Lecture Abstracts
Fundamentally New Aspects of Tunnel Diode Transitions in Multi-Junction Photovoltaics

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Tunnel diodes constitute an essential part of multi-junction concentrator photovoltaics. These tunnel junctions exhibit a transition from low-resistance tunneling to high-resistance thermal diffusion, commonly at current densities of the order of 102-103 mA/mm². Experimental evidence of a fundamentally new effect is reported and confirmed in distinct cell architectures: the dependence of the threshold current density on the extent of localized irradiation. It is also shown that photovoltaic cells with a non-uniform metal grid can possess an additional spatial dependence to the threshold current density.

These new phenomena should be observable in all solar cell tunnel diodes subjected to inhomogeneous illumination, and are posited to stem from the lateral spreading of excess majority carriers (similar to current spreading in LEDs). The implications for concentrator solar cells will also be addressed.
Impact of the Thomson Effect on Concentrating Photovoltaic Cells

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Photovoltaic cells convert most of the absorbed photon energy to heat [1]. While the effect of the resulting increase in cell temperature on the conversion efficiency has been well established [2], the effect of the temperature gradient created by removal of the generated heat by thermal conduction has so far been ignored. This temperature gradient is significant in concentrating photovoltaic (CPV) cells, typically exposed to photon fluxes 500 to 2,000 times higher than natural sunlight [3]. The Thomson effect interaction between this temperature gradient and the electrical current in the cell can either increase or decrease the electrical power output of the cell [4]. Here we show that the Thomson effect has a non-negligible impact on the conversion efficiency of Triple junction CPV cells, comparable to the impact of typical series resistance. The effect may also have a significant impact on the performance of other high power optoelectronic devices.

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Novel Solar Concentrators from Third-Generation non-Imaging Optics

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Department of Solar Energy and Environmental Physics, Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer Campus, Israel The thermodynamic limit for solar concentration quantifies the tradeoff between flux concentration and optical tolerance – especially germane when designs that can maximize the latter embody the potential to substantially improve the robustness and reduce the cost of high-concentration optics. Third-generation non-imaging optics create the possibility of optical designs that can realize the fundamental bound, but, unlike earlier generations of optical design, can also simultaneously accommodate pivotal practical constraints such as (a) allowing a sizable gap between the absorber and the optic at no loss in collection efficiency, (b) obviating the need for optical bonds, and (c) avoiding damage at off-axis orientation.

A new class of dual-mirror non-imaging concentrator will be presented, including several examples of particularly promising designs for concentrator photovoltaics, with angular acceptance superior to those of the best current optics for a given concentration. One tailors the two mirror contours to the two families of incident extreme rays - albeit with a cumbersome, numerical mathematical procedure – while implementing the guiding tenet of non-imaging optics that incident extreme rays also be extreme at the absorber. (In contrast, in the two earlier generations of non-imaging optical designs – compound parabolic concentrators and so-called tailored edge-ray concentrators – the contours are tailored only to one family of extreme rays.) These fundamentally new design notions allow either higher concentration at fixed acceptance angle or marked increases in optical tolerance at fixed concentration. The former is important for realizing progressively higher solar conversion efficiencies, and the latter for more affordable and resilient systems.
Vertical Junction Photovoltaic Cells for Concentrated PV

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Concentrator Photovoltaics (CPV) is a growing field in solar energy harvesting. To date almost all high concentration PV cells are based on III-V semiconductors in a tandem arrangement, and there has been very little success in the use of Si cells under high concentration.

We propose a novel Vertical Junction (VJ) array comprises of series-connected vertical p-n junctions within a single cell. The proposed device offers significant advantages over conventional cells: higher voltage, allowing parallel cell connections with significant reduction in mismatch losses and reduction in need for secondary optics; smaller inactive area loss; lower series resistance loss; decoupling of optical and electronic effects into orthogonal dimensions, allowing better optimization of junction dimensions.

We present comprehensive numerical modeling of a Si vertical junction that shows its outstanding behavior under high solar concentration. A large increase in the active layer photoconductivity, usually negligible in most PV cells, lowers drastically the cell’s series resistance under high concentration. As a result, the VMJ device exhibits efficiencies well above 30% for concentration of around 1000 suns.
Semi-Empirical Model for Multi-Junction Solar Cells

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Understanding terrestrial multi-junction solar cells is critical for designing high concentration photovoltaic systems. These cells are typically exposed to high levels of radiation intensity, while operating at temperatures up till 100°C.

Lately, two major cell manufacturers, Sharp Corp. and Spectrolab, Inc. provided vast experimental data of their triple-junction cell characteristics at wide range of concentration levels (1÷1000X) and operating temperatures (25÷120°C) [1,2]. However, a satisfactory cell model, calibrated at the full range of operating conditions was not yet presented. Recently, the predictions of a one diode, equivalent circuit, semi-empirical model were compared to the Sharp Corp. data [3]. The results were acceptable, except for the open circuit voltage and efficiency temperature coefficients, and further work was called for.

In the present study, a two diode equivalent circuit, semi-empirical model is proposed. Each (cell) set of coefficients was determined by comparing between the model predictions and the accordant manufacturer data, and performing regression analysis. The dark current model was validated successfully against the data by comparing the open circuit voltage. A better agreement between the cell’s characteristics model predictions and the data, including temperature coefficients, was obtained. A correlation between the cell efficiency and the concentration ratio and operating temperature is suggested.

References


Kaleidoscope Homogenizers in Partly Shaded Parabolic Dishes

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Kaleidoscope homogenizers serve to improve the uniformity of the flux incident on a receiver located close to the focal point of a concentrating system; such flux uniformity is required for the optimal operation of a photovoltaic module placed on that surface. Designs for such kaleidoscopes have been proposed, which consider the transformation of flux density from that given by a solar disk and the concentrator to that received at the end surface.

When tracking concentrating systems are placed close to each other, one collector may shade another, causing the incoming flux density to be different - specifically to be that generated only by part of the concentrator. This has the potential to increase the non-uniformity of the incident flux on the PV receiver, leading to reduced performance due to either mismatch effects or activation of bypass modes.

The flux distribution received at a PV module using different homogenizer parameters and shadow sizes is explored here, and the implications for design of kaleidoscopes and modeling of the output of an attached PV module receiver are discussed.

Calculations were done using the ray-tracing technique. The implementation of ray-tracing code was done in an open, extensible way, that could potentially serve other researchers, and is also briefly presented.
Development and Commercialization of Renewable Energy Technologies on the Way to Creating a Thriving RE Industry in Israel

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The renewable Energy revolution creates great opportunities for new innovative players to enter the enormous Energy marketplace so far controlled by traditional big players.

Introducing new green technologies into the market is a very challenging task. Such technologies must usually survive for many years under extreme outdoor conditions while maintaining high level of performances in order to insure reliability and ROI. The key element is for such technologies to become “Bankable”, which is a necessary milestone for large scale implementation.

In order to become bankable, technologies must go through a structured process form the lab, through prototype, beta site and a full scale commercial pilot that will include proper training for the technology installers and operators. Those stages prove to be challenging on the financial and engineering levels especially in Israel. In order to facilitate this process, government should offer suitable frameworks for supporting new green technologies and giving the opportunity for ground breaking concepts to reach maturity.

The Israeli minister of Trade, Industry and Labor is currently developing such a framework – The Renewable Energy Technology center, which will demonstrate a holistic approach to developing and commercializing innovative RE technologies. One of the main activities of this center will be locating and developing relevant IP from the academy thus creating a substantial funding source for academic research in the field. This framework has another unique character; it intends to support regional economic development for peripheral regions such as the Negev and Arava desert in Israel. Developing and commercializing green technologies are suitable for peripheral regions because of the special land and climate requirements and the fact they are new.

Such a technological center fits perfectly into a wider model for solving the energy crisis by advancing all necessary components while generating substantial regional development such as the Eilat Eilot Renewable Energy model. Within this project, an academic RE unit was sent and is now looking to hire highly qualified researchers.

The technological center aims at taking advantage of the great potential and enhancing the creation of an RE industry in Israel that will be similar to the thriving Hi-Tech industry and thus creating a huge business opportunity for Israel as well a boost for scientific research in the field.
Assessment of the Potential for Distributed Photovoltaic Electricity Production in Israel

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A significant portion of Israel’s electricity can be produced either by large utility-scale solar power stations or with small, distributed solar power systems. Producing energy in large solar power stations requires vast tracts of land and may necessitate an extensive upgrade of the power grid. Distributed production using photovoltaic panels on rooftops, on the other hand, does not have these drawbacks and takes advantage of the omnipresence of insolation. However, it is not clear if sufficient rooftop area is available.

