Faculty of Engineering, ECE School
Electro-Optics and Photonics Engineering Dep.

International Day of Light 16 May

אוניברסיטת בן-גוריון בנגב
Ben-Gurion University of the Negev

International Day of Light 2019: young researchers conference

Location: building 51, room 015

Program

Keynote Presentation : *Topological Photonics* 11:10-11:55

Presenter: **Mordechai (Moti) Segev**, the Technion, Israel.

Short Biography: Moti Segev is the Robert J. Shillman Distinguished Professor of Physics, at the Technion, Israel. He received his BSc and PhD from the Technion in 1985 and 1990. After postdoc at Caltech, he joined Princeton as Assistant Professor (1994), becoming Associate Professor in 1997, and Professor in 1999. Subsequently, Moti went back to Israel, and in 2009 was appointed as Distinguished Professor.

Moti's interests are mainly in nonlinear optics, photonics, solitons, sub-wavelength imaging, lasers, quantum simulators and quantum electronics, although he finds entertainment in more demanding fields such as basketball and hiking. He has won numerous international awards, among them the 2007 Quantum Electronics Prize of the European Physics Society, the 2009 Max Born Award of the Optical Society of America, and the 2014 Arthur Schawlow Prize of the American Physical Society, which are the highest professional awards of the three scientific societies. In 2011, he was elected to the Israel Academy of Sciences and Humanities, and in 2015 he was elected to the National Academy of Science (NAS) of the United States of America. In 2014 Moti Segev won the Israel Prize in Physics and Chemistry (highest honor in Israel).

However, above all his personal achievements, he takes pride in the success of his graduate students and postdocs, among them are currently 21 professors in the USA, Germany, Taiwan, Croatia, Italy, India and Israel, and many holding senior R&D positions in the industry.

Sponsors:

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Faculty of Engineering Sciences

9:00-9:30 Welcome reception

9:30-9:40 Opening Remarks : **Prof. Adrian Stern** , Electro-Optics and Photonics Eng. Dep. Head

Session I: Chair *Prof. Adrian Stren*

9:40-9:55 **Lightning-fast solution of scattering problems in nanophotonics: an effortless modal approach**
Parry Yu Chen, Yonatan Sivan

Abstract: Nanoresonators can enhance quantum light with matter interaction by orders of magnitude, enabling for example spectroscopy on individual molecules, engineered blackbody emission spectra for energy harvesting, and potentially generating single photons for quantum computing. However, numerical design remains challenging as enhancement is highly sensitive to positions and orientations. Ideally, simulation methods are general, reliable, fast, and accurate, though rarely does any one method satisfy all four criteria. We demonstrate a working implementation of a method satisfying all four criteria, generating the field produced by an arbitrary arrangement of nanoparticles excited by a near field source. This yields the Green's tensor, a fundamental electromagnetic quantity necessary for simulating quantum light-matter interactions. The method's reliability enables automation, further exploiting its efficiency. Our method expands the Green's function using the source free modes of the system. Called normal mode expansion, this efficient, simple, and rigorous method has long been used for closed systems, but its generalization to open systems relevant to nanophotonics has faced difficulties. We successfully generalize normal mode expansion (GENOME), overcoming these practical and theoretical difficulties, and recovering the simplicity and rigour of normal mode expansion for closed systems. For practical purposes, mode generation is the most computationally intensive part of any modal expansion. While GENOME is compatible any numerical method such as COMSOL, our advantages stem from an efficient mode generation technique we developed called reexpansion. It finds modes with exponential convergence, and underpins GENOME's extraordinary efficiency and reliability. We demonstrate GENOME's working implementation, validating results against direct COMSOL simulation. We also survey results from ongoing collaborations that solve numerically difficult problems, including nanoplasmonic assisted two photon emission, thermal radiation and near field heat transfer of interacting nanoparticles, and radiation near interacting anisotropic cylinders.

9:55-10:10 **Tailoring the trapping potential of cesium atoms using nano-antennas of different shapes on waveguide**
Angeleene S. Ang, Alexander S. Shalin, Alina Karabchevsky

Abstract: "Trapped atoms can be used for the study of the fundamental problems in quantum information processing and condensed matter physics. These optical traps are usually constructed by creating an artificial optical potential using overlapped counter-propagating lasers, which poses a challenge in miniaturization and integration into larger systems. Plasmonic nanoantennas confine light at nanoscale allowing creating sufficient optical forces to trap an atom. However, plasmonic optical traps are made of noble metals, which exhibit ohmic losses in the visible range. These losses are destructive for alkali atoms; the alkali gases typically used in ultracold atom experiments since their optical transitions lie within in the visible range. Here, we explore an optical nano-antenna made of silicon to convert light into a strongly confined field. This nano-antenna is placed on top of a ridge waveguide made of silicon nitride. The confined field generates a sharp intensity gradient that creates a strong force which traps atoms. In our set-up, we use bichromatic fields, both detuned from transition – the redshifted light attracts towards the waveguide surface, and the blueshifted light repulses away from the waveguide surface. By balancing repulsive and attractive forces, we create a potential minimum.

