Nanogranular Compound Material Layers Serve as Storage for Infra-Red to Ultra-Violet Photons for the Energy Supply of Electric Machines

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Energy harvesting from the atmosphere

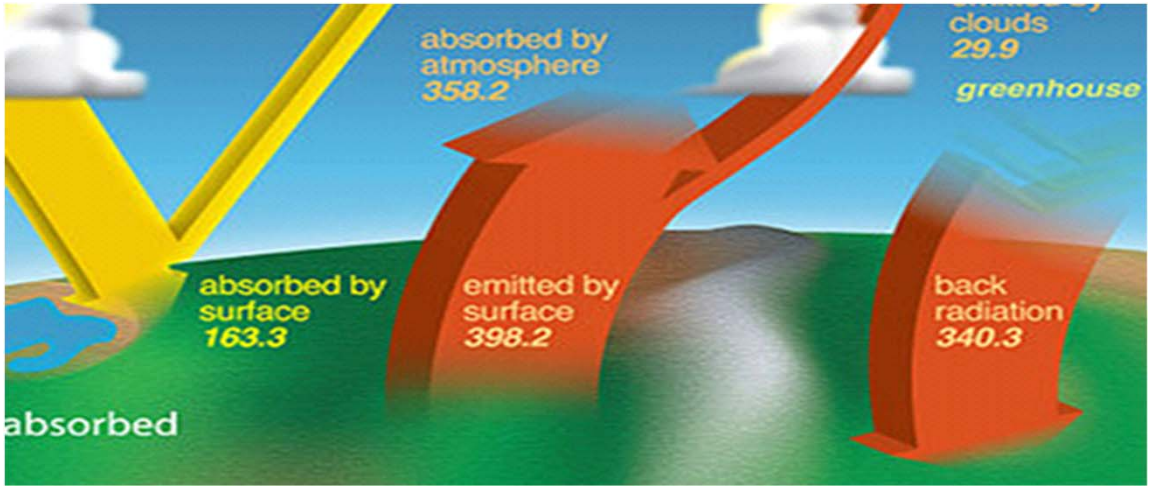
Koops GranMat® can be applied for harvesting of Green-House-Gase- Emission in the IR

The Challenge:
The IR window in the upper atmosphere transmits without loss energies in the 7 µ to 10 µm wavelength regime.
Standard Silicon solar cells can capture only 1,3 eV and up. (Yellow to blue).
Therefore they can only catch energy at day light , and not in the dark, and in portions of single photons only.

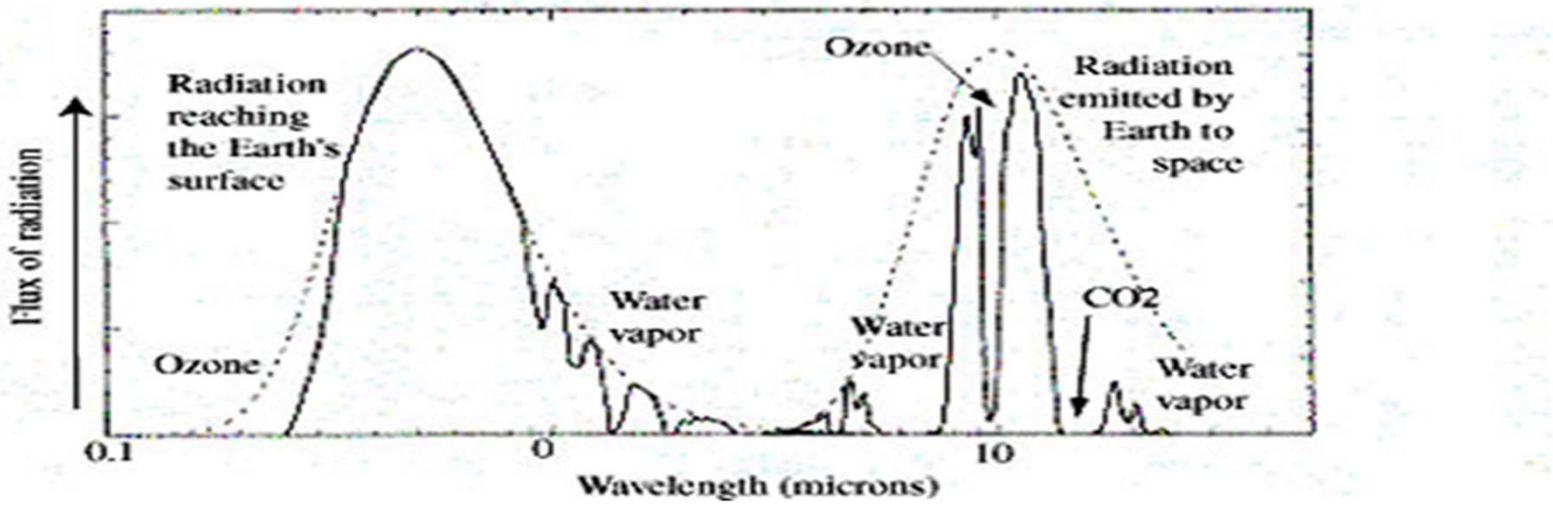
Koops GranMat® however accepts IR radiation in the 7 µm to 10 µm in the form of Bosons at room temperature, and stores them at room temperature with very high numbers: 10^28 /cm².