Assessment of available rooftop area in Israel shows that a yearly electricity production, equivalent to 32% of the country’s consumption, can be achieved.

As will be shown, producing 10% of Israel’s electrical power needs (some 50 TWh yr⁻¹) using PV cells with 16% peak efficiency and a load factor of 1/6 requires a net area of 24 km², a considerable area for a country the size of Israel (total area ~ 20,000 km²).

To address this question data compiled by the Israeli Central Bureau of Statistics was used. Aerial orthophotos (planimetrically corrected aerial photographs) were analyzed and used to calculate the total rooftop area in Israel. Typical solar panel efficiencies and local insolation data were obtained. These sets of data allowed calculating the potential of distributed PV production in Israel and comparing it to the total electricity consumption.

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It is a common view now that human activities, like agriculture and industry, contribute to climatic changes. The prime greenhouse gas (GHG), Carbon Dioxide (CO\textsubscript{2}), is mainly emitted in fossil-fuel-based energy generation processes. Shimon Peres, the president of Israel, declared at the Copenhagen Climate Change Conference 2009, that Israel will reduce GHG emissions by 20 percent - below projections of "business as usual" growth in 2020. In order to reach this goal Israel should consider alternative economic policy incentives such as emission taxes and tradable emission permits. As a result, consumers will see energy price, which incorporates external cost of energy production from fossil fuels. Households will aspire to energy consumption effectiveness and industry will look for alternative, less polluted, energy sources, e.g. solar energy. In addition to its clean nature, this energy will become chipper relatively to taxed conventional energy sources.

This research employs a static Computable General Equilibrium (CGE) model of the Israeli economy. Initially, to this end, a social accounting matrix (SAM) is constructed to serve as a benchmark by combining physical energy and emission data and economic data from various sources. The efficacy of decentralized economic incentives for GHG emission reduction, such as carbon taxes on emissions and emission permits, is assessed in terms of their impact on economic welfare.
Grid Requirement to Incorporate Large Amounts of Electricity Generated by Photovoltaic systems. The case of Israel

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This presentation addresses the problem of how to match the intermittent electric output of photovoltaic (PV) to the requirements of the electricity grid in as efficient a manner as possible. To examine various limitations to injecting large amounts of PV power into Israel’s electricity grid, I used a complete set of hourly demand data for the year 2006. For this purpose, I also developed a simulation model that could predict the hourly output of PV plant located in the Negev Desert.

I then constructed a mathematical algorithm, based on Hadamard matrices that enabled me to assess the grid matching capability of these intermittent energy sources with and without energy storage. I used my algorithm to examine the compatibility of these resources with the hourly electricity demand of Israel during the year 2006.

Some of the major findings include:

1. The economically constrained flexibility factor (ff) of the IEC grid was found to be close to ff = 0.65, but, the data indicated that, technically, the existing IEC grid could operate at considerably higher flexibility levels, albeit with a radically different operating strategy. The results suggest that ff = 0.80 is an achievable and worthwhile flexibility goal for purposes of efficient solar penetration without storage.

2. At the increased grid flexibility level of ff = 0.80, a ND-sized PV system could have provided only 9.8% of the 2006 energy demand, but by allowing approximately 5% PV energy dumping, approximately 20% annual penetration into the IEC grid would have been feasible without the need for storage.

3. The calculated increase in hourly grid-ramping requirements caused by large PV systems is found to be well within the hourly ramping capability of the existing IEC grid. However, the grid ramping range that is achievable, based on the technical capabilities of the IEC’s existing plants, could limit PV penetration even though the required ramping rate can be met.

4. In my study of storage, I imposed the constraint that no PV energy losses are permitted other than those due to storage inefficiency. This constraint leads to powerful linkages between the energy capacity and power capacity of storage, and PV system size, and
their combined effect on grid penetration. Various strategies are then examined for enhancing grid penetration, based upon this newfound knowledge. Specific strategies examined include: PV energy dumping, and baseload rescheduling both on a seasonal basis and shorter time periods. We found, *inter alia*, that at high grid flexibilities (in the range $ff = 0.8 – 1$), PV grid penetration levels could be possible in the range 60% to 90% of annual requirements. Moreover, with appropriately designed storage and accurate forecasting, a future grid could be operated at $ff = 1$.

**References:**


Solomon, A.A., D. Faiman and G. Meron. Properties and uses of storage for enhancing the grid penetration of very large scale photovoltaic systems. - Submitted to *Energy Policy*
Full Landscape of Aplanatic Optics for Solar Concentration Near the Termodynamic Limit

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Originally developed to ameliorate image quality in telescopes, aplanatic optics were only recently analyzed as maximum-performance light-transfer systems with concentration approaching the fundamental limit. A basic categorization scheme is presented that appears to cover the full spectrum of aplanatic designs, illustrated for far-field dual-mirror concentrators and motivated by high-irradiance solar applications, especially concentrator photovoltaics.

The 8 fundamental classes of dual-mirror aplanatic optics offer a physically transparent categorization that permits the identification of an assortment of distinct optics, including several previously unrecognized classes of concentrators. Analytic solutions for the reflector contours allow the rapid exploration of a multitude of configurations, and facilitate design and optimization procedures. Aplanats also allow a nominally loss-less gap between the mirrors and absorber (i.e., at no loss in efficiency or concentration).

This study was initially motivated by photovoltaic concentrators (mainly with the constraint of passive cooling) but revealed a rich spectrum of high-performance optical designs that could be useful for (1) concentrator photovoltaics with active cooling, (2) solar thermal concentrators, (3) infrared concentration, and (4) collimating light from quasi-lambertian sources (where the roles of target and source are reversed).
Utilization of Quantum Dots in Luminescent Solar Concentrator

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The ability of quantum dots to absorb a wide spectral range and emit in an easily tuned narrow range of wavelengths, can be used in luminescent solar concentrators. Since the cells that perform the conversion from light to electricity together with the so-called balance of systems (BOS) costs, which normally scales with the area, are the most expensive components of photovoltaic systems, it would appear to be advantageous to reduce the required area of cells and bring down the cost of the BOS for a given power output, by concentrating the sunlight prior to illuminating them.

The typical Luminescent Solar Concentrator (LSC) is a plate of transparent material, such as plastic or glass, which contains luminescent centers that absorb and then re-emit light, such as organic dyes or quantum dots. An incident beam of light absorbed by luminescent centers and then emitted at a different wavelength (in the normal case of Stokes fluorescence, the emitted wavelength will be shifted to a longer wavelength). If the probability of emission is equal in all directions, part of the light will leave the transparent medium, while another part will be reflected back because it intersects the surface at an angle leading to total internal reflection. Thus the captured light is guided within the transparent sheet (collector). Concentrated light can thus be obtained at the edge of the collector onto which PV cell is mounted, which then, in turn, generates electricity. The edges of the concentrator not contacted by PV cells have to be covered with mirrors. LSCs offer a unique advantage with respect to other types of concentrators, such as mirrors and lenses in that they can also collect most of the diffuse light.

The use of LSCs for the concentration of sunlight was suggested first in the 1970s. Although significant advances were made in early work, after some years further progress was limited by the materials available at that time (dye molecules) and interest was dormant for decades. Only recently new progress in materials (mainly in quantum dots) as well as theoretical advances rekindled interest.

In this presentation, recent as well as early developments in the field of LSCs will be reviewed and key issues for an optical efficiency improvement will be addressed.
An Ultra-High Irradiance Solar Furnace for Solar Cell Characterization and Nanomaterial Synthesis

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1. Introduction and Aims
Previous studies depicted how highly localized irradiation of concentrator solar cells in real-sun fiber-optic concentrators can elucidate new and occasionally unanticipated device physics. The concentrators in those studies (a) restricted the experiments to relatively low power levels and hence were fully applicable only to mm-scale, rather than cm-scale, cells, and (b) were not conducive to moderating the temporal character of the solar input due the inherent divergence of the delivered light.

We report the experimental realization of a converging solar furnace with a net solar power delivery of 150 W onto a target ~6-7 mm in diameter, with capabilities to achieve (1) a variety of flux maps on the target, (2) concentration boosts to over 20,000 kW/m\(^2\) with mirrored and all-dielectric terminal concentrators, (3) effectively flash real-sun illumination of the order of a ms that allows current-voltage (I-V) curves to be measured with only insubstantial increases in cell temperature, and (4) long-term real-sun testing of advanced solar cells and materials. The solar furnace also serves as a unique driver for the photothermal synthesis of inorganic nanomaterials, such as fullerene-like and nanotube structures for MoS2, WS2, SiO2 and carbon.