We show how the varying the silicon nano-antenna shapes affects the light focusing at nanoscale on top of the waveguide is affected. We considered nanoantennas of a conical, a cubical, a hemispherical, and hemielliptical shapes. We also explore hemielliptical nanoantennas in the case where the its major axis is either parallel or perpendicular to the incident propagation".

10:10-10:25 **Photon management utilizing deep-Subwavelength sidewall features in Nanopillar arrays for broadband absorption enhancement of the solar radiation**
Ashish Prajapati, Yevgeny Faingold, Shay Fadida, Jordi Llobet, Mariana Antunes, Helder Fonseca, Carlos Calaza, João Gaspar, and Gil Shalev

Abstract: Silicon nanopillar (NP) arrays are known for their efficient light trapping and broadband absorption enhancement of solar radiation. In the current study, we examine the effect of deep subwavelength sidewall scalloping (DSSS) on the broadband absorption of the arrays. The formation of DSSS is a side effect of top-down dry etching of NP arrays of several microns height. We use finite-difference time-domain (FDTD) electromagnetic calculations to show that the presence of DSSS can

result in efficient excitation of optical modes in both the arrays and the underlying substrates. We demonstrate a broadband absorption enhancement of >10% in a DSSS-NP array with an underlying substrate. We use electrical device calculations to solve the Poisson and Continuity equations to examine the effect of DSSS on the electrical performance of a photovoltaic cell, as the main concern is the degradation of the open-circuit voltage due to surface recombination (DSSS produces higher surface-to-volume ratio). We show that the effect of DSSS on open-circuit voltage is negligible. Finally, deep-subwavelength sidewall features offer a novel and an interesting photon management strategy towards absorption enhancement.

10:25-10:40 **Surface Enhanced Near-IR Absorption (SENIRA) of Molecular Overtone Transitions with Gold Nanorods**

Daler R. Dadadzhanov and Alina Karabchevsky

Abstract: Near-infrared (NIR) spectroscopy is an analytical technique for detection and recognition of chemical substances based on vibrational modes of their molecular constituents. This method has found numerous applications in different fields including pharmaceutical analysis, food quality determination and nondestructive analysis of biological materials to name a few. As compared to the mid-IR spectroscopy, NIR vibration spectroscopy is much more convenient due to the availability of highly sensitive detectors and high-power radiation sources in this spectral range. On the other hand, molecular overtone bands lying in the NIR spectral region are forbidden in harmonic oscillator approximations. Such bands arise only from the anharmonicity of molecular vibrations which is rather weak. Therefore, the overtone bands are much weaker than the fundamental modes lying in the lower frequency range, so their absorption is smaller. Local field enhancement is a promising way to overcome this limitation by means of collective oscillations of free electrons in form of surface plasmon-polariton (SPP) in thin metal films or localized surface plasmon resonance (LSPR) in small metal nanoparticles and to enhance overtone absorption. We propose a novel platform for the detection and recognition of chemical substances based on the vibrational overtone modes of their molecular constituents by local field enhancement of gold nanorods. Here we report the nontrivial enhanced absorption, by two orders of magnitude, in the analyte is accompanied by the reduced absorption in the gold nanorods that overruns the absorption enhancement of the analyte and forms the signal that may be readily sensed in the far field. Our results pave a road toward a new class of surface enhanced near-infrared absorption-based sensors

10:40-11:00 Coffee break

Session II: Chair *Prof. Gabby Sarusi*

11:10-11:55 Invited keynote: *Prof. Motti Segev*, Technion
Topological Photonics

11:55-12:10 **Multiscale LiDAR compressive sensing with Russian dolls ordered Hadamard basis**

Vladislav Kravets and Adrian Stern

Abstract: We introduce an application of multiscale-ordering of the Hadamard basis for compressive 3D LIDAR acquisition. Improvement in quality of the reconstruction and other advantages over conventional compressed sensing will be presented.

12:10-12:25 **Deep neural network for reconstruction of compressive sensing hyperspectral images**

Yaron Heiser, Yaniv Oiknine and Adrian Stern

Abstract: In the recent years, we have developed several architectures for compressive hyperspectral imagers. The compressive sensing design has allowed the reduction of the enormous acquisition effort associated with the huge dimensionality of the hyperspectral data. Unfortunately, the reduced sensing effort offered by the CS approach comes on the account of increased post-sensing computational burden. Conventional CS reconstruction involves algorithms that solve a l1 minimization problem. Those algorithms are iterative and typically very computationally heavy. The computation burden is even more prominent when reconstructing 3D hyperspectral data, where each spectral image may have Gigavoxel size. Motivated by this, we have investigate replacing the CS iterative reconstruction step with an appropriate Deep Neural Network.

