ITMO UNIVERSITY

Saint Petersburg, Russia

Creation of light-emitting structures based on CdSe nanoplatelets

Ruslan Azizov

PhD student 1st year

Scientific supervisor: Sergey Makarov

Faculty of Physics

Introduction

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Light-emitting structures based on CdSe nanoplatelets

Advantages of CdSe nanoparticles:
1) Narrow photoluminescence band
2) Short photoluminescence lifetime
3) Low Auger recombination rate

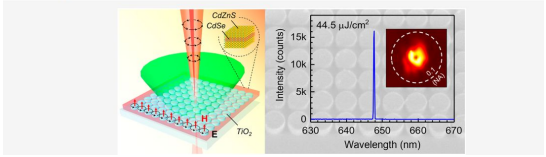
Disadvantages of CdSe nanoparticles :
1) High photochemical degradation rate
2) Large number of nonradiative energy relaxation channels

Articles, underlying proposed approach:

NANO LETTERS

Room-Temperature Lasing in Colloidal Nanoplatelets via Mie-Resonant Bound States in the Continuum

Mengfei Wu,[⊥] Son Tung Ha,[⊥] Sushant Shendre, Emek G. Durmusoglu, Weon-Kyu Koh, Diego R. Abujetas, José A. Sánchez-Gil, Ramón Paniagua-Domínguez, Hilmi Volkan Demir,* and Arseniy I. Kuznetsov*



Ultralow Threshold Optical Gain Enabled by Quantum Rings of Inverted Type-I CdS/CdSe Core/Crown Nanoplatelets in the Blue

*Savas Delikanli, Furkan Isik, Farzan Shabani, Hamed Dehghanpour Baruj, Nima Taghipour, and Hilmi Volkan Demir**

Single-Mode Lasing from a Single 7 nm Thick Monolayer of Colloidal Quantum Wells in a Monolithic Microcavity

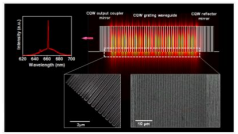
*Sina Foroutan-Barenji, Onur Erdem, Savas Delikanli, Huseyin Bilge Yagci, Negar Gheshlaghi, Yemliha Altintas, and Hilmi Volkan Demir**

Self-Resonant Microlasers of Colloidal Quantum Wells Constructed by Direct Deep Patterning

Negar Gheshlaghi, Sina Foroutan-Barenji, Onur Erdem, Yemliha Altintas, Farzan Shabani, Muhammad Hamza Humayun, and Hilmi Volkan Demir*

NANO LETTERS

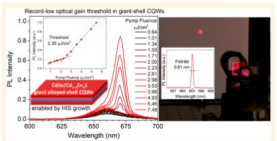
Cite This: *Nano Lett.* 2021, 21, 4598−4605



Giant Alloyed Hot Injection Shells Enable Ultralow Optical Gain Threshold in Colloidal Quantum Wells

Yemliha Altintas,[†,‡,⊥] Kivanc Gungor,[†,⊥] Yuan Gao,[§,⊥] Mustafa Sak,[†] Ulviyya Quliyeva,[†] Golam Bappi,[§] Evren Mutlugun,[*,†,‡] Edward H. Sargent,[*,§] and Hilmi Volkan Demir[*,†,∥]

ACSNANO



Purpose of research

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Development and experimental investigation of resonant nanostructures based on CdSe nanoplatelets for low-threshold laser generation

(full research cycle including numerical modelling, fabrication and post-processing of CdSe NPL films, and measurement of emission characteristics)

PLAN for 2021-2025

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Refinement of solution-based fabrication methods for creation of CdSe NPL films

- Spin coating
- Self-assembly

Development of designs of optical resonators (metasurfaces) for CdSe photoluminescence enhancement and lasing

- Fourier modal method calculations
- Full wave numerical modelling

Fabrication of optical resonators from CdSe films

- Laser ablation / force lithography / focused ion beam milling / …

Experimental studies of the fabricated structures

- Photoluminescence -> Amplified spontaneous emission -> Lasing with optical pump

Exploring the possibility of electrically pumped lasing in CdSe nanostructures

Designing the carrier injection layers -> numerical modelling -> fabrication -> testing -> repeat