2. Solar furnace design and flux distribution
Fig. 1 includes a schematic and photo of the solar furnace. An outdoor flat faceted heliostat on a precision dual-axis tracker reflects sunlight through a lab window to a flat mirror tilted at 45° that redirects the radiation to a downward-facing horizontal NA = 0.40 parabolic dish, 500 mm in diameter. At a normal beam irradiation of ~900 W/m\(^2\), we measured 150 W of solar power within a focal spot 6-7 mm in diameter (~4.500 suns).

Introducing an ellipsoidal mirror of NA = 0.95 allowed a boost to ~22,000 suns in a converging configuration. Comparable irradiance was also attained with an all-dielectric nonimaging secondary concentrator sited in the parabola’s focus, albeit with the concentrated light diverging toward the target. The use of irises permits creation of strongly peaked flux maps on the solar cell or chemical reactor absorbers.
Fig 1. Schematic (a) and side photo (b) of the solar furnace, plus flux maps (with photos of the light from a diffuser plate used in the measurements): (c) in the paraboloid’s focal plane (~4,500 suns), (d) in the focal plane nearer the ellipsoid (~22,000 suns).

3. Concentrator photovoltaic and nanomaterial synthesis experiments
Our presentation reports I-V measurements on concentrator solar cells over irradiance levels from 0 to 22,000 suns (with flux maps varying from highly peaked to uniform) that reveal novel tunnel diode and series resistance effects. We also report the high-temperature photothermal synthesis of inorganic fullerene-like and nanotube nanostructures not even achievable with oven-assisted laser ablation, due in part to the unique annealing conditions created in this genre of solar-driven reactor.

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The phenomenon of secondary electron emission (SEE) from diamond is suggested to be harnessed for solar energy conversion technologies. Polycrystalline diamond films are well known for their high secondary electron yield. Diamonds have a low electron affinity. By applying hydrogen/Cesium monolayer on the diamond surface an effective negative electron affinity (NEA) might be achieved. This means that the conduction band minimum at the surface is higher than the vacuum level so when a conduction electron approaches the diamond surface its total energy is higher than that of the vacuum level and thus it has a significant chance to detach from the solid and escape into the outer space. Therefore, polycrystalline diamond films are excellent candidates for secondary electron emitters.

A possible device for solar energy conversion that utilizes the phenomenon of SEE can be described as follows: the diamond film, deposited on a conductive substrate, will constitute the negative electrode. Since the SEE is known to be proportional to the diamond's temperature, concentrating mirrors can be used to heat the negative electrode in order to enhance the SEE yield. By placing a cold collector a few hundreds of microns in front of the emitter and by maintaining a high vacuum within the interelectrode space, secondary electrons are expected be ejected from the diamond surface and reach the collector. From there the electrons will flow through a resistor connected to the substrate of the negative electrode. Applying an electric bias between the electrodes can further increase the SEE and thus enable the use of lower temperatures (far less than 1000°C). An additional aspect of such theoretical device could be the usage of the solar IR & visible light (which constitute the majority of the solar irradiance reaches the earth's surface at sea level) not only to heat the diamond film but also to excite electrons, in nitrogen doped diamond, from the dopant level to the conduction band minimum (located 1.5 eV above it).

In this short talk I shall present the main principles of a theoretical diamond based solar conversion device based on the SEE phenomenon, and the obstacles lying ahead.
Grain Boundary Conduction in CVD Diamond Films

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Diamonds exhibit many extreme properties such as exceptional hardness, Chemical inertness and a high stability at elevated temperatures. Diamonds have a very high band gap (5.5 eV) and are thus insulating, but when a diamond crystal surface is hydrogenated, two interesting things happen:

• A surface conductivity appears
• The surface has negative electron affinity

Negative electron affinity describes the situation when the Vacuum energy level is below the conduction band minimum. This means that every electron that is excited enough to go over the band gap has enough energy to be emitted, which is a very desirable property for an electron emitter for solid-state solar cells and heat-electricity conversion devices.

But, since a diamond crystal is highly resistive, electron emission stops very quickly due to charging effects.

In our lab, we grow thin polycrystalline diamond films through a CVD process (Chemical Vapor Deposition), which show bulk conductance. The conduction mechanism isn't fully understood and probably has to do with the grain boundaries, where different carbon and hydrogen structures exist.

In the talk, these matters will be discussed and some recent experimental results will be presented.
Built-in Quantum Dot Antennas in Dye-Sensitized Solar Cells

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A new design of dye-sensitized solar cells involves colloidal semiconductor quantum dots that serve as antennas, funneling absorbed light to the charge separating dye molecules via nonradiative energy transfer. The colloidal quantum dot donors are incorporated into the solid titania electrode resulting in high energy transfer efficiency and significant improvement of the cell stability. This design practically separates the processes of light absorption and charge carrier injection, enabling us to optimize each of these separately. IPCE measurements show a full coverage of the visible spectrum despite the use of a red absorbing dye, limited only by the efficiency of charge injection from the dye to the titania electrode. Time resolved luminescence measurements clearly relate this to Förster resonance energy transfer from the QDs to the dye. The presented design introduces new degrees of freedom in the utilization of quantum dot sensitizers for PV cells. In particular, it opens the way towards the utilization of new materials whose band offsets do not allow direct charge injection.
Recombination Inhibiting Barrier Layer for Type II Dye Sensitized Solar Cell

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Type II dye sensitized solar cells (DSSCs) differ from conventional DSSCs by their mechanism of electron injection. Instead of photoexcitation of the dye, followed by electron injection to the semiconductor conduction band, in type II DSSCs there is a direct electron injection from the HOMO level of the dye to the conduction band of the semiconductor. The main drawback of such cells is their extremely rapid back electron transfer rate. Herein we present a new approach for inhibiting back electron transfer in type II DSSCs using thin layer barrier coating of SrTiO$_3$ between the semiconductor and the dye. A 70% improvement in charge collection efficiency is reported. A proposed mechanism for the operation of the SrTiO$_3$ barrier layer is being presented.
ETA Solar Cells Using Sb$_2$S$_3$ Absorber

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One of the challenges for alternative energy is to produce photovoltaic (PV) cells that are cheap, efficient and reliable over a reasonable lifespan. A fairly new concept is the ETA (Extremely Thin Absorber) cell: A thin layer of an absorbing material is deposited on a porous, transparent n-type semiconductor with a high internal surface area, while the pore volume is filled with a transparent p-type semiconductor.

We found that chemically deposited Sb$_2$S$_3$ shows promising photovoltaic behavior as the light absorbing material in an ETA cell, with TiO$_2$ nanoparticles as the electron conducting mesoporous film, and CuSCN as the pore-filling hole conductor. A thin layer of In$_x$(OH)$_y$S$_z$ – chemically deposited between TiO$_2$ nanoparticles and Sb$_2$S$_3$ – promotes the nucleation of Sb$_2$S$_3$ on TiO$_2$.

A SCN$^-$ solution treatment of the Sb$_2$S$_3$ before the CuSCN decreases the resistivity of the cell, thus improving cell performance. Additionally, aging of the cells improves the $J_{SC}$ and FF of the cell, which is tentatively ascribed to increase in the conductivity of CuSCN.

We achieved solar conversion efficiencies up to 3.4% from a cell with the structure: porous TiO$_2$/In$_x$(OH)$_y$S$_z$/Sb$_2$S$_3$/SCN$^-$ treatment/CuSCN. We also carried out some preliminary operational stability measurements of Sb$_2$S$_3$ cells and found them to be stable over 3 days of operation under load.
The Affect of Sb Doping on ZnO Films Morphology

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ZnO is a wide band gap (3.3 eV) semiconductor with many actual and potential applications. ZnO normally exhibits intrinsic n-type conductivity. p-type doping is much rarer, but has been accomplished in some cases using group V dopants. Chemical Bath Deposition (CBD) is a common method used to deposit ZnO films, yet only a very little work has been done with one step CBD which include extrinsic doping of ZnO. While there are many different ‘recipes’ for this deposition, they are almost all performed in aqueous solutions (typically at 70-90°C) and in general are believed to be based on formation of hydroxylated Zn species which at the reaction temperature form ZnO.