12:25-12:40 **Non-Invasive imaging through a thin scattering layer using a SLM***

Saswata Mukherjee, A. Vijayakumar and Joseph Rosen

Abstract: Imaging through scattering layers would facilitate in seeing objects hidden behind turbid medium and biological tissues. Several techniques have been developed to overcome the problem, which can be broadly classified into invasive and non-invasive imaging technique depending on whether the PSF of the system is available or not. In these study we have demonstrated a non-invasive imaging technique which reconstructs the image of the hidden object using a Phase-retrieval algorithm. A spatially incoherent light is used to critically illuminate the object. The light diffracted by the object is incident on the scatterer kept at a distance Zs from it. A relay system projects the light pattern at a distance Zr from the scatterer onto SLM where a coded phase mask synthesized using Gerchberg-Saxton algorithm is displayed, along with a quadratic phase mask to focus the light onto the sensor kept at a distance Zh from SLM. The secondary scattering mask allows us to have a better approximation to the delta function obtained from the autocorrelation of the PSF and additionally allows us to take two camera shots to reduce background noise by subtracting one from the other. The final intensity pattern recorded by the sensor is used to extract information about the hidden object using a Phase-retrieval algorithm.

12:40-12:55 **Resolution Enhancement of incoherent imaging systems using a phase-only spatial light modulator***

Mani Ratnam Rai and Joseph Rosen

Abstract: The lateral resolution of any optical system is defined by its numerical aperture (NA). Comparing between the coherent and incoherent imaging systems with the same NA, incoherent systems have a higher resolution than that of coherent systems by a factor of 1.5. Various techniques like structured illumination, or stochastic optical reconstruction microscopy have been developed to enhance the lateral resolution. Even though these techniques have immense potential for improving the imaging resolution beyond the diffraction limit, the complexity of the techniques, the relatively long data acquisition time, and the special experimental requirements justify the search for simpler methods. In this study, we present a novel technique to increase the lateral resolution of a conventional imaging system by introducing a phase-only spatial light modulator (SLM) between the object to be imaged and the input aperture of the optical system used for imaging. In this technique, a coded phase mask (CPM) is displayed on the SLM, which scatters the light and increases the effective NA beyond the inherent NA of the optical system. Hence, the method improves the overall imaging resolution. In this technique, a system calibration is done by recording the intensity response pattern to a point object located at the same axial position of the object and filtered by the same CPM. The object reconstruction is done by a non-linear cross-correlation between the intensity responses of the point object and of the imaged object.

12:55-13:10 **Superresolution Far-Field Imaging by Annular Array of Coded Phase Apertures***

Angika Bulbul and Joseph Rosen

Abstract: Resolution of the far-field imaging systems, such as space and earth-based telescopes are often limited by the finite aperture of the optical systems. We present partial aperture and synthetic aperture imaging techniques, based on interferenceless coded aperture correlation holography. Partial aperture imaging system is composed of a ring-shaped aperture, or several small subapertures only along the boundary of the full aperture. In synthetic aperture imaging system, two subapertures move in synchronized manner at a specific position, along the boundary of whole synthetic aperture. In such systems, light diffracted from an object and from a guide-star is modulated by pseudorandom coded phase mask. Then, the reflected intensity patterns are recorded and further digitally processed. Image of the object is reconstructed by the cross-correlation between the intensity responses of the object and of the guide-star recorded under identical conditions. The proposed synthetic aperture technique is realized by two satellites, moving only along the boundary of the synthetic aperture. As holography is an indirect imaging technique, the space between recording and reconstruction provides ample opportunity to apply synthetic aperture procedures. Unlike other schemes of synthetic aperture, there is no need to sample any other part of the synthetic aperture beside its border. The proposed techniques with aperture area as low as 1.4% and 0.43% respectively, of full aperture area can be a promising solution for the data saving and for reduced data acquisition time. Moreover, the methods can save device volume and weight, while maintaining the resolution of complete aperture, features that are beyond the limits of direct imaging systems.