KOOPS GranMat® can be applied for harvesting of Green-House-Gas- Emission in the IR

NASA recorded in 10 years of measurements the in 2009 published average data in W/m².
In addition to the sun light, which sends 160 W/m² to the earth during the day. Only 25% of this energy can be absorbed using Si-Solar Cells: which is 40 W/m².
The green house gas molecules in the upper atmosphere send in the infra-red window of the earth's atmosphere Infra-Red photons with 340 W/m² directly to the earth in day and night. This is a 8,5- fold energy supply compared to the energy supply in the visible Spectrum.



The earths atmosphere has an un-attenuated transmission region at 5 µm to 10 µm, where no absorption loss by water hinders the energy supply at day and night.
"Energy Budget of the Earth" of NASA, Leob et al., J. Clim, 2009, Treuberth et al. BAMS.2009, NP 2010- 05- 265 - LaRC

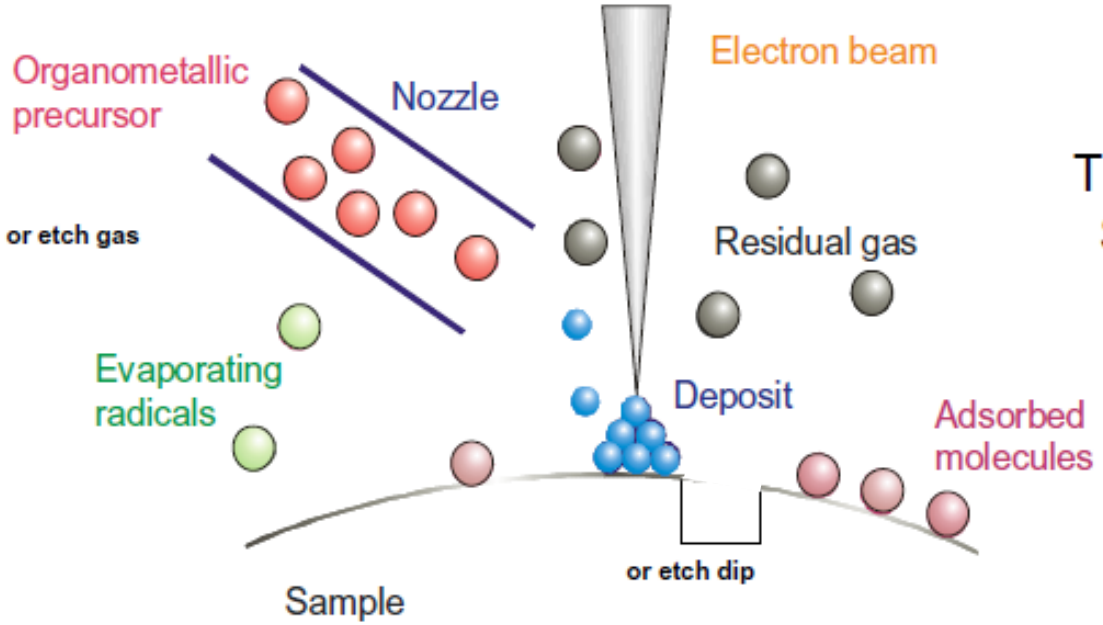


The IR reception of Pt/C is in the gap before 10 µm, where there is no absorption.