In the present study, Sb-doped ZnO were deposited where the Zn was complexed by ethanolamine with a co-complex of either ethylenediamine or ammonia. CBD ZnO films typically grow with nanorod morphology. Deposition parameters such as pH, nature of the complexing agents, concentrations and anion of the the zinc salt can strongly affect the film morphology. Addition of Sb (as potassium antimony tartrate; 1 mole% w.r.t. the Zn concentration) to the deposition solution greatly decreased the growth rate and also changed the film morphology. In contrast to the gradually-tapered, pointed, undoped ZnO nanorods, straight nanorods with flatter and rougher tops and denser, more oriented (seen both by XRD and SEM) packing of the rods were obtained. Investigation of the film evolution showed that initially a slow deposition of a compact layer of (Zn,Sb) oxide occurs, followed by increasing growth rate of ZnO rods as the relative Sb concentration decreases.

We find that these films are particularly effective for use as the nanoporous ZnO substrates for semiconductor-sensitized solar cells, in particular, solid state (ETA – Extremely Thin Absorber) cells. This is mainly due to the efficient blocking action of the compact layer. Normally, ETA cells require a predeposited dense oxide layer (to prevent shorting between the solid hole conductor and the conducting glass substrate) followed by the nanoporous layer. Using the films described here, a separate blocking layer is not required. We note that dense layers of ZnO can form also in the absence of Sb. However, these dense layers are much less effective in ETA cells.

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Hybrid Structures of Porous Silicon and Conjugated Polymers for Photovoltaic Applications

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We report on a novel approach to synthesize hybrid nanostructures of meso porous silicon (PS) and conjugated organic polymers that are suitable for solar cell applications. Meso-PS substrates with relatively large pores have been exploited for electrochemical polymerization of organic monomers that were introduced into the PS matrices. We present electrical characteristics of a device having relatively thin films of the hybrid medium, which demonstrate a photovoltaic mode of operation of the device.

REFERENCES
Biochemical and Crystallographic Analysis of the Phycobilisome Photosynthetic Antenna

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The development of alternative energy resources is a major area of research with global implications due to dwindling world energy resources. One of the most promising areas of research is the attempt to mimic the biological process of photosynthesis. One of the reasons for the high efficiency of the photosynthetic process is due to the nature of its initial step, the capture of light energy. The absorption of light energy is performed by pigment-protein complexes called light harvesting antennas that transfer the absorbed energy to the photochemical reaction centers with a quantum efficiency of near unity. In cyanobacteria and red algae the major antenna is called the Phycobilisome (PBS). The PBS is an extremely large complex, with a molecular weight of 3-7MDa which is made up of pigmented proteins known as phycobiliproteins (PBP)s and unpigmented proteins known as linker proteins. Our goal is to obtain high resolution crystal structures of the entire PBS complex and the two major PBS subcomplexes, (rods and cores), isolated from the cyanobacterium Thermosynechococcus vulcanus.

Intact PBS was isolated in high phosphate buffer by sucrose gradient ultracentrifugation. Small blue crystals shaped like half moons were obtained in stabilization buffer in two to four weeks. Crystals and protein obtained from the dissolution of extensively washed crystals were analyzed by fluorescence spectroscopy, SDS-PAGE, mass spectrometry (MS) and confocal microscopy. The results of these experiments indicate that the crystals contain intact, functional PBS complex. Dynamic light scattering showed that the crystallized material had a molecular weight of at least 2.8MDa. Preliminary diffraction experiments have indicated that the present crystals diffract to a resolution of ~ 4Å.

In the process of PBS isolation, fractions of the two subcomplexes were also obtained, and successfully crystallized. Large blue rod crystals, containing phycocyanin and the three rod linker proteins were obtained and two data sets were collected on beam line ID14-1 at ESRF, Grenoble. The structure was determined by molecular replacement to a resolution of 1.8 Å in the space group H32, with a monomer in the asymmetric unit. Core crystals have been studied by confocal fluorescence microscopy, however require further improvement in order to perform structure determination.

The PBS self assembles to function as an efficient antennae complex and also may disassemble under environmental pressure to serve as an internal storage of nutrients for synthesis of proteins, other metabolites or as a source of energy. The only protein shown to be directly related to the PBS degradation is the non bleaching A (NblA) protein which is a small protein with a molecular weight of only 7-7.5 KDa. The structural, functional and mutational analysis of NblA suggests a mode by which the NblA interacts with the PBS. It is proposed that such a small protein degrades a giant complex by the penetration of a dimer of NblA into a gap formed by two hexamers causing the rod to disassemble.
**De novo** Design of Minimal Analogs of Photosynthetic Light Harvesting Complexes

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Light harvesting complexes (LHCs) of photosynthetic organisms are natural protein-pigment (mainly chlorophylls [Chls] and bacteriochlorophylls [BChls]) assemblies capable of capturing light and efficiently transferring it to reaction centers, where it is converted to chemical energy. All LHCs keep a relatively high pigment-to-protein ratio, yet their structures, pigment composition, and organization vary considerably among species. The ability of the proteins to assemble a large number of (B)Chls into specific geometries that permit optimal excitation-energy transfer (EET) is the key to LHCs functionality. We aim at understanding the parameters that control the inter-pigment distances and relative orientation, as well as the factors affecting their chemical properties. For this purpose we design *de-novo* small proteins that maintain the essential features of the natural complexes. Thus far, we have constructed a minimal, yet functional, water-soluble analog of LH proteins, based on a transmembranal Chl-binding structural motif found in natural oxygenic photosystems. The new protein, labeled PS3H2, was found to bind multiple molecules of a water-soluble BChl derivative, and the spectral properties of the protein-pigment complex were indicative of inter-pigment excitonic interactions. Additionally, specific protein oligomerization was observed upon pigment binding. By constructing a series of mutants eliminating putative Chl binding sites, and comparing the mutants to the original prototype we identified specific pigment binding locations and their influence on complex assembly. This novel system will provide new insight into the critical factors essential for LHCs assembly and functionality. These may be exploited to construct artificial LH proteins to be incorporated in solar-energy conversion devices.
Efficiency of Bifacial Si Solar Cells at Low Irradiances.
Influence of Design and Fabrication Conditions

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Standard irradiation for solar cell and module characterization and certification (AM1.5, 25°C 1000 W/m²) is not achievable during most of the operating time of terrestrial modules. Power generated at irradiance levels down to 100 W/m² contributes significant and sometimes a dominating part of complete energy production of the PV system. Moreover there are many solar cell applications where the working illumination is far lower than "one sun". Use of bifacial cells in many cases is advisable due to the scattered (diffused) character of incident radiation, and the contribution of both cell sides may be comparable.

Solar cell efficiency decreases with decreasing irradiance. The influence of Si parameters, of cell design and of fabrication technology on solar cell efficiency are different when the cell is working at standard or low irradiance. The goal of this study is the evaluation of some parameters of solar cell structure and fabrication processes on bifacial cell characteristics at decreased irradiance (down to ~0.01 Sun).

Experimental bifacial cell samples were prepared ≤ 4 cm² in area with passivated front and rear surfaces. n⁺-p⁺ solar cell structures were used. The resistivity range of the starting Si was 1–25 Ω.cm. Combined thermal diffusion – ion implantation technology was used for solar cell fabrication: open tube P diffusion with POCl₃ as a diffusant source and 30 keV B ion implantation with subsequent annealing and impurity drive-in.

Modeling using the PC1D program results in highest cell efficiencies for low ρ Si (~0.5 – 3 Ω.cm), however the experimental results on n⁺-p⁺ cells indicate shifting the optimum to a higher ρ range. The positive effect of low resistivity Si is hindered in this case by a corresponding increase of effective back surface recombination, Seff, when a BSF is formed by ion implantation. At the same time, the tendency of Seff increasing with decreasing irradiance level can be seen. Therefore, high resistivity Si (of ρ ≥10 Ω.cm) is more suitable for solar cells fabricated using the above technology and intended for low irradiance.

Lifetime dependence on injection level can result in a sub linear decrease of photo generated current, Ip, and corresponding efficiency degradation with a decrease of irradiance, E. Significantly such an effect can take place under back illumination. A 7 to 9 % decrease of front Ip/E and back Ip/E 2 times lower, was measured with variation of E from 100 to 1mW/cm² for solar cells, in which defects were introduced due to light degradation. The efficiency decrease was obviously even more drastic. Therefore starting Si resistant to light degradation should be used.

Among other design parameters which can be optimized for solar cells intended for low irradiances are lower emitter doping levels as well as smaller surface area metallization contacting the semiconductor.
Co-Assembly of Titania Precursor and Water Soluble Polythiophene into Mesostructured Photovoltaic Films

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Hybrid organic/inorganic solid-state solar cells are considered a promising low-cost alternative to conventional inorganic semiconductor photovoltaic devices. In these devices, in order to dissociate excitons into free charge carriers and provide carrier transport to the electrodes, a donor-acceptor phase separation on a sub-20 nm length scale is needed, while maintaining continuity and orientation of each individual phase on a much longer length scale.