13:10-14:10 Lunch break + Poster session

Session III: Chair *Prof. Amiel Yeshaya*

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* **The work was supported by the Israel Ministry of Science and Technology (MOST)**

14:10-14:25 KLA Price awarding

14:25-15:05 Invited talk: *Dr. Avner Safrani*, KLA **Low Coherence Dual Interferometry System for Wafer Thickness Measurements**

15:05-15:20 **Studies at Ben-Gurion University of continuous wave diode pumped cesium and potassium lasers with gas circulation**

E. Yacoby, I. Auslender, K. Waichman, B. D. Barmashenko and S. Rosenwak

Abstract: Diode pumped alkali lasers (DPALs) have been studied extensively in recent years. In spite of the high efficiency of DPALs, high pumping power results in heat release, mainly due to the relaxation and quenching processes, and leads to temperature rise and decrease of the power and efficiency of the laser. A very efficient way to remove this heat is to circulate the gas mixture through the laser cell. Experimental and theoretical study of Cs DPAL with gas circulation, operating at CW mode for several hours without temperature variation in time is reported. In the calculations we used a 3D computational fluid dynamics model, solving the kinetics equations relevant to the laser operation and the fluid dynamic equations. Maximum output power of 24 W with slope efficiency of 48% was obtained at CW operation mode. The experimental and theoretical values of the power are in good agreement. It was found that for flow velocities of 1-5 m/s the lasing power was not affected by the gas temperature rise, being only several degrees. However, for small flow velocities (< 1 m/s) the power decreases with decreasing velocity. The good agreement between the calculated and measured values indicates that our model is suitable for estimating the performance of flowing-gas DPALs and hence can be applied for studying their scaling-up to higher powers. Operation of high power flowing-gas DPAL devices is studied for both Cs and K lasers and it is shown that MW powers are achievable.

15:20-15:35 **Experimental and theoretical studies of diode-pumped alkali lasers**

Ilya Auslender and Boris Barmashenko

Abstract: Diode pumped alkali lasers (DPALs) are of interest due to their great potential as high power, efficient lasers. The gaseous medium of DPAL, along with its high quantum efficiency, are the main reasons for the high optical quality of the output beam and power scalability. This makes these lasers efficient convertors of un-phased, poor beam quality radiation from diode laser arrays or stacks to high beam quality laser radiation of alkali atoms. Hence, currently DPALs are among the leading candidates for the role of high-power lasers of the next generation. In the talk I will present our recent experimental and theoretical studies of DPALs. In the experimental part of the research, we built static and flowing-gas DPAL systems and performed measurements to study optical and kinetic features of the laser. The theoretical part deals with developing numerical models for studying optical performance of DPALs, evaluating laser power and beam quality for different laser parameters.

15:35-15:55 **Femtosecond inscription of tunable, narrow-band, and phase shifted fiber Bragg gratings**

Aviran Halstuch, and Amiel A Ishaaya

Abstract: A Fiber Bragg Grating (FBG) is a periodic modulation of the fiber core refractive index, typically, a few millimetres long. FBGs find commercial applications in optical communication as wavelength filters and add\drop multiplexers, in fiber lasers as reflective mirrors, in fiber sensors as temperature and strain gauges, and in numerous other fields. Typically, FBGs are inscribed using a UV laser and a phase mask (PM) in photosensitive fibers only.
In the early 2000s, femtosecond lasers have become important tools for processing a variety of materials including inscription of FBGs. The main advantage of using a femtosecond laser source is that its high peak power pulses can deliver energy ultrafast into materials, resulting in high precision and minimal collateral damage.
In the last decade, the technique of FBG inscription in optical fibers with femtosecond lasers and a PM has proven to be far more versatile than the standard UV-laser grating writing techniques. This led to inscription of FBGs in various non-sensitized transparent materials. Here we show how we inscribe high quality FBGs in silica fibers using an 800 nm Ti:Sapphire femtosecond laser with a 35 fs pulse duration and 1 KHz repetition rate. We demonstrate how we can fine-tune the center Bragg wavelength up to ~1 nm with pre and post fs treatment to the fiber. We show how to create phase-shifted-gratings by inscribing two “different” FBGs on the same section of the fiber. Finally, we show how we can inscribe narrow bandwidth FBGs with less than 60 pm width.

15:55-16:10 Coffee break

Session IV: Chair *Prof. Shlomi Arnon*

16:10-16:25 **Energy band alignment role of CBD grown PbS(Th,O)/CdS heterojunctions for PV SWIR detection**

Hadar Manis-Levy, Ran Eitan Abutbul, Tzvi Templeman, Nitzan Maman, Arie Grosman, Rafi Shikler, Iris Visoly-Fisher, Yuval Golan, Amir Saar and Gabby Sarusi
Abstract: P-type PbS(Th,O) nano-crystal based layers, that are quantum confined to absorb SWIR light around 1550nm (Eg=0.8eV), were grown on two different n-type CdS intermediate layers (Eg=2.4eV) that were deposited by different protocols on FTO substrate using Chemical Bath Deposition (CBD) technique. Morphological, optical and electrical characterizations of the grown layers were analyzed. It is shown that although the optical properties of the PbS(Th,O) layer are independent of the underlying CdS layer, vertical electrical measurements showed high dependency on the type of the CdS layer, which is attributed to the energy band alignment of the PbS(Th,O)/CdS heterojunctions. Energy band alignment simulations showed that the only option to exhibit photovoltaic current is when both Fermi and conduction band levels of the n-type CdS are positioned between these levels of the p-type PbS(Th,O). Such alignment creates a type II heterojunction without a barrier. Controlling such limiting conditions when growing the layer with CBD method is quite challenging, suggesting why it is hard to observe photovoltaic effects in narrow band gap thin film layers in that configuration. Experimental results support the simulations, proving the necessity to control the heterojunction layers characteristics required for an efficient SWIR based photovoltaic detection device.

