LU ASI Kvantu Optikas laboratorija

Jānis Alnis

Pārskats par 2023.gadu.

2024.01.18.

Dalība projektos

ERAF vadītājs Prof. R. Ganeev

J. Alnis, I. Brice, L. Mīlgrāve, K. Draguns, A. Atvars, U. Bērziņš

Quantum dots - kvantu punkti nelineārās īpašības pētīšana
ar z-scan un mikrorezonatoru pārklāšanas metodēm.

VPP «MOTE» sadaļā Polimēru Fotonika

J. Alnis, I. Brice, L. Mīlgrāve

Polimēru mikroriņķis uz čipas sensoriem: temp. mitrumam u.c.
Centīsimies nākotnē apvienot ar gāzu hromatogrāfu.

Kvantu Iniciatīva

I. Brice, L. Mīlgrāve, K. Draguns, J. Alnis

Jauna lekciju kursa gatavošana «Kvantu tehnoloģijas».

2024 LZP U. Bērziņš ar Gēteborgu Prof. D. Hanstorp un CERN

Radioaktīvo elementu Cl un Po lāzerspektroskopija

Publikācijas Scopus

H. Barhum, D. S. Kolchanov, M. Attrash, R. Unis, J. Alnis, T. Salgals, Ibrahim Yehiaa, P. Ginzburg

Thin-film conformal fluorescent SU8-phenylenediamine

Nanoscale 15, 17544–17554, 2023

https://doi.org/10.1039/D3NR02744A

I. Brice, V.V.Kim, A. Ostrovskis, A. Sedulis, T. Salgals, S. Spolitis,

V. Bobrovs, J. Alnis, R.A. Ganeev

Whispering gallery mode resonator surface functionalization for active applications

Proceedings of SPIE 125690C, Conference on Nonlinear Optics and Applications XIII, 12569,

Prague, APR 24-25, 2023

https://DOI10.1117/12.2664936

I. Brice, V.V. Kim, A. Ostrovskis, A. Sedulis, T. Salgals, S. Spolitis, V. Bobrovs, J. Alnis, R. A. Ganeev

Quantum-Dot-Induced Modification of Surface Functionalization for Active Applications of Whispering Gallery Mode Resonators

Nanomaterials 13, 1997, 2023

https://DOI10.3390/nano13131997

R. Murnieks, T. Salgals, J. Alnis, A. Ostrovskis, O. Ozolins, I. Brice, A. Sedulis, K. Draguns, I. Lyashuk, R. Berkis, A. Udalcovs, T. Bi, XD Pang, J. Porins, S. Spolitis, P. Del'haye, V. Bobrovs

Silica micro-rod resonator-based Kerr frequency comb for high-speed short-reach optical interconnects

Optics Express 31 (12) , pp.20306-20320, 2023

https://doi.org/10.1364/OE.488436

Konferences

Inga Brice, Vyacheslav V. Kim, Armands Ostrovskis, Arvıds Sedulis, Toms Salgals, Janis Alnis, Rashid Ganeev.
Whispering gallery mode resonator surface functionalization for active applications,
Proceedings of SPIE. Vol.12569: Nonlinear Optics and Applications XIII. Čehija, Prague, 24.-25. Apr.,2023.

Lase Milgrave, Arturs Bundulis, Janis Alnis, Aigars Atvars.
Single-mode polymer ring resonator for sensor applications. (Student paper)
24th European Conference on Integrated Optics , 19 - 21 April 2023, University of Twente, Netherlands,

Janis Alnis, Inga Brice, Liga Gile, Arvids Sedulis, Lase Milgrave, Kristians Draguns, Aigars Atvars,
Optical whispering gallery micro-resonators (WGMR),
Nordic Optics and Photonics Days 2023. 19-21 April, 2023 | Riga, Latvia.
Sagatavots un prezentēts posteris un vinnēta Hamamatsu balva par labāko posteri.

Iegūtas intelektuālā īpašuma tiesības

1 Latvijas patents

Poriņš, J., Ostrovskis, A., Ozoliņš, O., Bobrovs, V., Salgals, T., Draguns, K., Spolītis, S., Alnis, J., Brice, I., Sedulis, A. Uz silīcija dioksīda mikrostieņa rezonatora veidots daudzviļņu gaismas avots datu pārraidei šķiedru optiskajās telekomunikāciju sistēmās. Patents Nr. V15717B (piešķirts 20.04.2023.) (patenta pieteikums iesniegts 13.05.2022.) https://ortus.rtu.lv/science/lv/patents/536

Patents tapis kā ERAF projekta Nr. 1.1.1.1/18/A/155 “Uz čukstošās galerijas modas mikrorezonatora bāzes veidota optisko frekvenču ķemmes ģeneratora izstrāde un tā pielietojumi telekomunikacijās” (16.05.20219. – 15.05.2022.) rezultāts. Projekta koordinators: Latvijas Universitāte (J. Alnis). Projekta partneri: Rīgas Tehniskā Universitāte, SIA “AFFOC Solutions”.