This energy can be absorbed with multi-layer materials. The energy harvesting requires only a field-gradient in the receiver layers, to move the electrical energy to the user.

To harvest the energy from the green-house gases in the earth atmosphere sheets of glass or polymers can be coated with electron-beam induced deposition materials. Presently Pt/C or Au/C nanogranular compound materials are known. Pt/C has a low bandgap like 0.128 eV also in layers in the material.

Principle of Fine Line 3-Dimensional Lithography using Electron-Beam Induced Deposition and Etching



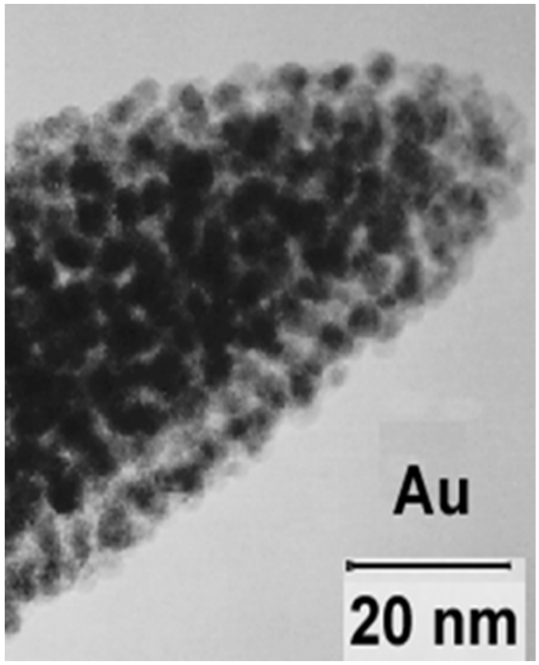
TEM 30 to 200 kV
SEM 1 to 30 kV
2 nm spot
1 pA to 10 nA

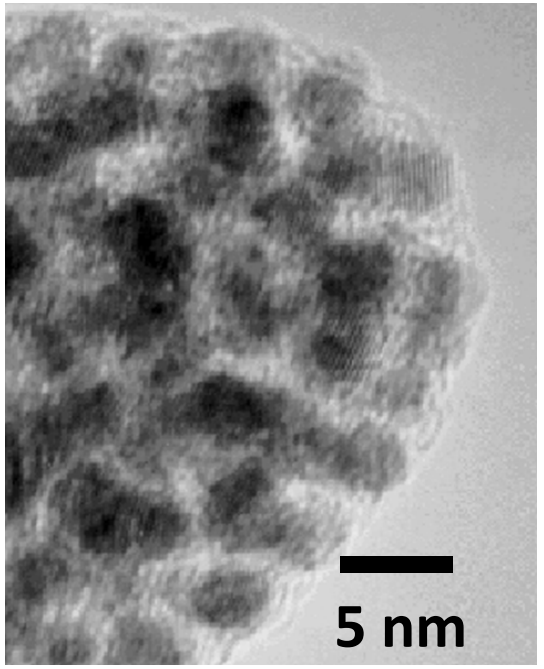
Cracking of adsorbed molecules by electrons of high energy
Power density: 60 MW/cm^2, corresponds to
one quarter of the temperature at the surface of the sun, or
Radiation damage dose 100 m off the center of the atomic bomb
-> Deposition of fragments
-> Evaporation of vaporized radicals
-> Evaporation of volatile reaction products of precursor and sample