In this work, a sub 20 nm phase separation between a donor conjugate polymer species and inorganic metal oxide acceptor is achieved by harnessing the evaporation induced self-assembly (EISA) and sol-gel chemistry methodologies. The selection of a water soluble polythiophene (P3SHT), in contrast to highly hydrophobic conjugated polymers commonly used in organic solar cells, enables the co-assembly of the organic and inorganic components to from a P3SHT-incorporated 3D-cubic mesoscopically ordered Titania thin film. This approach enables processing without any toxic organic solvent, and provides high polymer-uptake leading to high chromophore concentration in the film. The influence of process parameters including solvent and relative humidity on the structure formation are examined by glancing-incidence small angle X-ray spectroscopy (GISAXS) and transmission electron microscopy (TEM). Furthermore, the location of the P3SHT in the layer is investigated using optical absorption, TEM and energy filter TEM (EFTEM). GISAXS and TEM micrograph clearly show that after optimization of the process parameters, highly ordered 3D cubic Titania mesostructure films are obtained with average lattice parameter of ~16.0 nm. EFTEM study show that the conjugated polymer is indeed confined in the Titania mesostructure, but is also partly interconnected. Thus, this ordered bulk heterojunction is promising for efficient exciton disassociation in high performance solar cells.
Plasmonic Enhanced Solar Cells

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Recently large efforts are made towards making thinner solar cells, whether to reduce cost of c-Si or to increase carrier collection efficiency. However in order to maintain high efficiencies in thin solar cells effective light management is crucial.

The scattering from metallic nano particles near their localized plasmon resonance is a promising way of enhancing the light absorption and quantum efficiency in solar cells. Increased photo current and quantum efficiencies have been observed in a wide range of solar cells – from standard c-Si to various types of organic and a-Si thin film solar cells.

The origin of these phenomena is the collective oscillation of free electrons in the metal particles interacting with the incident light called surface plasmons. However the specific mechanisms originating from these surface plasmons were not studied. Here we present the effects of plasmonic -semiconductor interactions including enhanced delivery of light into the silicon absorber, angular scattering, localized field enhancement etc. – All contributing to enhanced solar cell efficiency. Various properties of the metal particles such as composition, size and geometry lead to different weightings of the above mentioned mechanisms.

Measurements of plasmonic enhanced organic solar cell fabricated with metal nano particles will be presented in details. Here the plasmonic interaction may contribute also in the carrier collection path.
On Compatibility of Capacitive Based Converters to PV Sources

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Processes of development and manufacturing of integrated circuits based on semiconductors gained much progress during the last decade, both concerning the density of transistors for a unit area, increased manufacturing yield, reducing power consumption, etc. Large Scale Distribution of the power into cellular units which processes a couple of dozen of milliwatts, enable the use of a cellular unit, which is implemented by capacitive based converters. This Topology, when connected to a rigid voltage source, has an inherent disadvantage of generating EMC pollution since the current’s shape is very narrow. That is due to the fact that no inductance participates in the processing to limit the transition time of the current’s slope. These spikes require treatment in the form of external large capacitors or inductors or complexity in the design by introducing interleaving techniques.

In this work, the theory of connecting versatile capacitive based converters such as the General Transposed Series Parallel converter to a Photovoltaic Source is presented. The "soft" source characteristics of a PV based source makes it a natural power source for working with a SC converter. The PV source is connected to the load with a SC converter as an interface for meeting the power source as well as the load characteristics requirements (See Fig.1). The converters performance is analyzed when connected to a PV source and an ideal rigid voltage source.

![Diagram of SC converter](image.jpg)

Fig.1: A SC converter as an interface between a PV source and a load
Studies of Photo-absorption Enhancement in Si Substrate by Embedded Ag Nano – Shells

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The Localized Surface Plasmon Resonance (LSPR) exhibited in nano-particles, embedded in a dielectric medium has recently been shown to enhance the absorption as well as the photo-generation effect in several light-sensitive structures including solar cells.

Literature refers to several enhancement mechanisms supported by LSPR, depending on the particular device structure and configuration. These mechanisms include:

1. Enhanced light trapping via Mie scattering by the nano-particles;
2. Absorption enhancement via increased E-Field intensity in the semiconductor regions adjacent to the nano-particles, due to the excitation of plasmons.
3. Absorption enhancement in the underlying semiconductor substrate, via plasmonic coupling between adjacent nano-particles;
4. Photo-generation enhancement via plasmonic E-field effect on the exciton dissociation in organic-semiconductors;

We have been conducting computer simulation studies on the photo-generation enhancement of nano-particle-related LSPR, based on FDTD simulation.

Results of this study addressing photo-generation enhancement by Ag nano-shells embedded in the silicon substrate in several configurations, will be presented along with a theoretical analysis of these simulation results, which appear to support the second mechanism indicated above.
Biofuels from Wet Organic Waste by Solar Super-Critical Water Gasification (SCWG)

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The study of a Supercritical Water Gasification (SCWG) process for conversion of wet biomass into renewable fuels, with optional use of solar heat input and cogeneration of power, was undertaken. The SCWG reaction is thermodynamically characterized by high pressure and moderate temperature relative to other biomass gasification processes, which require significantly higher temperature. The water serves simultaneously as the transport medium, solvent, and reactant, obviating the need to dry the organic feedstock, and yielding more efficient conversion, without formation of tars and other undesired products. The combustible gaseous fuel is enriched by the hydrogen contained in the water.

A comprehensive simulation was developed and validated in order to analyze the thermodynamic behavior of a fuel and power cogeneration plant. The performance of a supercritical cogeneration cycle was compared against a superposition of a supercritical fuel production cycle and corresponding Rankine cycle. The cogeneration cycle produces fuel and mechanical power simultaneously, while the two reference cycles produce these products separately. The simulations considered the impact of the main operational parameters: heat input temperature, biomass input fraction relative to the water, isentropic efficiency of the turbine stages, and efficiency of the fuel cell used to convert the hydrogen to electricity. Results show overall conversion efficiency from heat to electricity of up to 51% at process temperature of 600°C, corresponding to second-law efficiency of up to 66%. These results show a potential to achieve very good performance at moderate temperatures that are easier to handle using conventional technologies.
Solar Energy Storage in PCM for Domestic Water Heating Systems

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Solar energy is becoming a very important and meaningful field of ongoing research. Nowadays there exist economical and environmental motivations to reduce the depletion of fossil fuel resources and increase the use of renewable clean types of energy sources, among which is solar energy. The surging price of oil, air pollution and global warming effects provide sufficient justifications to sustain that trend.

Thermally stratified water storage tanks are widely used in energy conservation systems and considered to be effective. Within those tanks, heat is stored in its sensible form. Heat storage in the form of latent heat is yet to be exploited. Storage of heat by a process of phase change can surpass the efficiency attained by sensible heat storage. Such is the case of Phase Changing Materials (PCM). They provide higher heat storage density at relatively low temperatures. The storage tanks bridge the mismatch obstacle that exists between the times of heat storage to the times of consumption. To maximize the heat collection and storage capacity, we are conducting a research on the benefits gained from the addition of PCM plates into water tanks for domestic water systems (DWS).

The research is conducted by means of a numerical simulation model and an experimental test facility. The PCM material used is Paraffin that is placed within a 300 liter water tank equipped with a frame to hold the PCM plates. For comparison, a control system was added that is comprised of a standard 300 liter water tank. Each tank is equipped with two solar collectors. The objective of the test facility is both calibration and validation of the numerical model. Numerical calculations unveiled precisely the advantages gained by the incorporation of the PCM in solar domestic water systems. Those advantages are attributed to the lower temperature of heat storage that reduces losses and increase the collector efficiency. Furthermore, the quantity of unusable heat stored is reduced.
Hydrogen Peroxide (H₂O₂) as a Probe for Solar Induced Water Splitting

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Sun light induced water splitting is the “holy grail” in photoelectrochemistry. The benchmark efficiency results were accomplished by Grätzel silicon doped Hematite photoelectrode. The limiting factors of this system are bulk recombination and the inability of the photo-generated holes to transfer to the water and oxidize it. In order to deconvolute between this mechanisms, one needs to find a hole scavenger that will take all the holes that come to the surface. In this work we examine H₂O₂ as an ideal hole scavenger.