1 zinātība – “Mikrosfēras rezonatoru izgatavošana, testēšana un modelēšana”, Latvijas Universitāte. Par zinātību 2023. gadā ir noslēgts licences līgums. Zinātība ir tapusi kā ERAF projekta Nr. 1.1.1.1/16/A/259 “Jaunu čukstošās galerijas modu mikrorezonatoru izstrāde optisko frekvenču standartu un biosensoru pielietojumiem, un to raksturošana ar femtosekunžu optisko frekvenču ķemmi” (01.03.2017. - 28.02.2020.) rezultāts. Projekta koordinators: Latvijas Universitāte (J. Alnis).

Stažēšanās ārzemēs

- Telavivas univ. Prof. P. Ginzburg grupā 2 ned. J. Alnis.
- Trento Univ. Prof. L. Pavesi grupā. Optiskie čipi. 2 ned. J. Alnis, L. Mīlgrāve, K. Draguns. Nolasīta lekcija seminārā.
- Lundas Univ. K. Draguns. Optiskie Neironu tīkli.
- Minsteres Univ. K. Draguns. Tantāla pentoksīda Ta_2O_5 mikroriņķi uz čipa frekvenču ķemmēm.

Citi pasākumi

- Tenūrprofesora konkursā startēts un izveidots pētniecības plāns 6 gadiem.
- Lekcija par Nobela prēmiju fizikā LZA un fizikas skolotājiem.
- Lekcija Jauno fiziķu skolā par objektīvu izšķirtspēju ko nosaka skaitliskā apertūra.
- Zinātnes nakts.

Research Article | Vol. 31, No. 12 / 5 Jun 2023 / *Optics Express* 20306

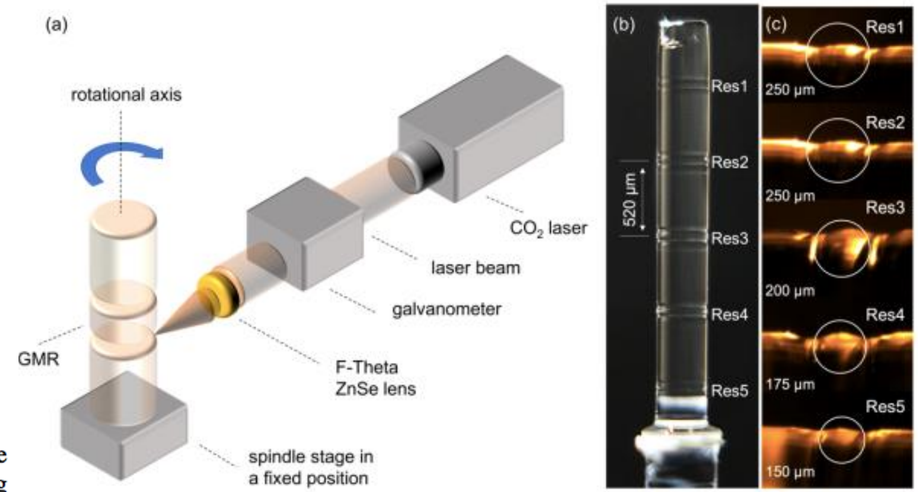
Optics EXPRESS

Sadarbība ar RTU

Silica micro-rod resonator-based Kerr frequency comb for high-speed short-reach optical interconnects

RIHARDS MURNIEKS,[1,*] TOMS SALGALS,[1] JANIS ALNIS,[2] ARMANDS OSTROVSKIS,[1] OSKARS OZOLINS,[1,3,4] INGA BRICE,[2] ARVIDS SEDULIS,[1,2] KRISTIANS DRAGUNS,[2] ILYA LYASHUK,[1] ROBERTS BERKIS,[2,5] ALEKSEJS UDALCOVS,[3] TOBY BI,[6,7] XIAODAN PANG,[1,3,4] JURGIS PORINS,[1] SANDIS SPOLITIS,[1] PASCAL DEL'HAYE,[6,7] AND VJACESLAVS BOBROVS[1]

Abstract: Conventional data center interconnects rely on power-hungry arrays of discrete wavelength laser sources. However, growing bandwidth demand severely challenges ensuring the power and spectral efficiency toward which data center interconnects tend to strive. Kerr frequency combs based on silica microresonators can replace multiple laser arrays, easing the pressure on data center interconnect infrastructure. Therefore, we experimentally demonstrate a bit rate of up to 100 Gbps/λ employing 4-level pulse amplitude modulated signal transmission over a 2 km long short-reach optical interconnect that can be considered a record using any Kerr frequency comb light source, specifically based on a silica micro-rod. In addition, data transmission using the non-return to zero on-off keying modulation format is demonstrated to achieve 60 Gbps/λ. The silica micro-rod resonator-based Kerr frequency comb light source generates an optical frequency comb in the optical C-band with 90 GHz spacing between optical carriers. Data transmission is supported by frequency domain pre-equalization techniques to compensate amplitude–frequency distortions and limited bandwidths of electrical system components. Additionally, achievable results are enhanced with offline digital signal processing, implementing post-equalization using feed-forward and feedback taps.