Results: Work plan

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1) Calculations of high Refractive index layer thickness

2) Synthesis of ini CdSe NPL solution

3) Creation of CdSe NPL films by spin-coating method on Silicon substrate

4) Measuring the roughness and thickness of films on AFM setup

5) Applying an additional TiO_2 layer to silicon substrates

6) Refractive index measurements of the TiO_2 and CdSe layers

7) Creation of CdSe NPL films by Self-Assembling method

8) Measuring the roughness of films on AFM setup

9) Creation of CdSe NPL films modified substrates

10) ASE measurements

1) Calculation of TiO_2 layer thickness

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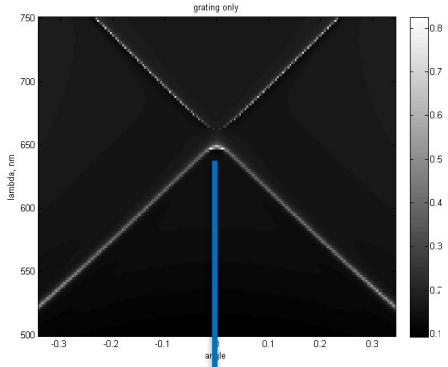

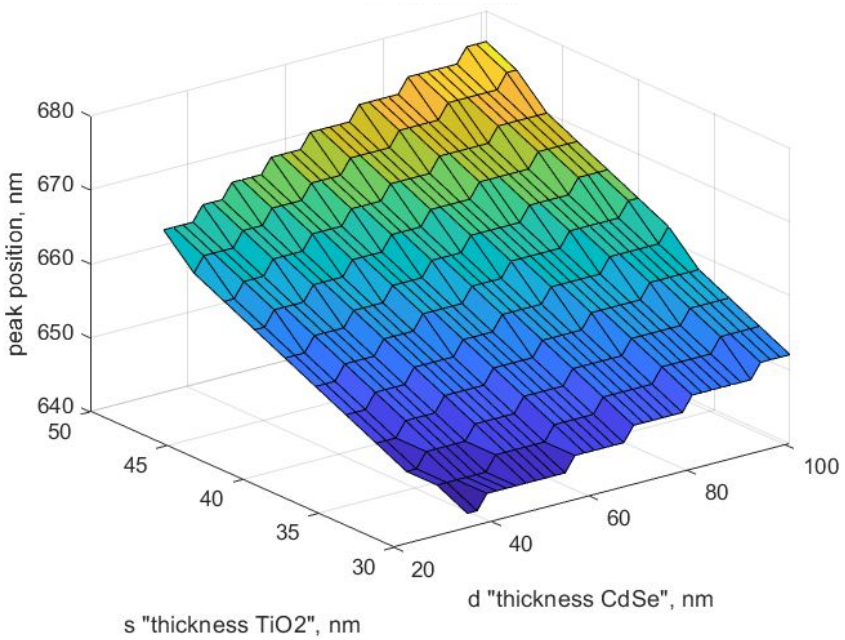

Estimated layer thicknesses:

TiO_2 (nm)	CdSe (nm)
38	47
36	49
34	59
32	69
30	81

2) Synthesis of ini CdSe NPL solutions

Two groups of solutions were prepared:
1) Centrifugation of the ini solution, and then redissolution of the precipitate in hexane
2) Centrifugation of the supernatant and then redissolution in hexane or toluene

Progress

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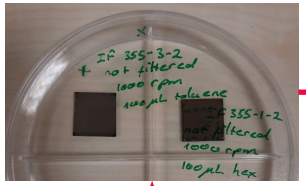
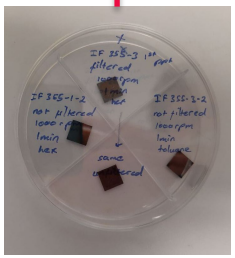
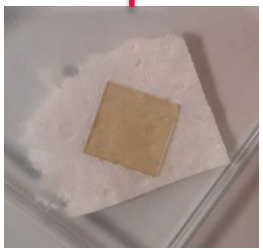
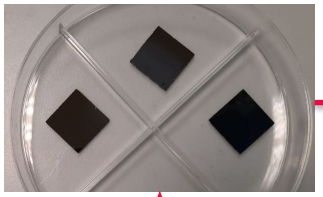