Metal crystals in a Fullerene matrix

Dimethyl-Gold-Trifluoro-Acetyl-acetonate

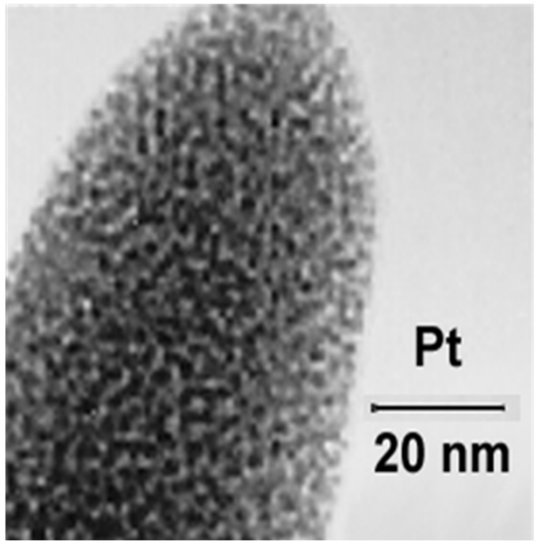
Crystal size
Au: 3-4 nm
I max: 1 Ga/cm²

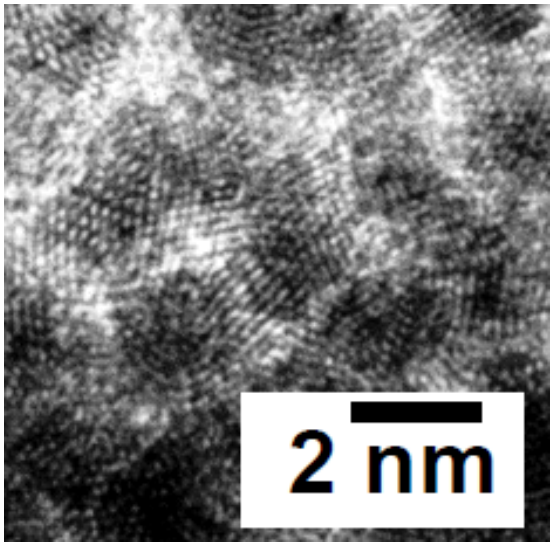




Cyclopentadienyl-Platinum-Trimethyl
Pt: 1,8 – 2,1 nm
I max: >1 Ga/cm²

NGM nanogranular materials aggregate during deposition with crystals showing no percolation.