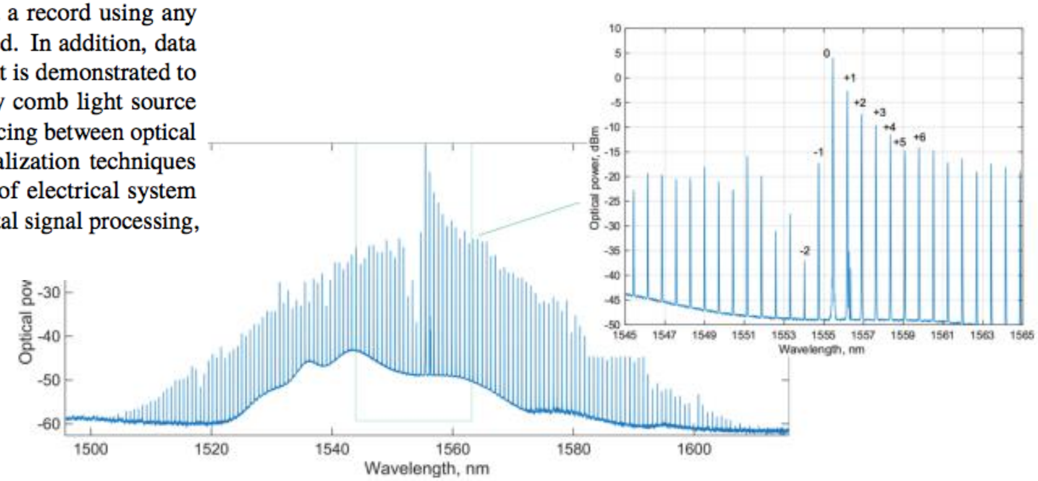
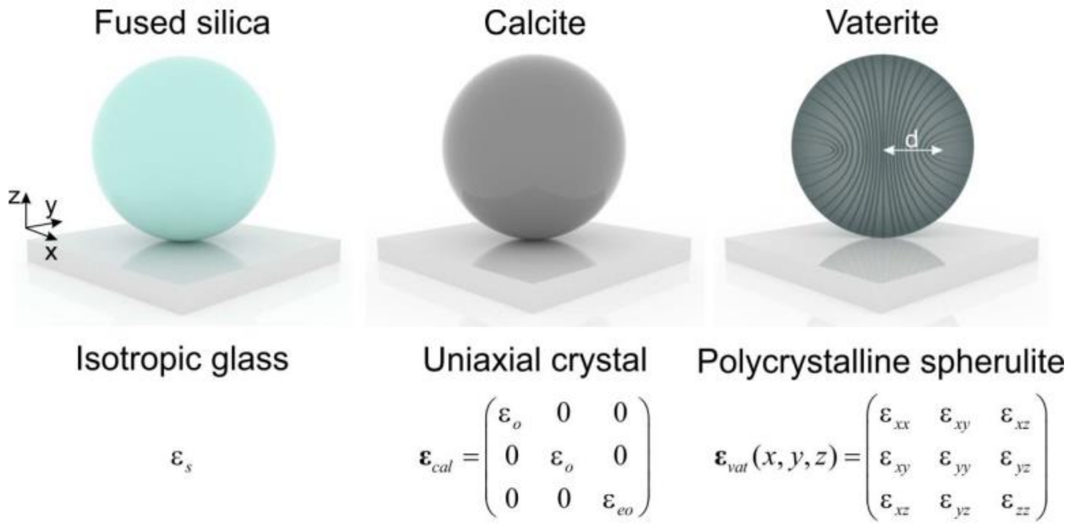
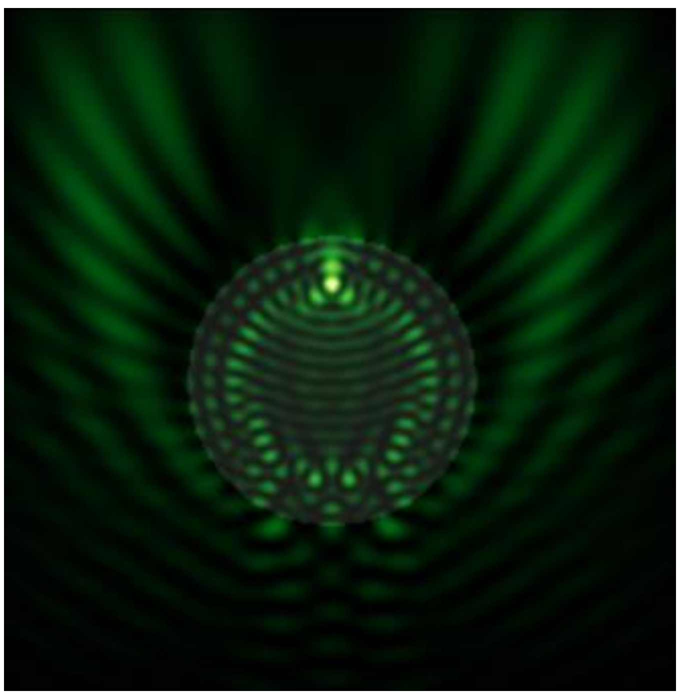