The photoelectrochemical behavior of Hematite electrodes deposited by Ultrasonic Spray Paralysis (USP) Pulse Laser Deposition (PLD) and APCVD was studied with and without H₂O₂. Two electrochemical methods were used: standard IV measurement with and without light, I vs. Time with different potentials and light pulses. The results were interpreted by Gerischer model

This work demonstrates that H₂O₂ can be used as a probe to diagnose whether the limiting factor for the photo current is the bulk recombination or the holes transfer kinetics to the electrolyte. We conclude that bulk recombination is limiting the saturation photocurrent and the slow hole transfer kinetics is responsible for the onset voltage needed.
Dramatically Enhanced Photo-Induced Processes within Porous Silicon

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Porous Silicon (PS) is a material composed of submicron to nanometer scale pores surrounded by Silicon crystallites. PS samples are prepared by electrochemical etching in Ethanoic solutions of Hydrofluoric acid (HF). Immediately after the etching process the surface is Hydrogen-terminated, and thus relatively inert.

PS samples exhibit unique characteristics, fundamentally different from those of bulk Silicon. Particularly, the porous morphology results in an enormous surface area (200-500 m² g⁻¹). This vast surface area can be valuable in a variety of fields, e.g. catalysis and gas detection.

The photo-induced desorption of N₂O and Xe from PS following laser irradiation at 193nm was found to have an unusually large cross section (10⁻¹⁵ cm²), more than two orders of magnitude larger than from a flat Si surface. This phenomenon is explored using real time tracking of the desorbed species, TOF measurements and post- irradiation uptake measurements of the remaining adsorbates.

Better understanding of these unusual photochemical properties can be valuable in developing photochemical and photovoltaic devices. Such a photovoltaic cell-composed of porous silicon, conducting polymer and nano particles is currently being prepared and explored in collaboration with other research groups at the Hebrew university.
Electrochemical Behavior of Positive Electrodes for Advanced Lithium-Ion Batteries: Brief Review

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There is a growing interest in substituted spinel LiMn$_{2-x}$M$_x$O$_4$ and layered LiMnM$_1$M$_2$O$_2$ lithiated oxides (M, M$_1$, M$_2$ are transition metals, like Ni, Co, Cr, Al, Cu, Ti) as promising materials of positive electrodes for advanced Li-ion batteries that can operate up to 4.6 – 5.0 V. Although electrodes based on these oxides are well studied, several issues, for instance the use of nano-particles as electrode active mass, surface chemistry developed on the electrodes during cycling and ageing, are still open and should be clarified.

The goal of the present work was to study the electrochemical behavior and electrode/solution interactions of positive electrodes prepared from nano- or submicron particles, in Li cells. These electrodes comprised LiMn$_{3/2}$Ni$_{1/2}$O$_4$, LiMnM$_1$M$_2$O$_2$ and integrated materials of the general formulae xLi$_2$MnO$_3$·(1-x)LiMn$_{1/3}$Ni$_{1/3}$Co$_{1/3}$O$_2$, all synthesized by the self-combustion reaction.

We have found that by varying the temperature from 700 °C to 900 °C and duration (1–22 h) of annealing of the as-prepared lithiated oxides, nano- to submicron and micron sized particles of these materials can be produced. We followed the electrochemical performance of the cathodes comprising nano-sized or submicron particles of the spinel and layered materials with various active areas produced by the same synthetic technique.

Capacities up to 180-200 mAh/g could be reached during prolonged cycling of LiNi$_{1/3}$Mn$_{1/3}$Co$_{1/3}$O$_2$ electrodes at room temperature and at elevated temperatures (60 °C) in ethylene carbonate (EC) – dimethyl carbonate (DMC)/LiPF$_6$ solutions. We have found that electrodes prepared from LiNi$_{1/3}$Mn$_{1/3}$Co$_{1/3}$O$_2$ nano-particles may demonstrate a slower kinetics and less reversible electrochemical behavior, compared to their micro-sized counterparts, due to enhanced passivation phenomena, related to the high surface reactivity of the nano-particles. The capacity retention found with these electrodes was notable even when these cycling experiments included prolonged ageing of the cell. Regarding electrodes prepared from LiMn$_{3/2}$Ni$_{1/2}$O$_4$ which red-ox potential is around 4.8 V: this material is intrinsically stable in standard electrolyte solutions. We have also shown that xLi$_2$MnO$_3$·(1-x)LiMn$_{1/3}$Ni$_{1/3}$Co$_{1/3}$O$_2$ electrodes (x=0.3; x=0.5; x=0.7) comprising submicron particles demonstrated stable cycling behavior and capacities around 200 mAh/g (x=0.5) at various rates up to 2C.

Electrochemical stability, rate capabilities of positive electrodes in Li-cells, as well as surface chemical reactions of these electrodes during cycling and ageing will be discussed in this presentation.
Oil Globule Proteins in Oleaginous Green Microalgae

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Microalgae accumulate neutral lipids mainly in the form of triacylglycerol (TAG). These TAGs can constitute up to 20-50% of their dry cell weight, under stress conditions. Microalgae-derived TAGs may be used as a renewable source for production of biodiesel, which is currently produced from crop plants. However, the main obstacle toward this goal is the lack of knowledge concerning the regulation and biosynthetic pathways of TAG in algae.

Today, most of the knowledge available on oil accumulation comes from plant seeds. There, TAG accumulation occurs mainly in special spherical organelles called oil bodies, which are comprised of TAG matrix surrounded by a phospholipid monolayer embedded with proteins. These proteins, mainly oleosins, are structural proteins that function in stabilizing the oil bodies. This stabilizing effect, altogether with the fact that oleosin synthesis is synchronized with that of TAG in the ER, led to the suggestion that oleosins are essential for the accumulation of TAG.

Oleosins were identified so far in plants and mosses but not in lower organisms. Preliminary work in our lab indicated the existence of oil globule associated proteins in several oleaginous green microalgae species of *Dunaliella* and *Chlorella*.

**Our research aim** is to isolate and clone these proteins, compare them to plant oleosins, find their structural similarities and their function in algae.

Identification and cloning of algal oleosins may lead to the enhancement of lipid accumulation not only in algae but also in other lipid accumulating organisms such as bacteria and fungi and serves as an important tool for solar energy production.
Regulation of Lipid Accumulation in Microalgae

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Microalgae accumulate neutral lipids mainly in the form of triacylglycerol (TAG) up to 20-50% of their dry cell weight, under stress conditions. These microalgae-derived TAGs may be used as a renewable source for production of biodiesel, currently produced from crop plants. Microalgae have numerous advantages over oil producing plants, including higher lipid yield per unit area, higher growth rates, and growth in arid areas, not suitable for conventional agriculture, thus not competing with food and feed resources. However, the microalgae-based biodiesel is still not economically feasible, because of high expenses of algae growth and oil extraction. It may be possible to improve lipid yield of algae by developing strains that accumulate lipids constitutively by mutagenesis and selection processes. Nevertheless, this approach has limitations, since currently there are neither selection methods of lipid-rich algae cells nor sufficient knowledge of regulation and biosynthetic pathways of TAG in algae.

Our aim is to isolate stable TAG accumulating algae strains and to investigate regulatory mechanisms of TAG production by green microalgae. For this purpose, we have developed a selection technique for oleaginous algae species, and by using this technique, we have isolated an algae strain that synthesizes enlarged amounts of TAG. We will study by differential protein analysis what proteins are up-regulated/ inhibited in the isolated strain, and then identify the genes regulating TAG accumulation. Also, by searching for chemical and biological triggers of TAG accumulation we discovered a new way to induce TAG accumulation in microalgae which increases the yield of TAG level and can cut down expenses of biodiesel production. This study will contribute to understanding the regulatory mechanisms of TAG biosynthesis in microalgae and to the progress in making microalgae an economical source of biodiesel.
Nanostructured Molecular Tandem SolarC by Self Assembly

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Organic photovoltaic solar cells are potentially low cost, easily processed structures, yet they exhibit low power conversion efficiencies in comparison to the main current PV technology. Two major causes are responsible to these relatively poor efficiencies: (a) short exciton diffusion length (<10nm) and (b) insufficient utilization of solar spectrum. Tandem organic solar cells are of great interest since they can cover a wider range of the solar spectrum.