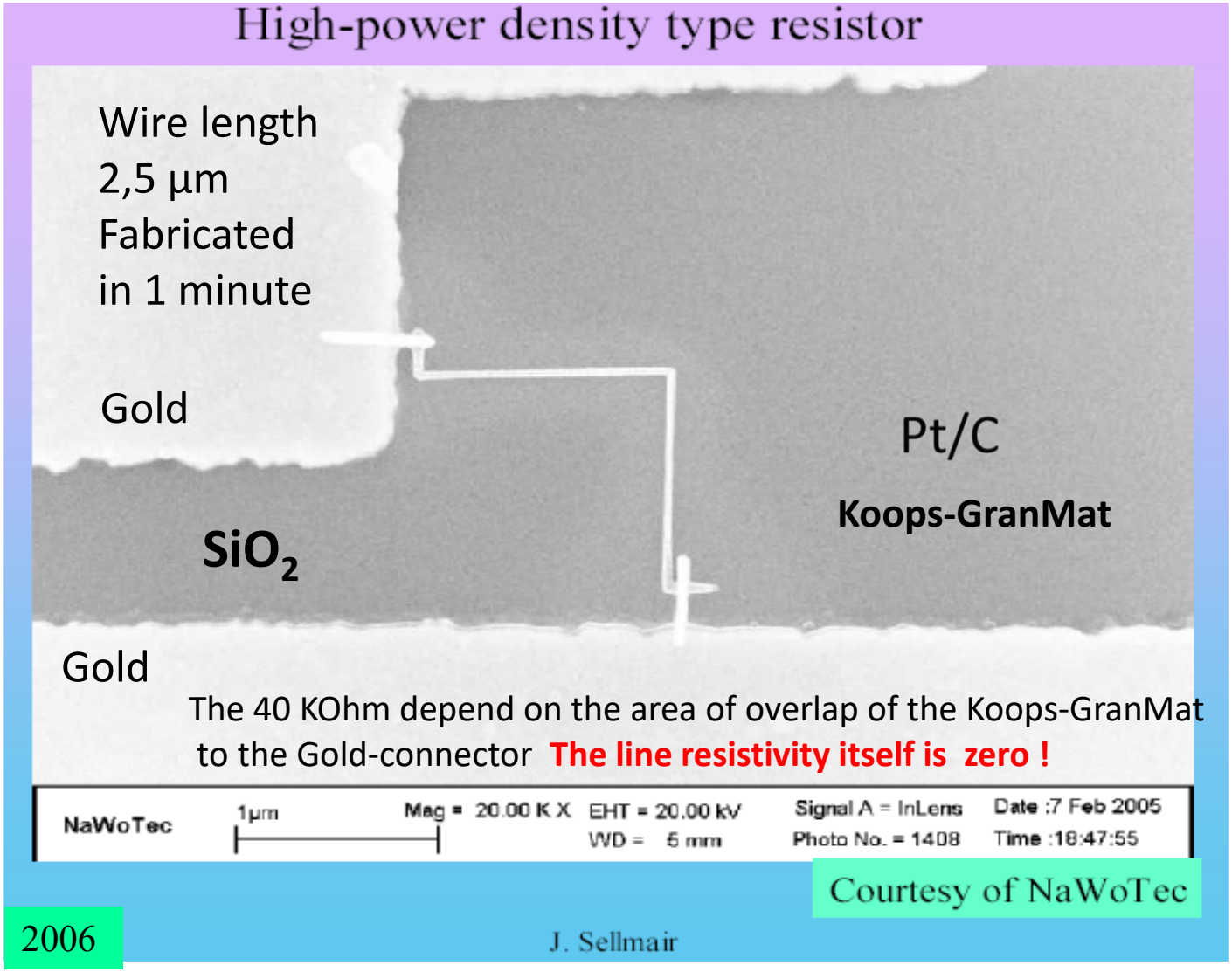




Giant Current Density in Koops-GranMat® carries an anomalous high current at Room Temperature

Review FEBIP	MA/cm²	Koops, H. W. P.; et al. Jpn. J. Appl. Phys. **1994**, 33, 7099-7107
Au/C Field Emitter	2 at tip 1000	Kretz, J.; Rudolph, M.; Weber, M.; Koops, H. W. P. Microelectron. Eng. **1994**, 23, 477-481
Pt/C Field emitter	2	Koops, H. W. P.; Schössler, C.; Kaya, A.; Weber, M. J. Vac. Sci. Technol. **1996**, B14, 4105.
Pt/C Wire arch	15	Edinger, K.; Rangelow, I. W.; Gotszalk, T. J. Vac. Sci. Technol. **2001**, B19, 2856-2860
Pt/C Fe Emitter	10	Floreani, F.; Koops, H.W.P.; Elsäßer, W. Nuclear Instruments and Methods in Physics Research A **2002**, 483, 488-492.
Pt/C Fieldemitter	100	J. Sellmair, NaWoTec, communication
HTc Superconductors 40 K		
Titan doped Mg B_2	< 1	P.C. Canfield, D. Budko, Spectrum d. Wiss. Juni 2005 p. 56