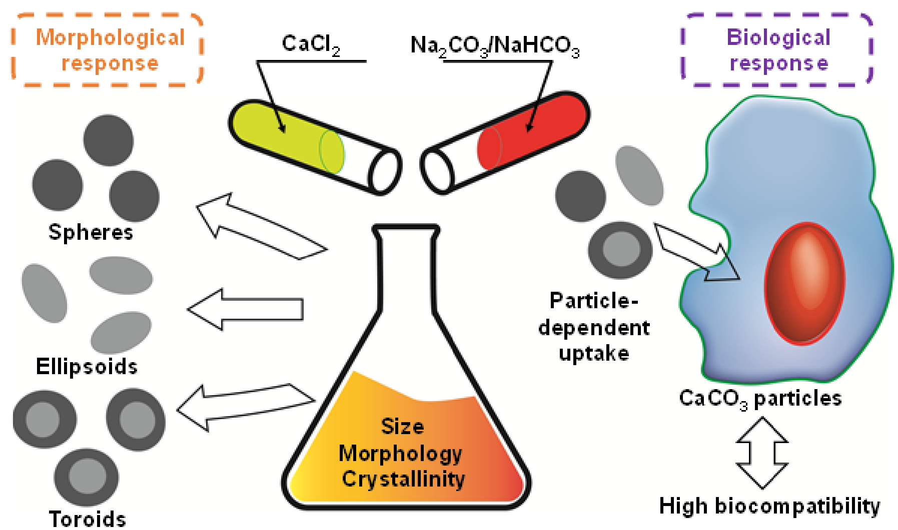
Fig. 4. The spectrum of silica micro-rod WGMR-based Kerr-OFC light source output, generated in WGMR (Res2, R = 700 µm, r = 250 µm and Q-factor of 2.6×10^7), with 89 GHz (~ 0.72 nm) mode spacing between comb carriers.

Sadarbība ar Prof. P. Ginzburga grupu Telavivas universitātē

- Optiskās pincentes
- Vaterits porains $CaCO_3$
- Organiskās krāsvielas lāzeriem







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Cite this: *Nanoscale*, 2023, **15**, 17544

Thin-film conformal fluorescent SU8-phenylenediamine†

Hani Barhum, *[a,b,c] Denis S. Kolchanov, [b,c] Mohammad Attrash,[d] Razan Unis,[a,e] Janis Alnis,[f] Toms Salgals,[g] Ibrahim Yehia[a] and Pavel Ginzburg[b,c]

The SU8 polymer is a negative photoresist widely used to produce high-quality coatings, with controllable thicknesses ranging from nanometers to millimeters, depending on fabrication protocols. Apart from conventional use cases in microelectronics and fluidics, SU8 is quite an attractive platform in nanophotonics. This material, being straightforwardly processed by ultraviolet lithography, is transparent to wavelengths longer than 500 nm. However, introducing fluorescent agents within the SU8 matrix remains a challenge owing to its high hydrophobicity. Here, we develop a process, where colorful quantum dots co-participate in the polymerization process by epoxide amination and become a part of a new fluorescent material – SU8-phenylenediamine. Through comprehensive characterization methods, including XPS and ^{1}H-NMR analyses, we demonstrate that *m*-PD covalently binds to SU8 epoxy sites with its molecular amine, virtually forming a new material and not just a mixture of two compounds. After characterizing the new