16:25-16:40 **Molecular–Reductant-induced-control of-a-Graphene Organic Interface for Electron injection**

Chen Klein and Gabby Sarusi
Abstract: Surface doping of graphene with redox-active molecules is an effective approach to tune its electrical properties, in particular for application as transparent electrodes. Here we present a study and application of surface n-doping of graphene with the molecular reductant (pentamethyl cyclopentadienyl)(1,3,5-trimethylbenzene) ruthenium-dimer([RuCp*Mes]2).Photoemission spectroscopy and carrier-transport measurements are combined to investigate doping-induced changes in the electronic structure of the interface between graphene and phenyldi(pyren-2-yl)phosphine oxide (POPy2), which is a low electron-affinity material that has been used as an electron-transport layer (ETL) in organic light-emitting diodes. Photoemission and Hall voltage measurements confirm the n-doping of graphene. Doping with 1−2 nm of [RuCp*Mes]2 reduces the graphene work function by 1.8 eV and the electron injection barrier by more than 1 eV, enhancing electron injection into POPy2 by several orders of magnitude. Graphene/POPy2/Al diodes with doped graphene cathodes exhibit reasonable stability in both nitrogen and air. These results represent a significant step toward the use of graphene as a transparent cathode for organic devices in general and for OLEDs in particular.

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16:40-16:55 **Near-field optical microscopy of silicon arrays composed of subwavelength light funnel arrays**

Ankit Chauhan and Gil Shalev
Abstract: Light trapping in arrays composed of subwavelength light funnel arrays (LF arrays) is a promising approach towards efficient broadband absorption of the solar radiation and surface arrays of subwavelength structures has an additional advancement towards ultra-thin photovoltaic (PV) cells. In the following we examine the origin of light trapping enhancement in LF arrays as compared to nanopillar (NP) arrays and we show that light trapping enhancement is due to favorable strong optical coupling between adjacent light funnels which is not realized in NP. We suggest that the enhanced light trapping and absorption in dense LF arrays is governed by strong modal excitation coupled with high filling ratio, unlike the absorption in dense optimized nanopillar arrays which is governed by weak modal excitation and high filling ratio. Finally, we make the distinction between two types of optical overlap: weak overlap in which the coupling between the sparse array modes and the impinging illumination increases with array densification, and strong overlap where the array densification introduces new highly absorbing modes. Finally, the study of the resonant behaviour of silicon non-imaging light concentrators (NLCs) provide a new route for achieving efficient control of both electric and magnetic components of light. We use near-field scanning optical microscopy (NSOM) to measure the near-field light intensity as function of array geometry.

16:55-17:10 **Light Funnel Arrays realized on Silicon-on-insulator**

Sarah Sowmya Priya Konedana and Gil Shalev
Abstract: Light trapping in the spectral range of visible to the near infrared is important for a plethora of energy-related photonic devices. The study numerically examines light trapping in arrays of subwavelength silicon light funnels (LF arrays) realized on silicon-on-insulator (SOI) wafers. We observe the possibility of light trapping beyond the Yablonovitch limit and ~5% enhancement beyond the limit is shown. The SOI wafers are used for two reasons: firstly, SOI wafers introduce two bottom interfaces which allow efficient optical coupling between the LF arrays and the underlying substrates and, secondly, the potential for the realization of energy harvesting photonic devices realized on SOI wafers. Strong light trapping and high absorption in LF array-substrate complexes is observed in relatively short LF arrays. The strong absorption peaks correspond to

a high optical intensity in the arrays which is 3-4 orders of magnitude higher than in ambient. We show that the overall transmission is low on account of the two bottom interfaces of the SOI geometry. Specifically, the strong absorption peaks are due to low transmission coupled with low reflectivity which suggests forward scattering by the arrays into the substrates. The dependency of the LF bottom diameter on the overall absorption of the complex is studied. We show that for small bottom diameter the excitation of the substrate is poor possibly due to lack of photonic states at the LF bottom. We show that the substrate excitation by a LF array is more efficient than the excitation by a nanopillar array as LFs provide a homogenous power spread in the substrate.