The slow lithography controlled by x,y,t- stream program generates metal nanocrystals with 2 to 4 nm diameter embedded in a carbon matrix material of 1 nm thickness. Spot exposure times needed are > 10 msec . For field emitters a large foot area (>500 nm diameter) must be deposited to allow the hopping of electrons from the connector metal into the excitonic states



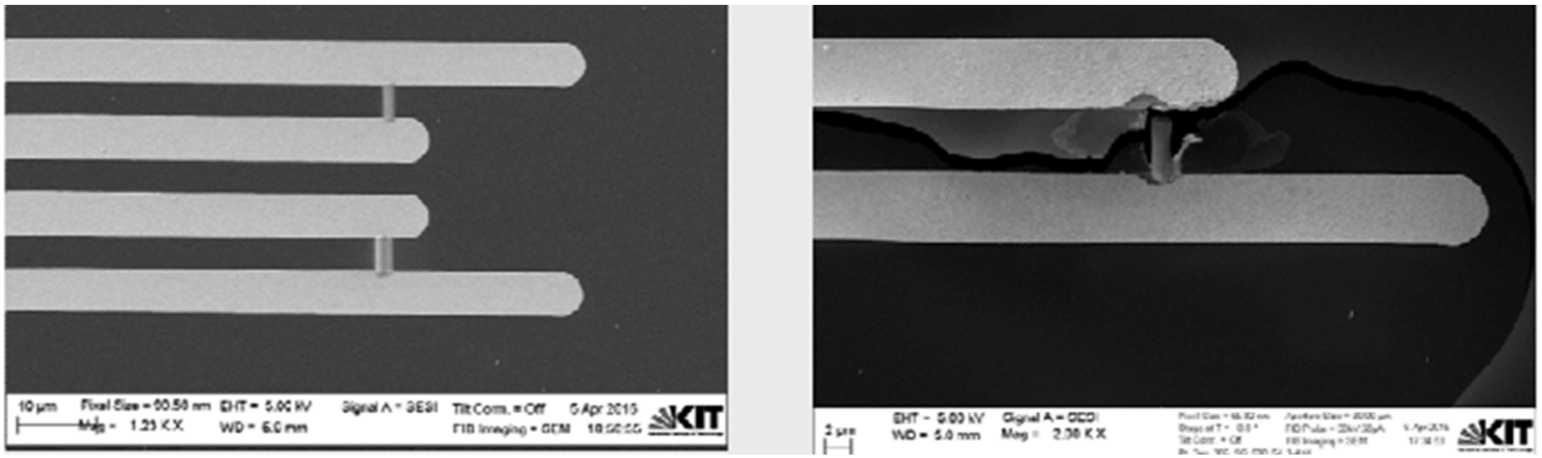
40 KΩ is measured as a contact resistance from the ovelapping areas at the rim of the contacts . Carried current density 10^9 A/cm².

Application for Access at KNMF:

Experimental Method

Measurements by Ankit Machanda PHD Thesis INT 2016

The experiment shall render the conditions to produce Pt/C routinely with FEBIP.