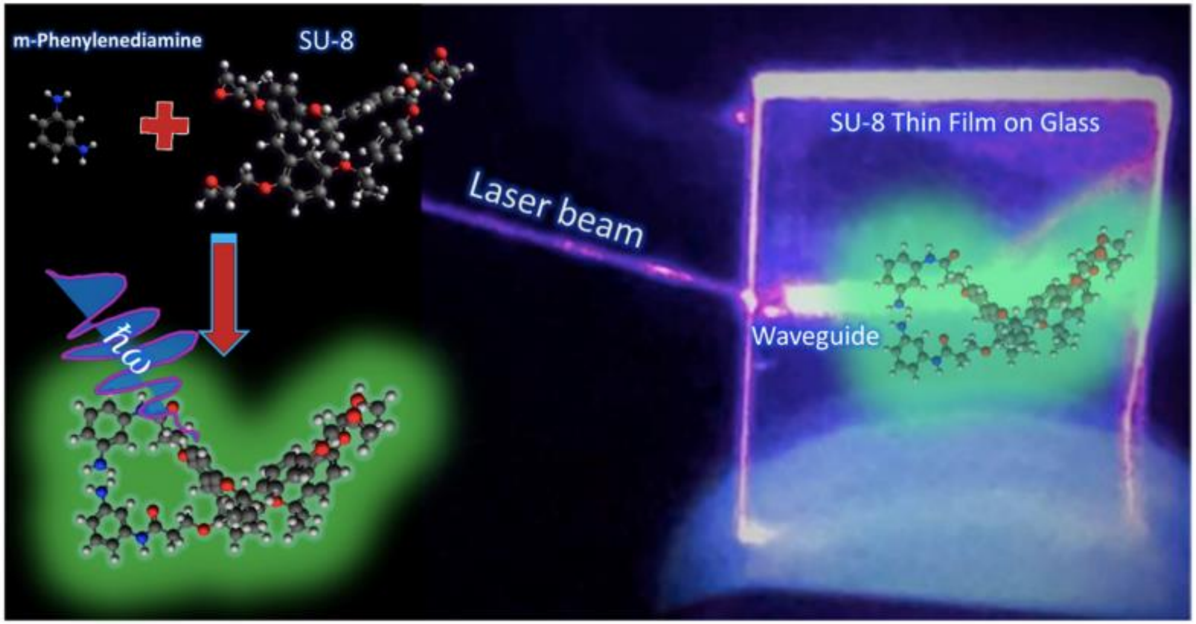
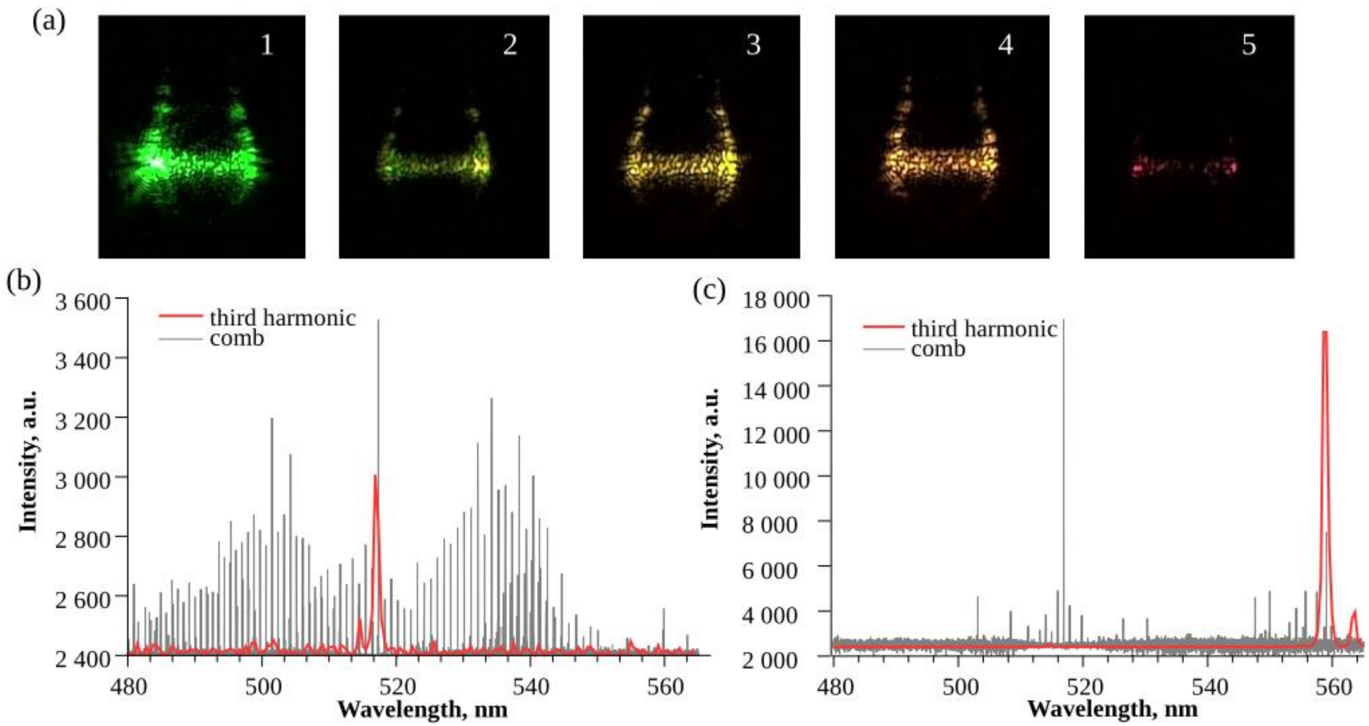


Fig. 1 Graphical illustrations and a practical application of the SU8 polymer before and after conjugation with *m*-phenylenediamine (*m*-PD). The upper left panel represents the dimeric form of the SU8 polymer prior to the conjugation process with *m*-PD. The lower left panel shows the resulting structure post-conjugation, depicting the modifications imparted to the SU8 polymer by *m*-PD. The right panel showcases a possible optoelectronic application: a glass slide with the polymer deposited onto its surface, and a waveguide fabricated within the polymer using a laser.