17:10-17:20 Concluding remarks *Prof. Adrian Stern*

13:10-14:10 Poster session

Up-conversion MMW imaging system based on Glow Discharge Detector row attached to commercial contact image sensor

Lidor Kahana, Daniel Rozban , Yitzhak Yitzhaky, Natan S. Kopeika, Amir Abramovich

Abstract: The proposed two dimensional millimeter wave imaging system is based on a row of very inexpensive detectors called glow discharge detectors (GDD) and a commercially inexpensive contact image sensor (CIS). The up-conversion detection method is based on detection of the light changes in luminous intensity of the GDD pixels due to the absorption of the MMW radiation. A Row of 44 GDD pixels was attached to a commercial CIS, constructing a MMW row sensor (MRS). The CIS samples the GDD row emitted light using a 1728 photo sensors array, then converts the analog data to digital data using a standard ADC board. In order to construct a full 2D MMW image of an object, the MRS is laid on top of a computerized X/Y translation stage similar to the mechanism of scanners and copy machines. A digital lock-in amplifier software algorithm is used to improve the sensitivity and SNR of the MRS signals. The entire system is controlled using LabVIEW software. The MRS is positioned in the image plane of a quasi-optical set up composed of MMW projection system and large aperture spherical imaging mirror. The projection system is used to illuminate the object. It is composed of a MMW source located at the focal point of an off axis parabolic mirror (OPM), which collimates the MMW radiation directed to the object. The large aperture imaging mirror is used to collect the MMW reflections from the object, creating an image at the location of the MRS. By scanning the image plane using the computerized X/Y translator, a 2D MMW image will be obtained.

Yellow LASER for Eye Surgery

Kobi Aflalo ,Adrian Stern and Irit Juwiler

Abstract: We examine the possibility of using a yellow wavelength (577nm) LASER for diabetic retinopathy eye surgery procedures. The main advantage of this wavelength is low intraocular scattering and higher absorption in hemoglobin comparing to the currently used green (532nm) laser. These features enable precise treatment using lower laser power. We use a multilayer eye model and a Monte Carlo simulation (MCML) and calculate the temperature distribution inside the eye. The blood vessel absorbs most of the energy due to high hemoglobin concentration. Photocoagulation occurs when the temperature reaches the range of 60-70 [ºC]. At that temperature tissue bleaching occurs. This research investigates the use of LASER for retinal eye surgery to treat diabetic retinopathy. In many cases the eye of diabetic patients is deprived of oxygen and nutrient due to insufficient blood circulation inside the retina. This in turn causes the formation of new brittle blood vessels on the surface of the retina. These new blood vessels leak and may cause retinal detachment, a condition that cannot be treated invasively. Therefore, laser radiation is used deliberately to destroy newly formed blood vessels and nearby retinal tissues thus preventing the need for oxygen and nourishments. Green laser, which is easily absorbed in blood vessels, is the most commonly used laser for this procedure. The goal of this research is to investigate whether a yellow laser is better suited for DR compared to green LASER. A Monte-Carlo simulation was used to calculate where most of the laser radiation is absorbed, and optimal LASER operation parameters for photocoagulation are found; i.e. LASER energy, pulse duration and spot size.

Developing a machine vision system for detecting laying hens

Odded Geffen, Yitzhak Yitzhaky, Nati Barchilon, Shelly Druyan, Ilan Halachmi

Abstract: The Israeli laying hens industry is regulated by quota; a farm can produce eggs according to a fixed number of hens. With the new community cages now integrated into the Israeli egg industry, a manual head count of the hens is an impossible task. The aim of this study is to develop a machine vision system that automatically counts the hens, and helps the regulator to control the industry. The hen house that was used is 87 m long stacked in 6 floors, with 37 community cages set in a row, each cage is 2.4 m long, housing 25 to 35 hens. The hen house has a narrow path along the cages. Consequently, a wide-angle

camera was applied (HD Action Camera 1080p) in order to frame the entire cage in a single field of view. The camera was mounted on a steel arm 0.85 m from the cages. The arm was connected to the feeder that moves along the cages. Videos were processed with a detection algorithm called Faster R-CNN (a convolutional neural network with a region proposal network). A feeding event appeared to be an adequate time to count the hens, as all hens were lined up in front of the cage, visible to the camera, making it possible to count. The detection algorithm was trained to detect hens in cages; it was tested on 4000 images and got an accuracy of 80%. The algorithm count was compared to human observer count used as ground truth.

Ultra-wideband and inexpensive glow discharge detector for millimeter wave wireless communication based on upconversion to visual light

Moti Ben Laish, Avihai Aharon, Daniel Rozban, Amir Abramovich, Yitzhak Yitzhaky and Natan S. Kopeika

Abstract: The demand for millimeter wave (MMW) communication systems has increased in recent years due to new technologies especially the New Radio standard (5G). The expensive cost of MMW detectors nowadays limits their widespread use. In the last years, new inexpensive MMW detectors were found in research. The detection method was based on up-conversion of the MMW to visible light. A miniature neon lamp as a glow discharge detector (GDD) and commercial photodiode were used in this detector scheme. This work focuses on the design of a new detector setup and measuring its parameters like noise equivalent power and bandwidth. One of the challenges is the ability to recover the phase of the transmitted signal. Because the new detector is square law detector, heterodyne detection method is desired. The detector measurements were performed in the 100 GHz region.