First experiments showed extremely high current conductivity > 10^9 A/cm²

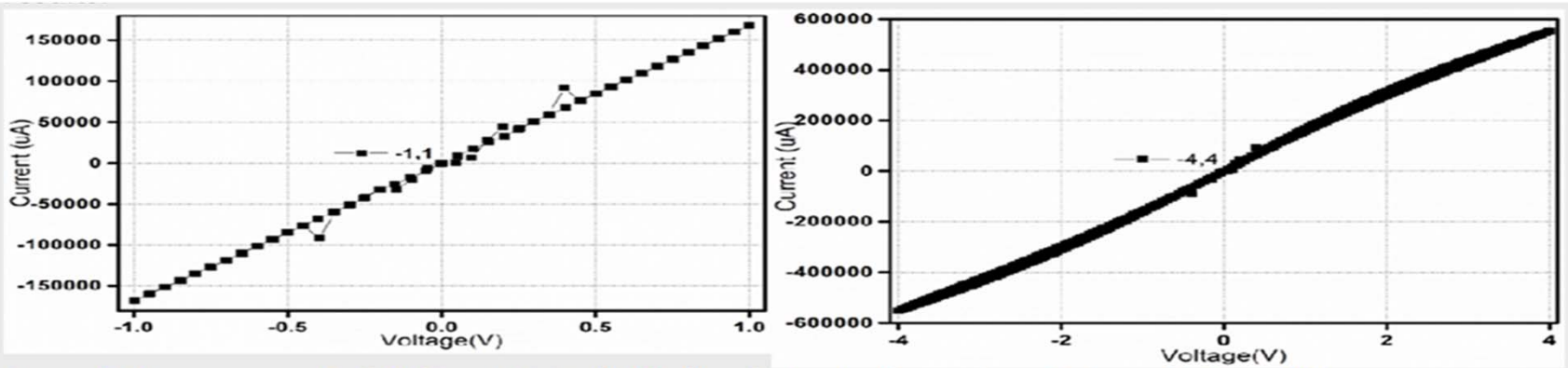
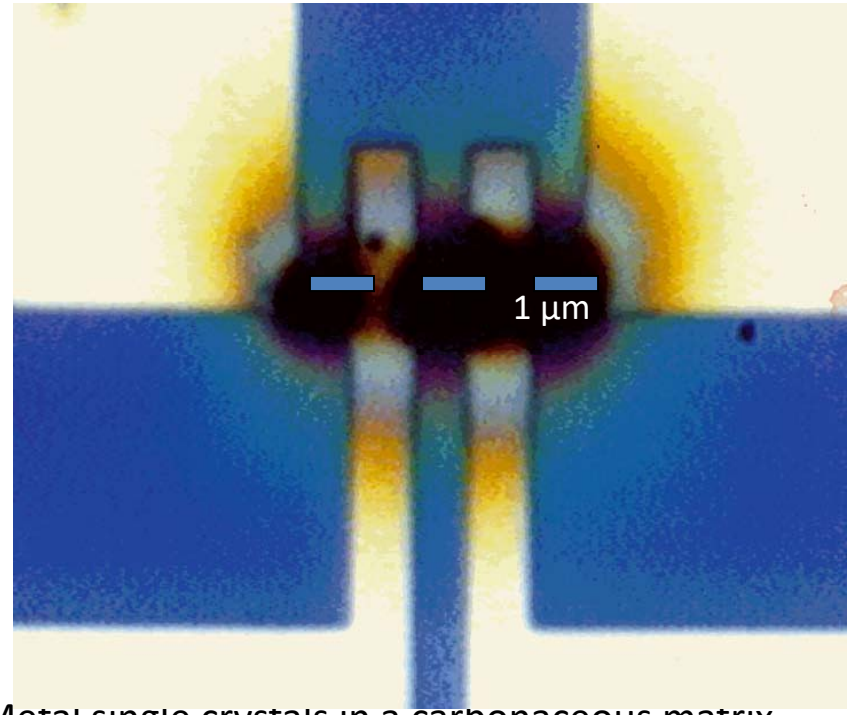


Figure2: Measurement of Pt/C resistivity (INT)after first set of experiments to optimize settings

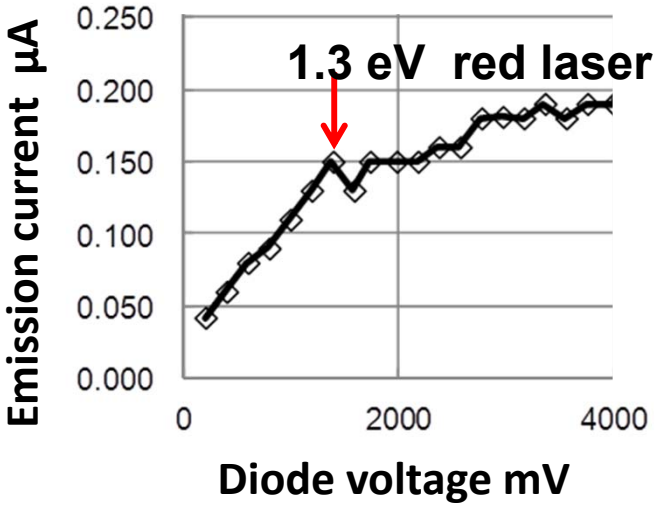
Nanocrystalline compound materials absorb light