Solar cells comprised of self assembled molecular monolayer (SAM) are less susceptible to exciton losses through recombination due to the size scale of the molecular layers. We adsorbed a self assembled monolayer of an asymmetric indane derivatives such as 5,6-dicarboxylic acid-1,3-dicyanomethylene-indane salt (5-carboxy-6-carboxylato-1, 3-bis (dicyanomethylene)-2, 3-dihydro-1H-inden-2-ide) via carboxylic acid binding groups onto an ITO substrate, and verified its adsorption using various surface characterization methods. Following chemical adsorption, we will deposit metal nanoparticles by photochemical reduction of metal ions onto the SAM as an interfacial layer in a molecular tandem cell. The subsequent molecular layer will adsorb onto the metal clusters. This stacked tandem cell will overcome the aforementioned problems and may pave the path towards more efficient organic PV solar cells.
ZnO-based Semiconductor-Sensitized (ETA) Solar Cells: the Importance of Uniform Coverage for Cell Performance

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Semiconductor-sensitized solar cells (SSSCs) are nanoporous photovoltaic devices consisting of a very thin (typically a few tens nm) semiconductor sandwiched between a nanoporous substrate. (almost always TiO₂ or ZnO) which removes electrons and a medium (solid or liquid) to remove holes. The very thin film reduces bulk electron-hole recombination while the nanoporous substrate allows a high geometric surface area and thus enough material to absorb the incident light. Solid state versions of the SSSC, using solid hole conductors, are commonly called ETA (Extremely Thin Absorber) cells.

In recent years the use of ZnO as the electron carrier in SSSC has increased. As a high band gap semiconductor with reasonable conduction properties, ZnO is a promising candidate to function as a window layer as well as an electron carrier. An economically cheap and commonly-used method for ZnO deposition is chemical bath deposition (CBD) which normally results in a film of highly-structured nanorods.

Ideally, for photovoltaic devices the complete surface of the highly-structured ZnO should be covered by a thin (one crystal thick) layer of the light-absorbing semiconductor. However, we found that direct coating of the ZnO with CdS or CdSe by CBD usually results in a very non-homogeneous growth of the CdS(e). Here we show how a conformal coverage of the ZnO by the chalcogenide absorber can be achieved and present results of ZnO/CdS/CuSCN solar cells showing how this coverage results in highly improved cell performance.

1 These authors contributed equally.
Lateral Polymeric Photonic Structures for Absorption Enhancement in Organic Solar Cells

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Organic solar cells are easy and inexpensive to manufacture. The main disadvantages of organic solar cells are their limited absorbance which results in low conversion efficiency, and the difficulty to integrate them with metal or semiconductor electrodes. We design a simple solid device that combines photovoltaic cells within a periodic polymeric structure. Theoretical calculations show that the periodic structure may enhance light absorption by optical resonance of the light captured inside the structure, thus increasing the conversion efficiency of the cells. Such structure can also provide mechanical support for electrodes.

Polymer structures were formed using surface electrohydrodynamic instabilities. Thin liquid films are influenced by spontaneous fluctuations that cause changes in the morphology of the film when a decrease in surface energy is involved. External forces such as electric fields and temperature gradients enhance the instabilities and enable the spontaneous formation of a polymeric structure. A 150 nm thick polystyrene and Poly(methyl-methacrylate) films were spin coated on indium tin oxide (ITO) coated substrates and subjected to an electric field and temperature gradient in a plate capacitor geometry. The structures received were characterized by optical and Atomic Force Microscopy (AFM) and found to have semi-ordered features with lateral resolution of 10-50 microns. Photoactive materials were inserted into the structure using electrodeposition. The optical properties of the embedded material will be characterized using advanced microscopy techniques.
Improving the Utility of Existing Solar Arrays

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Being able to correctly track the Maximal Power Point (MPP) of a solar array is of a paramount importance, especially when dealing with large and very large solar fields. Each deviation means – energy is not optimally harvested from the field. This is evident to the extreme, when local shading occurs. Then, locally-shaded cells turn into loads on the entire array. In the past, it was offered to deal with the problem using bypass diodes and halter diodes. This approach is not satisfactory, as the diodes only disconnect the shaded cells from the array at best, while not utilizing the energy these cell continue to absorb. It is offered to improve the utility by making sure all panels work in their respective optimal power points, using modifications done to the interconnection between them.

Knowing the working point of the panels of a solar array, it is possible to know the complete I/V curves of the panels, provided all parameters are known a-priori and then a construction of the complete I/V and I/P curves for the entire array can be performed, to any resolution. Then, one can get a very good approximation to the MPP of the entire array by simply taking an absolute maximum of the I/P curve, thus eliminating the risk of taking a local maxima and missing the MPP, as would be the case with older MPPT methods. Moreover: the panels can then be classified for meandering. Thus, an optimal interconnection can be readily deduced. This simple yet powerful procedure can improve the utility by a considerable percentage when weak or shaded cells are present.

Even more: proper interconnection of the panels saves the need to connect each panel through a MPPT converter. It is also shown that the power from the field may be transferred directly to the grid via the usual fields DC/AC converter which can function in the same time as an MPP tracker for the entire field, by control of the working voltage against the grid. So all MPP trackers (except the main inverter), can be effectively eliminated, without major impact on the field’s utility.
Light Harvesting Through Waveguide in Thin Film Photovoltaics

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Efficient conversion of sunlight into electric power in photovoltaic (PV) cells requires photon absorption close enough to the charge separating interface. In many absorber materials the diffusion length is shorter than the inverse absorption coefficient, thus the absorber thickness is a compromise between the poor optical absorption of thin layers and inefficient carrier collection beyond a certain cell thickness. Light trapping using waveguide integration provides a method to increase the optical path length through the absorber while its thickness remains below the minority carrier diffusion length. This method breaks the coupling between the optical and electric path in PV cells. In addition, it enables a spontaneous spectral splitting of the sunlight to a tandem-like multijunction PV system. A proof of concept is presented using a very thin dye-sensitized solar cell which absorbed only a small fraction of the light at normal incidence.

We aim at incorporating this method to solid state hetero-junction sensitized solar cells, where inorganic quantum dots are used as absorbers. As the hole conducting layer we propose to use an organic polymer, which thickness is limited by its low conductivity. The waveguide geometry can further be used to build multi-junction 3rd generation devices.
Optoelectronic Measurements of Single Molecules for Photovoltaics Applications

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Organic photovoltaic cells have drawn much attention in the recent years due to their potentially low cost and simplicity of fabrication, compared to their inorganic equivalents. A special type of organic cells consists of artificial photosynthetic systems made of molecules or supra-molecular assemblies, in which charge separation occurs within the molecule or assembly rather than at an interface. Such molecules offer a novel concept in photovoltaics: a self-assembled dyad structure, held together either by chemical or physical bonds, which includes a chromophore whose photoexcited state donates (or accepts) an electron from a nearby acceptor (donor) to generate an excited charge-separated state. Such molecules have shown a relatively long-lived charge separated state, extremely high quantum yields and significant photocurrents, and thus are promising candidates for single-component organic PV devices.

This research intends to study, by means of scanning probe microscopy, the structure-properties relations of the single molecular junction (a bottom-up approach), made from porphyrin-fullerene (donor-acceptor species) dyads, in an all-solid configuration. In such a configuration the dyad molecule is connected covalently to a transparent conductive electrode and to a counter electrode, as a way to conclude on the photovoltaic behavior of the single molecule and the molecular ensemble. Thus, it provides a rational way to design and improvement of the efficiency of molecular photovoltaic cells, to a point from which they would be able to compete economically with inorganic photovoltaic cells.
Opto-Electronic Characterization of Hybrid Photovoltaic Materials

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Hybrid organic-inorganic donor-acceptor systems have been suggested as low-cost, stable alternatives for solar energy conversion. Efficient charge generation and transport in such systems requires an organic-inorganic phase separation on a sub 20 nm length scale, and continuity of each phase through the film. We use surface photo-voltage spectroscopy to determine the photo-current path in a hybrid photovoltaic film comprised of MEH-PPV incorporated into meso-porous TiO$_2$. The effect of different wavelengths on different hybrid film combinations is compared.

Surface photovoltage measurements under white illumination show a major decrease in surface potential of MEH-PPV/ TiO$_2$, while meso-porous TiO$_2$ only shows no response. Replacing the TiO$_2$ meso-porous structure with SiO$_2$, i.e., MEH-PPV incorporated into porous SiO$_2$, reveals response in the opposite polarity to the one observed with TiO$_2$. Monochromatic illumination of comparable power at 532 and 376 nm, close to the MEH-PPV and TiO$_2$ absorption peaks, respectively, showed a significantly smaller photo-response. A model is suggested to describe the dipole fields that induce the surface photo-voltage, which points to possible routes of photo-induced charge generation and separation involving absorption and photo-response of both components of the hybrid material.
Improving the Performance of CdS Sensitized Solar Cell

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Dye sensitized solar cell (DSSC) has been extensively studied recently due to its simple materials and equipment required for its manufacturing. As an alternative to the ruthenium complex, semiconductor quantum dots (QDs) can be used.