Design and simulation of a chemical bio-sensor based on double ring resonator waveguide

Israel Hory and Gabby Sarusi

Abstract: Optical waveguide resonant cavities are commonly serve as high sensitivity sensors for refractive index change and label-free molecular sensing. Their compact size and easy and low-cost realization make them one of the most attractive candidate for biosensing. Additionally, they offer the prospect of being incorporated in laboratories-on-a-chip that are capable of doing measurements at the point-of-care at an affordable cost. In this work we studied a biochemical sensor made of cascaded double ring waveguide resonators made on AlGaN-GaN layer. We developed and simulated a new architecture of the sensing device that manage to reduce the detection threshold by two orders of magnitude compared to other waveguide based refractive index transducers. One ring is the reference that covered with Si -Oxide cladding and metal contact in order to apply bias on it so refractive index can be changed. The second ring waveguide is in direct contact with the analyte to be measured.
The idea is that without the analyte both rings are in resonance so light can travel from the laser to the detector through them. Once introducing the analyte, the two rings are off resonance thus the applied bias bring them into resonance once again. The apparatus can be very cost effective since it contains only 1550nm diode laser and detector. The GaN/AlGaN chip that hold the waveguides is disposable. The device detection limit determined by our simulations, is as high as 4e-9 RIU which is on par with the performance of state-of-the-art biochemical sensors. We will implemented it on GaN/AlGAN waver and the full lab set-up is already prepared for testing.

Silicon Mode Converters Based on Dielectric Metamaterial Waveguide

Yakov Greenberg and Alina Karabchevsky

Abstract: Mode converters are key components in on-chip mode-division multiplexing systems. Here, we propose a compact silicon mode-converter waveguide that converts a fundamental mode into higher order modes. Specifically, all-dielectric metasurface with tilted subwavelength periodic perturbations is used to enable mode conversion on the same silicon waveguide. We use both the effective index method (EIM) and the coupled-mode theory (CMT) in our analysis to get exact values for both the coupling coefficient and the length of the structure. The device parameters and performance are evaluated using full vectorial 3D-FDTD simulations and field decomposition methods.
In our design, we take advantage of the discrete and orthogonal waveguide modes to allow the design of compact and efficient mode conversion devices in a silicon waveguide. The proposed device is a co-directional coupler with a periodic index perturbation along the propagation direction. As a result of the tilted structure, the coupling coefficient changes along the propagation in a sinusoidal manner and allows mode conversion on the same waveguide. Our proposed waveguide mode converter can be scaled to realize arbitrary waveguide mode conversions.
In order to validate the model, we design, simulate and analyze two mode converters, which convert a fundamental TE0 mode into both first and second order (TE1 and TE2) modes, respectively. We obtain good agreement between simulated and analytically calculated results. We demonstrate conversion efficiencies of 92% and 94%, respectively. Our approach can potentially increase the data capacity of on-chip communications.

Hyperspectral imaging using a wedge shaped liquid crystal as a spectral multiplexer

Shaul Shmilovich, Yaniv Oiknine and Adrian Stern

Abstract: Performing spatial scanning of objects in order to acquire their spectral characteristics, is common in various fields, such as remote sensing and quality inspection. In this work, we present a new compact hyperspectral (HS) imager, which is based on a wedge shaped liquid crystal cell. The HS image acquisition process consists of push broom like spatial scanning, spectral multiplexing and l_1 minimization for spectral reconstruction. The spectral multiplexing attribute of the imager, enables better optical throughput compared to classical HS imagers. In addition, it allows to explore the possibility of significantly compressing the HS data during acquisition. The spatial scanning stage of the image acquisition, the imager's small size and its improved optical throughput, define the imager as suitable for mobile systems such as drones, planes and satellites. The experimental results show precision in the acquired HS data, similar to the precision obtained by classical HS imagers.

Frequency conversion from single nano-particles, Sum-frequency generation from touching dimer

Shimon Elkabetz, K. Nireekshan Reddy and Yonatan Sivan

Abstract: A scattering problem from nano-metallic structure of touching dimer was solved analytically earlier for two different cases, linear [1] and second harmonic generation (SH) [2]. The main method that was used in this two cases is transformation optics. The non-linear motivation comes from the strongly enhanced electric fields occurring near the touching point. Figure 1: Two nano-metallic structures: touching dimer and slab structure. In order to switch between the electric field distribution in the two systems we use inverse conformal transformation.