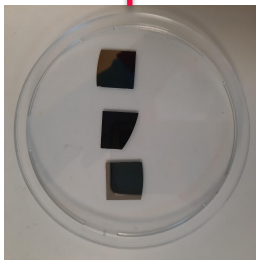


3) Spin-coating on Silicon substrate



5) Self-Assembling on Quartz substrate



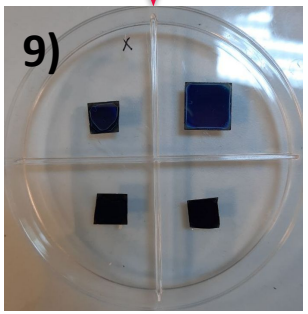


7) Applying TiO_2 layer to substrate

CdSe NPL

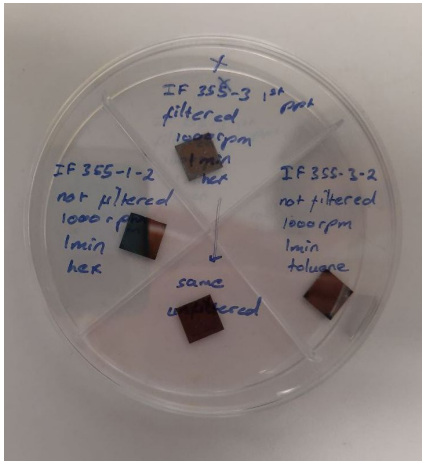
TiO_2

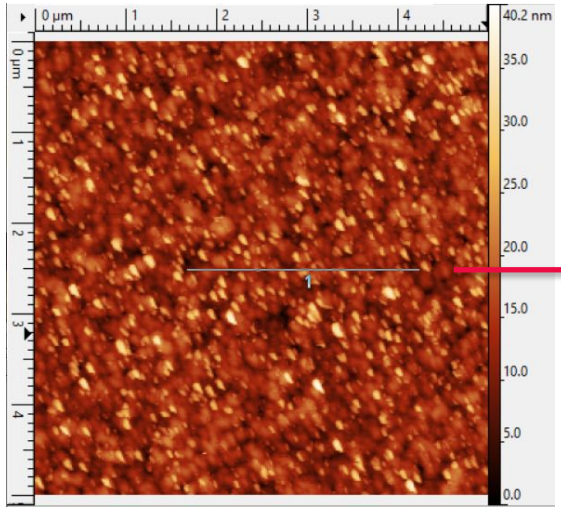
Silicon

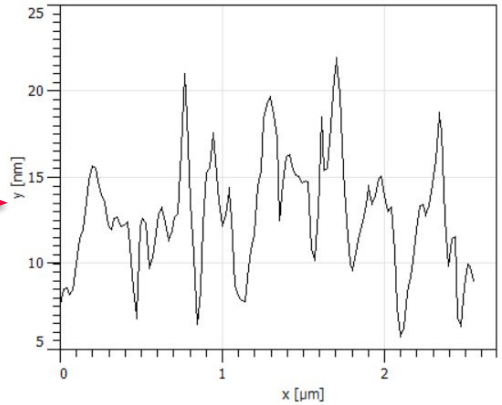


4) AFM measurements:

From Hexane:

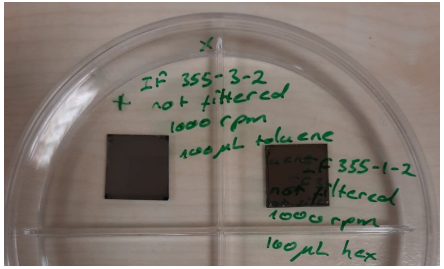


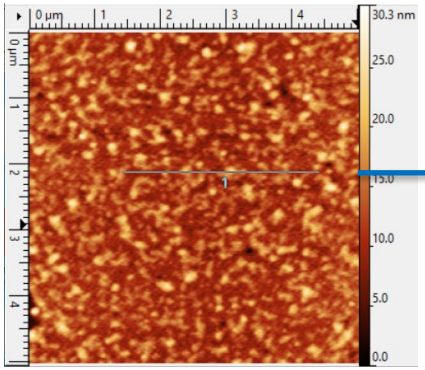


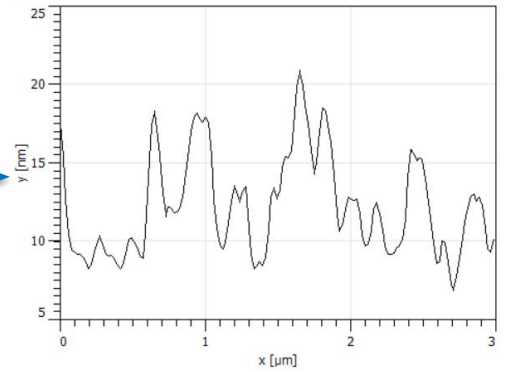


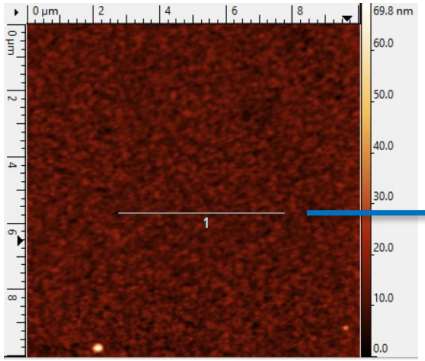
4) AFM measurements:

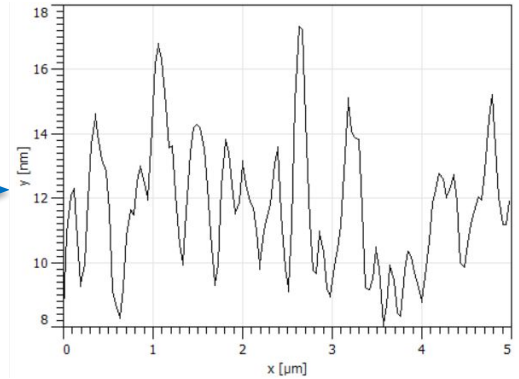
From Toluene:



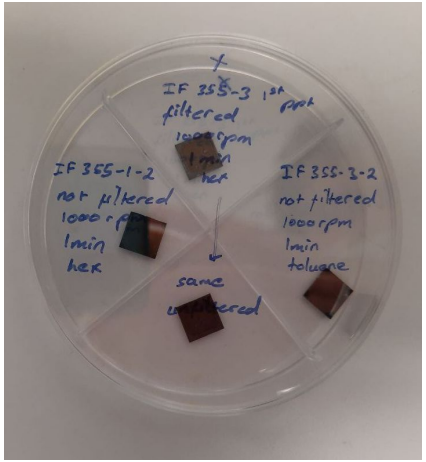


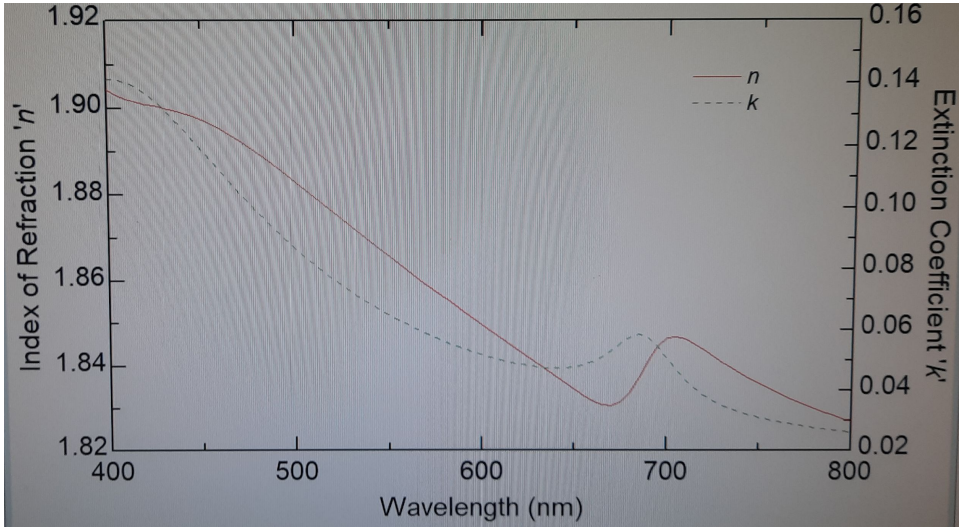






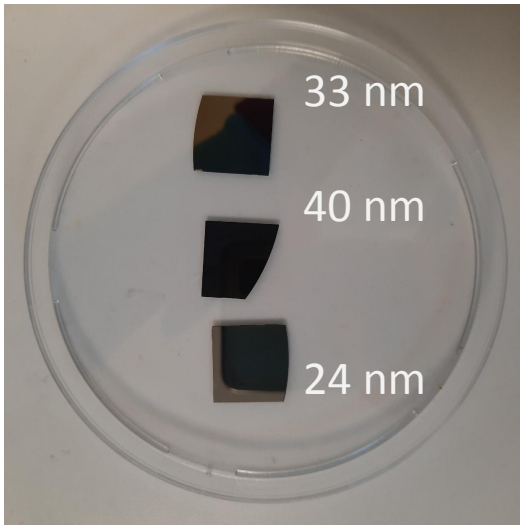
6) Ellipsometry of CdSe layer on Silicon substrate





5) Applying TiO_2 layer to substrates

1.



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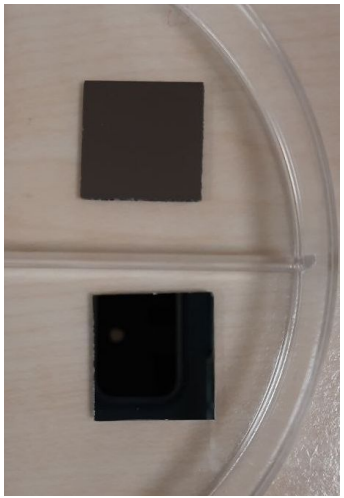

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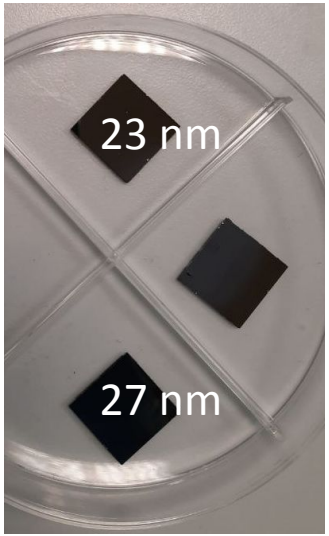
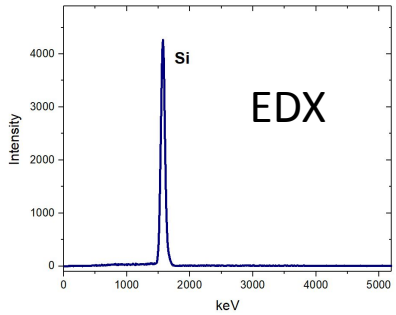
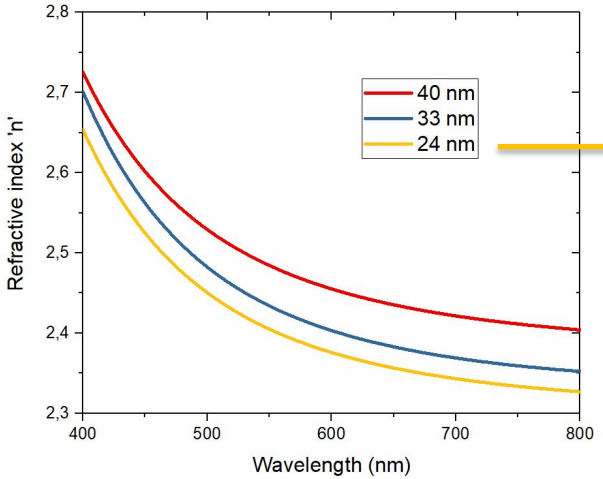


ALD goes wrong:

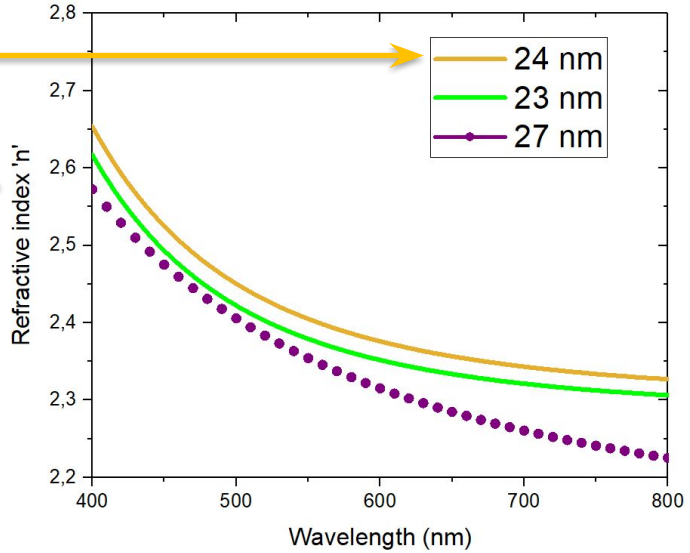


6) Ellipsometry of TiO_2 layer on Silcon substrate

1.



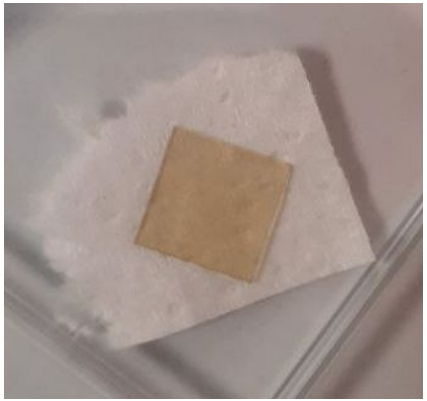
3.

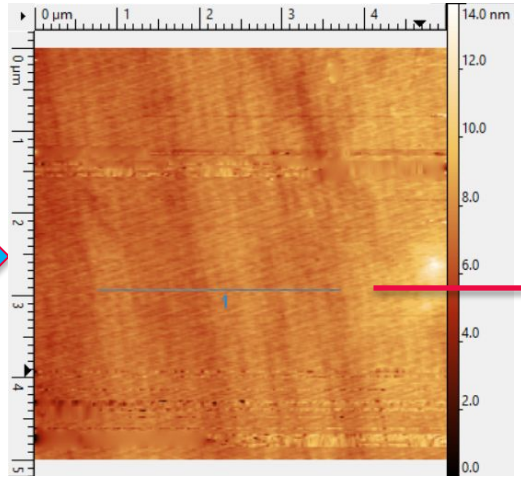


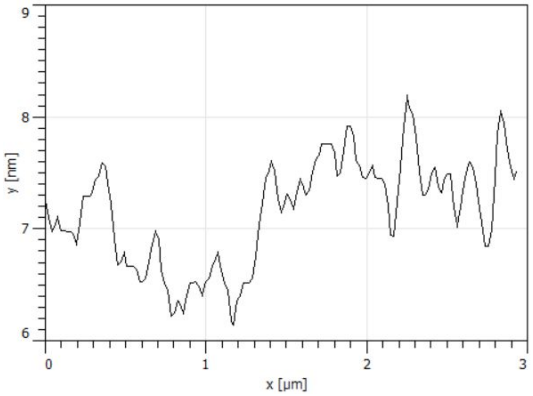
7-8) Self-Assembling on Quartz substrate

AFM measurements:

From Hexane

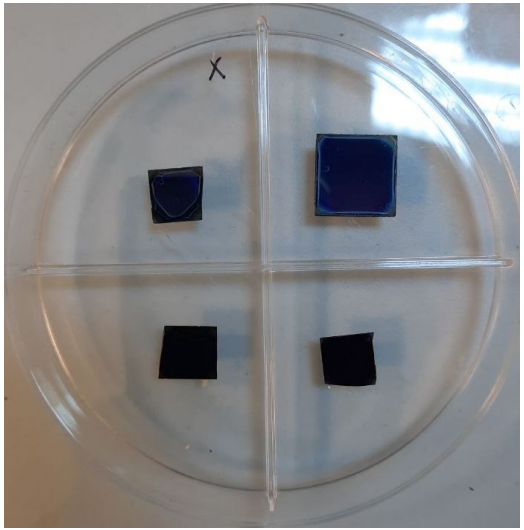






9) CdSe NPL films on modified substrate

Spin-coating:



Self-Assembling:

Today

…

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