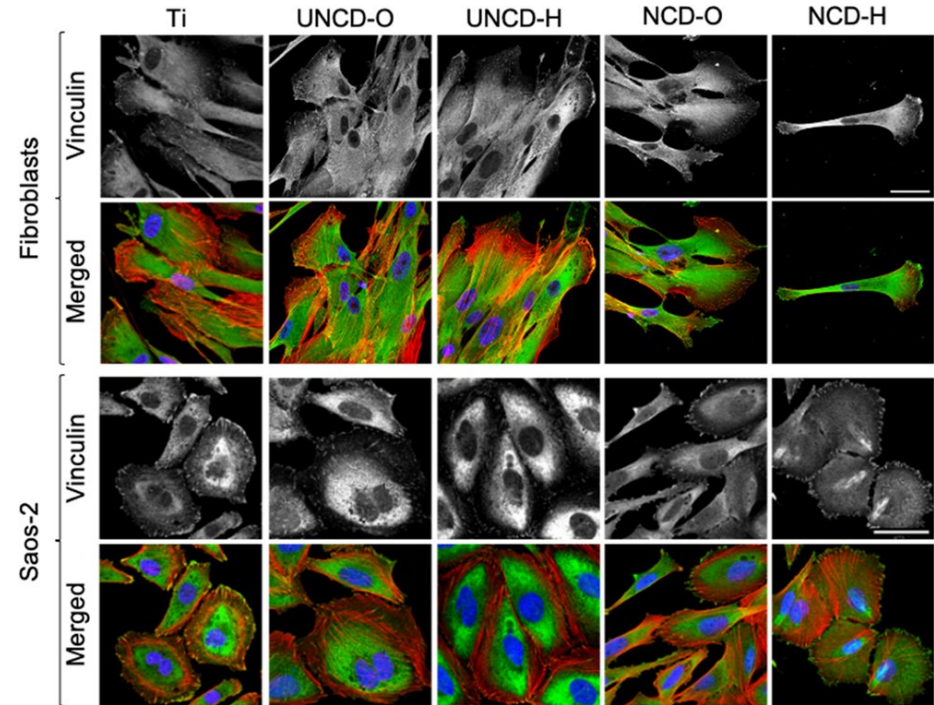
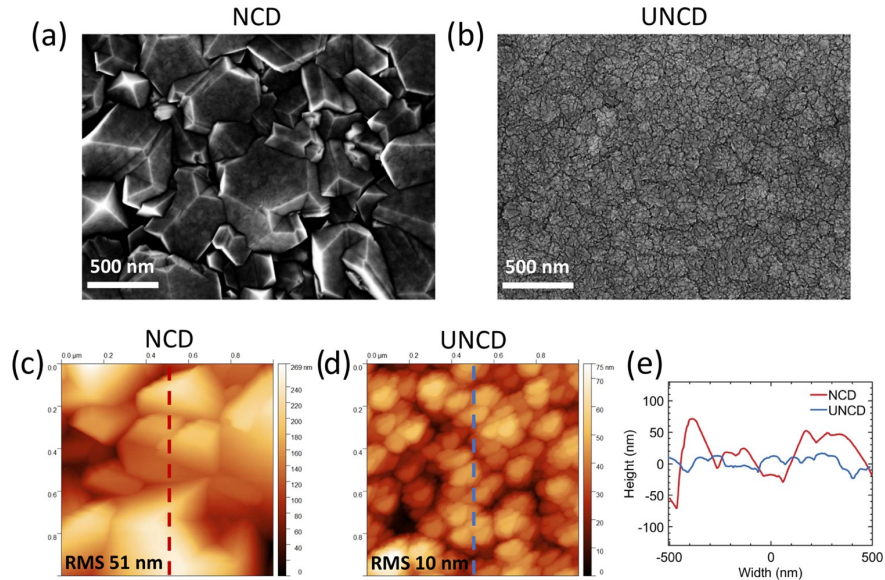
Coating of 3D objects by surface wave plasma chemical vapour deposition





# Phys-chem properties of diamond films

Surface roughness and chemical termination can be tuned to control cell growth



# Challenges and Limitations

## Manufacturing and Scalability

- Need for consistent production with uniform properties.
- Challenges in scalable surface functionalization methods.

## Biocompatibility and Safety

- Long-term toxicity studies and regulatory approvals required.
- Stability and accumulation in the body are concerns.

## Device Integration and Cost

- Difficulty in maintaining ND properties within devices.
- High production costs hinder large-scale implementation.



# Future Perspectives

## Advances in ND Production

- Focus on cost-effective, scalable synthesis methods.
- Improved surface functionalization for precise targeting.

## Potential Applications in Biomedicine

- Real-time diagnostics, neurotherapeutics, and theranostics.
- Integration in multi-functional devices for imaging and therapy.

## Path to Clinical Translation

- Address safety and regulatory standards.
- Continued research into biocompatibility and clearance pathways.



## Nanophysics Group



Dr. Justas Zalieckas  
**Lead researcher**  
justas.zalieckas@uib.no



Assoc. Prof.  
Martin Greve



Prof. Bodil Holst



Marit Hougen  
(PhD candidate)

Johannes Fiedler (Postdoctoral fellow)

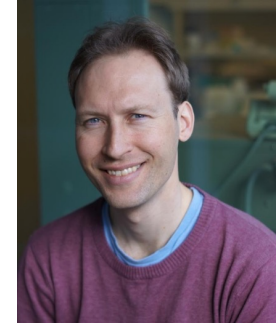
Katharina Hauer (PhD candidate)

Swayamprakash Sahoo (PhD candidate)

## Biomaterials Research Cluster



Prof. Mihaela R.  
Cimpan



Dr. Paul Johan Høl

## Haukeland University Hospital

Prof. Geir Hallan

Prof. Ove N. Furnes



[uib.no](http://uib.no)