A method to improve the efficiency and stability of CdS quantum dot sensitized solar cell immersed in I\textsubscript{3}/I\textsubscript{1} redox electrolyte is presented. Improved stability results from the coating of the TiO\textsubscript{2}/CdS electrode by a thin layer of an amorphous TiO\textsubscript{2}. Our results show that the TiO\textsubscript{2} coating passivates the surface states of the CdS thus significantly slowing recombination and degradation processes. Using the coating we present a proof of concept for a CdS/dye nanoscale suprastructured light collector. Furthermore we show that the QD energy levels can be aligned with respect to the TiO\textsubscript{2} bands in a systematic manner using molecular dipoles.
Development of Absorbing Coatings for Photothermal Solar Energy Conversion

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The world population continues to grow, and with it, increases the energy consumption. The ever-growing need in energy leads to search for renewable energy sources. Therefore, the pursuit for alternative energy sources - especially environment friendly - is of soaring significance. Evidently, solar energy is the ultimate and unlimited source of energy. Collecting less than 0.1% of the solar energy that reaches the earth would have provided the world’s energy consumption. Harnessing solar energy to produce electricity has been developed a long time ago; however, the efficiency of the available methods is low and lacking.

One of the appealing methods to convert solar energy into electricity is the photothermal approach. In this method, the solar radiation is absorbed by a surface of unique properties and converted into heat. The higher the temperature, the more efficient the process is. Until now, this process was carried out under low to medium temperatures (<500 °C), due to thermal limitations of the materials used. In order to maximize the energy conversion effectiveness, higher temperatures must be reached.

In our research we attempt to develop absorbing coatings for the efficient photothermal conversion based on thermally stable materials.

Our approach is based on the CERMET family - composite materials which consist of a ceramic matrix and homogeneously distributed absorbing metal or dielectric nanoparticles. We use the sol-gel technology to prepare a dispersion of nanoparticles made of various materials in an alumina sol-gel. The dispersion is then applied onto a substrate by different methods, such as roll, spin and dip-coating.

Results will be presented on various coatings, their characterization and modification to comply with the harsh requirements of an industrial application.
Flow Rate Maldistribution in Multi Heated Parallel Pipes

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One of the successful commercial applications of utilizing solar energy to produce electricity is based on power plants that use parabolic trough mirrors that focus the sun's radiation on an array of parallel pipes which are situated at the focal center of the mirror. Today’s power plants use oil as the circulating fluids inside these pipes. The oil is heated in the pipes and flows to a heat exchanger where it is used to boil water into steam in order to produce energy.

The main problem with this method is the use of two cycles: one for oil and one for water. This duality reduces the thermal efficiency of the power plant and increases the initial and operational costs. One way of solving these issues is to use water as the heated fluid inside the pipes, a method known as Direct Steam Generation (DSG). However, this method has encountered some problems, the critical of which is flow instability.

It is a common knowledge that maldistribution may occur in evaporating liquid flowing in parallel pipes with common inlet and outlet manifolds. This phenomenon occurs due to multiple steady state solutions some of which are unstable. One may obtain uneven flow rate distribution even for the case of equal heating of the pipes. For non equal heating higher flow rates may take place in the less heated pipes. This is quite an unfavorable flow phenomenon.

The theoretical model developed by Minzer et al. (2006) for the flow rate distribution is extended to a large number of pipes and different heating conditions. Stable and unstable solutions are identified and the model predictions are experimentally validated for different configurations involving two, three and four pipes. It is shown that the behavior of the system may depend on the history of the process exhibiting a hysteresis phenomenon.

Transient simulations are carried out using this model in order to study the time dependent system response to finite disturbances.
Comparison between LiPF$_6$ & LiClO$_4$ in Alkyl Carbonates Solutions for Rechargeable Li Ion Batteries

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In this work we wanted to test and compare the behavior of 2 different Li salts: LiClO$_4$ and LiPF$_6$ in standard alkyl carbonate solvents. LiPF$_6$ is the commonly used salt in rechargeable Li ion batteries. We chose to revisit LiClO$_4$ as an alternative and to compare the behavior of solutions containing the two Li salts. LiClO$_4$ may have advantages over LiPF$_6$ by elimination the uncontrolled, detrimental impact of HF & POF$_3$ that always exists in LiPF$_6$ solutions and affect badly the electrodes’ passivation. We were interested in the electrochemical behavior of both the anodic and the cathodic sides. The interesting aspects are the salt impact on the electrodes surface chemistry and on the thermal behavior of solutions and solutions + electrodes. We used Li, nickel, silicone and graphite anodes, Li[MnNiCo]O$_2$ (NMC) cathodes, measured the surface chemistry by ex-situ FTIR spectroscopy, XPS and the thermal behavior by DSC. We examine the possibility to use solutions containing both salts in Li ion batteries.
Carbon Engineering by Chemical Vapor Deposition, onto Active Carbon Fiber Electrodes for Selective Water Desalination

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There is a world crisis related to the supply of fresh water in many countries. This crisis creates a strong driving force to develop effective methods for water desalination. So far, all the technologies relevant to water desalination such as evaporation/condensation and reverse osmosis, de-ionize water unselectively by extracting the water out of the solution by different physical means. Unselective desalination processes are very problematic due to the fact that some of the nutrients in the water are essential for the consumer health (e.g. Mg$^{2+}$ and Ca$^{2+}$ ions) and hence should not be removed by desalination. For example, reverse osmosis filtering takes out all the ions that are present in the solution. Develop selective desalination should also increase the efficiency of the processes by lowering their energy consumption.

The use of the electrochemical properties of activated carbon cloth with large surface area in order to de-ionize brackish water is an efficient water desalinating method (called capacitive de-ionization CDI). The ions from the solution accumulate in the electrodes’ pores as a result of applied voltage, leaving diluted aqueous solution in the bulk. One of the advantages of the CDI method is that the salts are extracted from the solution, and not vice versa- therefore if one can get an ion sieving effect, e.g. by controlling the size of the pores, it may be possible to take out some of the ions very selectively. By using carbon chemical vapor deposition (CVD) onto active porous carbon fibers, we were able to reduce the pore size of the active carbon to obtain selective carbon molecular sieves (CMS) of variable properties. The pore size of these carbons was characterized by the adsorption of molecules of different dimensions (molecular probe adsorption) from the gas phase. By manipulating the several experimental parameters of the CVD process, the pore size of the CMS could be finely tuned to fall between sizes of alkaline earth cations (Ca$^{2+}$; Mg$^{2+}$, 6-7 Å in diameter), and the much smaller size of hydrated monovalent cations (4 Å in diameter). This was proven by voltammetric measurements of the pore-tailored carbon electrodes in the corresponding salt solutions, which also provided a measure of the differential capacity of the electrical double layer (EDL) vs the potential (e.g., at potentials negative to the potential of the zero charge, the EDL capacity was very small for CaCl$_2$ and MgCl$_2$ solutions, while it was high for NaCl solutions). The CVD process applied herein did not significantly reduce the specific surface area and the pore volume of the carbons. This implies that the carbon deposits are only superficial and that the pore blocking effect takes place only at the pores’ mouth. Hence, the adsorption processes related to these carbons involve surface barrier mechanisms. The importance of the selectivity thus obtained relates to a possible use of these carbon electrodes in electrochemical water desalination processes. By using these carbons as electrodes in capacitive water deionization processes, it is possible to selectively remove Na$^+$ cations, leaving Ca$^{2+}$ and Mg$^{2+}$ ions in the treated water.
Electro Spinning of Nanostructures-Conjugated Polymer Fibers for Photovoltaic Applications

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Semiconducting π-conjugated organic polymers are used in photovoltaic (PV) applications as electron donors together with nano-structures such as fullerene derivates which act as electron acceptors. Upon illumination of the hybrid mixture, light is absorbed by the conjugated polymer resulting in the formation of a bound electron- hole pair, exciton. Charge separation than takes place at the fullerene-polymer interface. Due to the short exciton diffusion lengths in these materials, mixing of the donor and acceptor on a nanometer scale is desirable to ensure efficient charge splitting. Furthermore, the exact configuration of the polymers and the phase behavior of the polymer-fullerene mixture plays an important role in the efficiency of the resulting device. Therefore, intense research efforts are directed towards the control of morphology of the blend. In the current study, we investigate the effect of spinning the blend into micrometric fibers via electrospinning. The process is expected to affect the conformation of the polymer, the morphology of the blends, and eventually, the PV efficiency of the blend.

SEM and TEM were used for structural characterization and spectroscopy for probing the electronic behavior.
Notes:
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