Sum-frequency generation (SFG), a nonlinear response, has one more degree of freedom from SH process. This can be significant in investigating the possibilities of improving SH response. So we found the analytical solution by using Maxwell general equation, conformal mapping and ansatz methods. In addition, we investigated parts of the analytical solution in order to compare the SFG and SH response. We show that our solution is in excellent agreement with numerical results Fig 2. The solution behaviour will be examined by three terms: 1.Hω3z,max- Maximum absolute magnetic response2. |jmz,max|- Maximum absolute magnetic current density 3. θmax- The place on the right circumference where the |jmz,max| occurs. 4. PM- Phase matching, which is inversely dependent on the magnetic response

Fig. 3a presents SFG response which weaker than SH response for all frequencies combinations, therefore we try to find out the reasons for that superiority. This superiority can be clarified by a condition that involves overlapping of enhanced electric fields, it is called overlapping condition and it comes from jmz element, see Fig 3b. It is not sufficient condition, by looking at θmax Fig 3c, we can conclude that Geometric factor (GF) effect is significant when overlapping condition exists at small frequencies combination.

An optical frequency atomic clock: the most accurate machine ever built

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Abstract: Optical atomic clocks are the most precise measurement devices built to date. At present, optical clocks reach instabilities in the range of 10-16 in 1 sec averaging time and uncertainty on the order of 10-18. The performance of optical clocks surpasses the traditional microwave clocks and will lead to a new definition of the SI second standard in the future. In BGU we are in advanced stages of building an Yb atom optical clock. The Yb has very narrow forbidden optical transitions which are suitable. Here the isolated atoms are held in an optical lattice (light standing wave) trap for long interrogation times. State-of-the-art lasers and electro-optics are being used to achieve cutting edge clock performance. For example, a sub-Hz linewidth laser is being employed to probe the atoms, and a frequency comb will be used to connect optical frequencies to frequencies of electronic devices (Nobel prize 2005). The clock is expected to be a center for time keeping in Israel (as the GPS becomes less reliable) and also serve for the development of new laser and optical techniques. Finally, as the optical atomic clock is the most accurate machine ever built by human-kind, it will be used to probe the very foundations of science such as quantum theory and general relativity, as well as be a tool in searches for dark matter, dark energy and new forces.

Improving Power Conversion Efficiency of Organic Solar Cells by Integrating Grating Metasurfaces

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Abstract: Employing organic semiconductors in solar cells proved to be a promising technology for solar-to-electrical energy conversion. One of the requirements for organic photovoltaic solar cells is an absorber layer with thickness down to 200 nm [1], which can result in low power conversion efficiency (PCE). However, by using a grating structure, it is possible to confine the light in the area of the thin absorber layer and to obtain enhanced absorbance. Another vital role of the grating structure is to act as an anti-reflection coating [2]. These both functions of the grating structure lead to a higher short circuit current density. In

this study, we examine 2D grating structures embedded in selected locations in an organic solar cell. We designed and analyzed several structures for obtaining increased efficiency compared to the smoothed layered structure. We performed the simulations and the optimizations with an in-house tool based on RCWA method on a MATLAB platform. Even though the typical properties of grating result in narrowing the spectral width, we have obtained an appropriate design for increasing the efficiency of the spectrum width that is compatible with the solar spectrum. For example, at wavelength 700 nm the absorbance and the short-circuit current density was 0.035 and 2.57 μA/cm2, respectively; where for the embedded grating structure we obtain 0.85 and 61.6 μA/cm2.

Unique Technology Proposition on Room Temperature THz Detection with Graphene on AlGaN/GaN HEMT

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Generally, THz-IR detectors involves microbolometer or chopper-pyroelectric unit, requiring complex MEMS and optical structures. We have completely done away with any complex structure, engineering all the detector concepts within a single transistor. Our proposition includes a unique blend of graphene technology with engineered grating-gate structures, for efficient THz-coupling to the 2DEG in AlGaN/GaN-HEMT. Monolayer graphene is an excellent Drude absorber, with fantastic mobility values of 4000 cm^2/Vs. Transfer of monolayer graphene on Al_2O_3/AlGaN/GaN heterostructure, introduces a virtual chopper manifested by the intraband transitions of graphene creating charge carrier modulations on exposure to THz, which is capacity-coupled to the 2DEG. This eventually enables room temperature operation of the detector. We have also re-engineered the grating-gate to create a spatially-modulated I_{DS} with similar frequency as the capacity-coupled 2DEG modulation and with higher amplitude, choosing optimal V_{GS}, at the drain-edge. This creates spatial drain-edge 2DEG modulation, locking the detector operation exactly at the modulation frequency. This has enabled us to lower down all noise effects substantially**.** For the first time, extensive mathematical simulations have verified a 1000-fold increase in responsivity compared to any prototype pyroelectric THz detector. We have gained 20% higher responsivity compared to the grating-gate model, while using pyroelectric $LiTaO_3$ gate instead of Al_2O_3 in the gate stack.