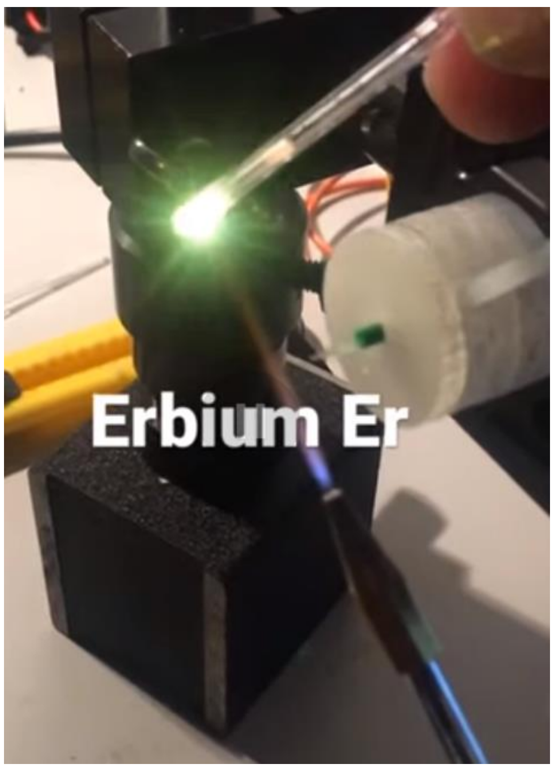
Whispering gallery mode resonator surface functionalization for active applications

Inga Brice[a], Vyacheslav V. Kim[b], Armands Ostrovskis[c], Arvīds Sedulis[a,c], Toms Salgals[c], Jānis Alnis[a], and Rashid Ganeev[b]



Whispering gallery mode resonator surface functionalization for active applications

Inga Brice[a], Vyacheslav V. Kim[b], Armands Ostrovskis[c], Arvīds Sedulis[a,c], Toms Salgals[c], Jānis Alnis[a], and Rashid Ganeev[b]



3.1.1 Erbium Laser

After dip coating, the optical fiber in Er containing solution structures or Er congaing material can be seen on the surface (see Fig. 6a). For lower concentrations of Er (1:10000; 1:40000; 1:100000; 1:200000; 1:500000), after fabrication the surface of the 185 µm microsphere is smooth (see Fig. 6a). Erbium is melted into the silica glass. Some material structures can still be seen on the stem of the sphere. For undiluted concentration of the erbium, some material structures on the surface of the microsphere can be also seen after the fabrication of the microsphere. All samples demonstrated green light emission when pumped with 1530-1560 nm light. For higher concentrations of Er, the emission was more intense.

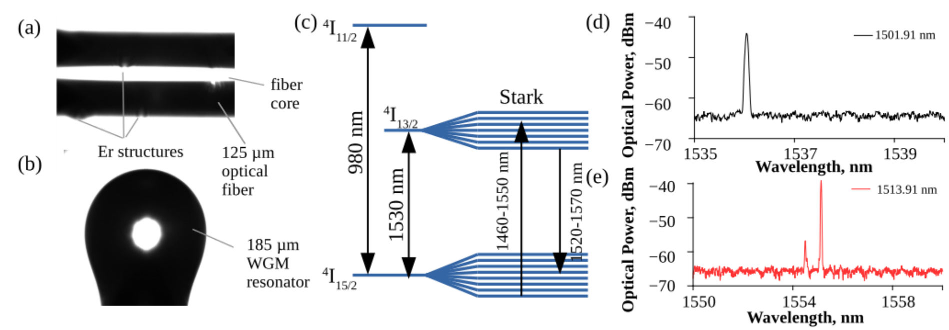
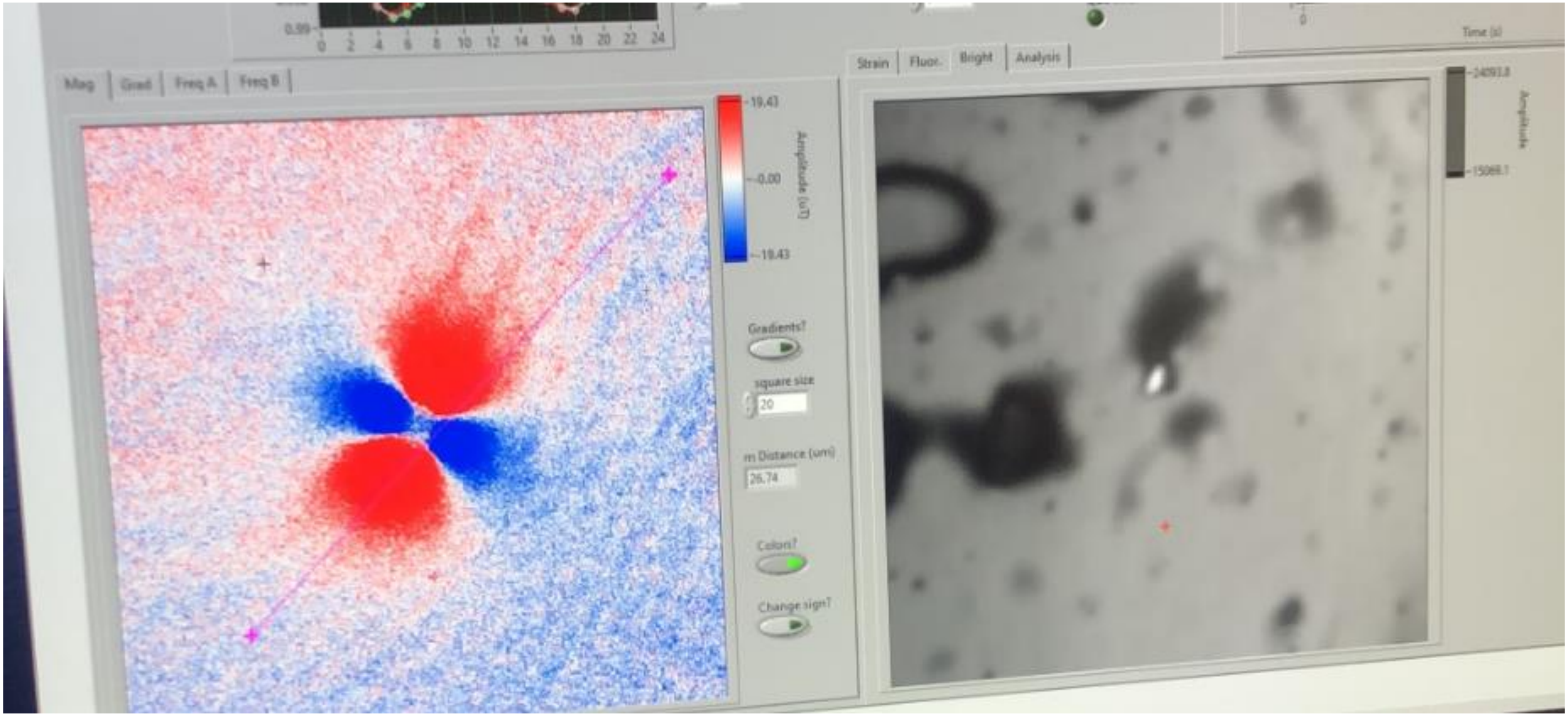


Figure 6. WGM resonator surface functionalization with Er^{3+} ions: (a) shadow microscopy image of an optical fiber after dip coating in Er solution; (b) shadow microscopy image of fabricated microsphere; (a) Er^{3+} 4f transition levels $^4I_{11/2}$, $^4I_{13/2}$ and $^4I_{15/2}$ in silicate glass; (d) lasing at 1536 nm of 1:10000 sample when pumping with 1501.91 nm; (e) lasing at 1555 nm of 1:10000 sample when pumping at 1513.91 nm.

Sadarbība ar LU Lāzercentra Prof. M. Auziņa dimantu magnetometru laboratoriju Dr. Ilja Fescenko

- Ar NV centru magnetometru vizualizēts 10 nm mazuvmagnētisku nanodaļiņu magētiskais lauks kuras atrodas apmēram 1 mikrometru diametra vaterīta $CaCO_3$ piciņu porās. Vaterīts ar nanodaļiņām no Prof. P. Ginzburga grupas Telavivā



Lorenca atraktors – haotiska kustība

Diferenciālvienādojumu risināšana: ar 3 metodēm

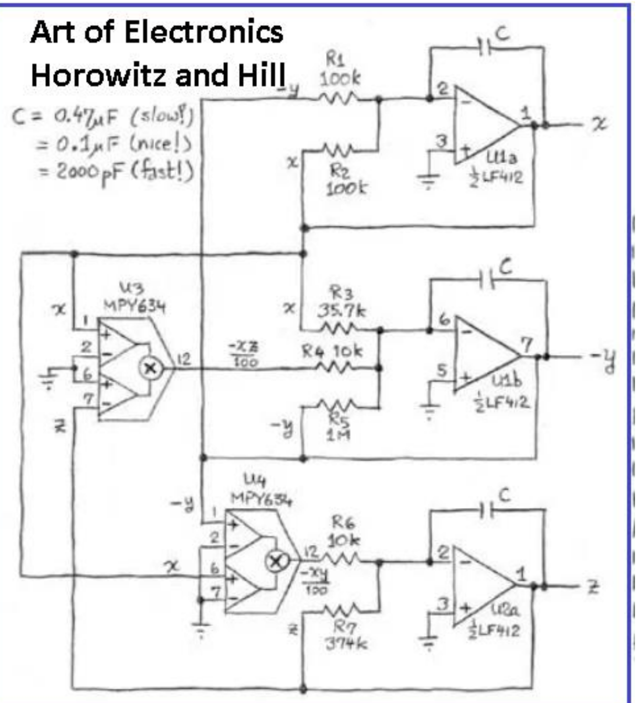
- Analogais skaitļotājs
- Arduino
- MATLAB

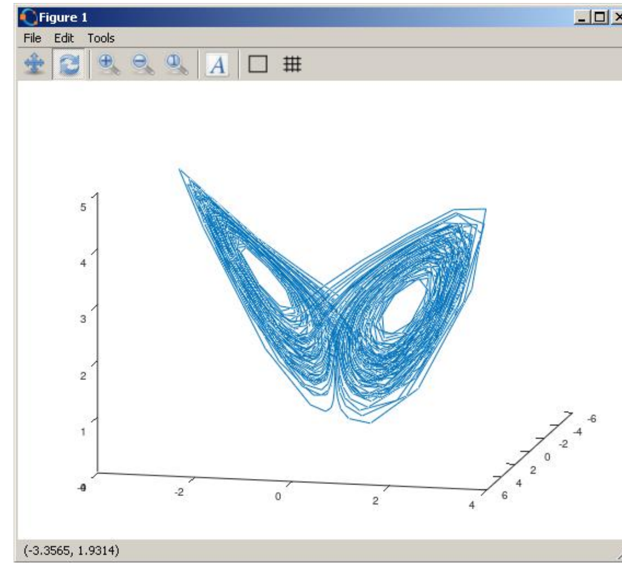
$$dx/dt = 10(y - x)$$

$$dy/dt = 28x - y - xz$$

$$dz/dt = xy - (8/3)z$$

Art of Electronics
Horowitz and Hill





Arduino cikls:

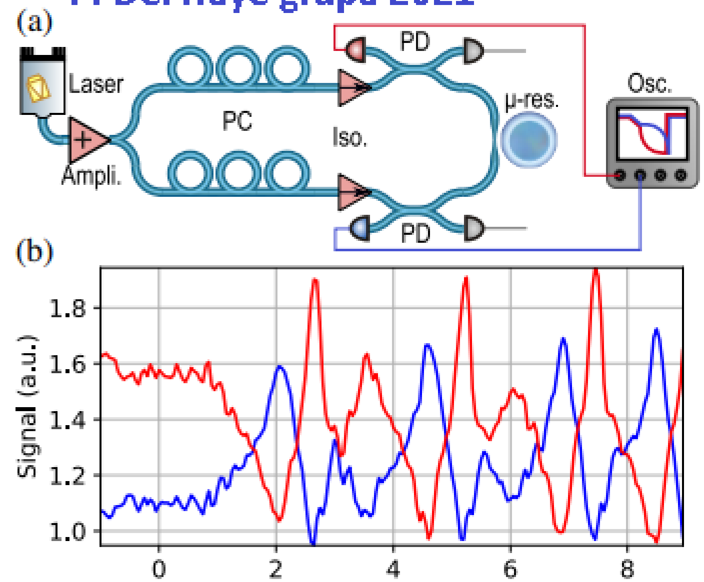
```
xdot = 10*(y-x);
ydot = 28*x-y-xz;
zdot = x*y-8/3*z;

dt=0.02;
x = x + (xdot*dt);
y = y + (ydot*dt);
z = z + (zdot*dt);
```

MATLAB:

```
sigma = 10; beta = 8/3; rho = 28;
f = @(t,a) [-sigma*a(1)/5 + sigma*a(2); rho*a(1) - a(2) -
a(1)*a(3); -beta*a(3) + a(1)*a(2)];
[t,a] = ode45(f,[0 100],[1 1 1]);     % Runge-Kutta 4th/5th
order ODE solver
plot3(a(:,1),a(:,2),a(:,3))s
```

Haoss optiskos mikrorezonatoros
P. Del Haye grupa 2021



Radona detektēšana iekštelpās

ar gaisa filtru + Geigera skaitītāju, Vilsona miglas kameru, CsI kristāla scintilatoru+PMT, fotodiodes detektoru, jonu kameru. Granīta oļi - radona avots. Komerciālie *Radon Eye* un *Radiacode 102*.