Room-Temperature EBID NGM IR-Vis- THz detector



Metal single crystals in a carbonaceous matrix (Fullerenes) show high VIS light absorption

Field emission characteristics of NGM Diode under red light illumination (1,3 eV)

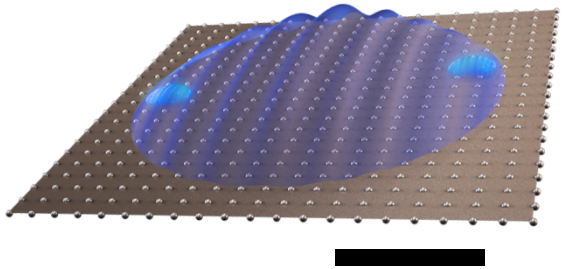


Pt/C NGM photocell = 72 mW/cm²
Typically Si solarcell = 20,4 mW/cm²
Experiment not optimized

Pt/C :180 meV are needed for the excitation of one electron:
Au/C : needs 60 meV to free 1 electron

H.W.P. Koops, A. Kaya, M. Weber, "Fabrication and Characterization of Platinum Nanocrystalline Material Grown by Electron-beam Induced Deposition", J. Vac. Sci. Technol. B 13(6) Nov/Dec (1995)

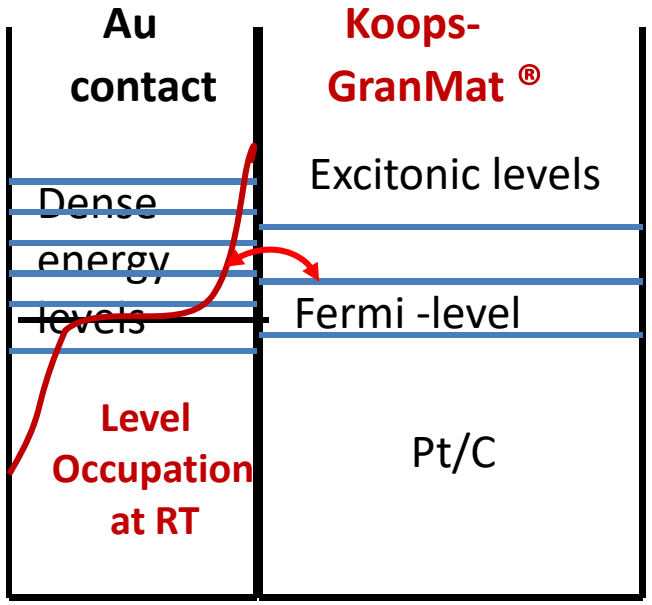
Koops-GranMat® is a cluster of excitons at room temperature, explained by Bohr's atom model. It contains **Koops-Pairs** in a **condensate** formed by overlapping excitonic surface states. These states are filled by Maxwell temperature distribution of electrons in the conduction band of the contact metal



2 charges – Electron, + Hole attract each other

2 Bohr Magnons (Spin) repell each other

The Maxwell energy distribution of charges in thermal distribution in the contact area supplies the current.
If the contact area is not large enough, the Gold contact area will melt at 250 KA/cm² current density, as observed several times



Electrons emitted from the condensate energy state in field emission are coherent

Investigating field electron emission from such materials Takai and Murakami in 2008 found a coherent emission from several sites , indicated by Young's interference patterns

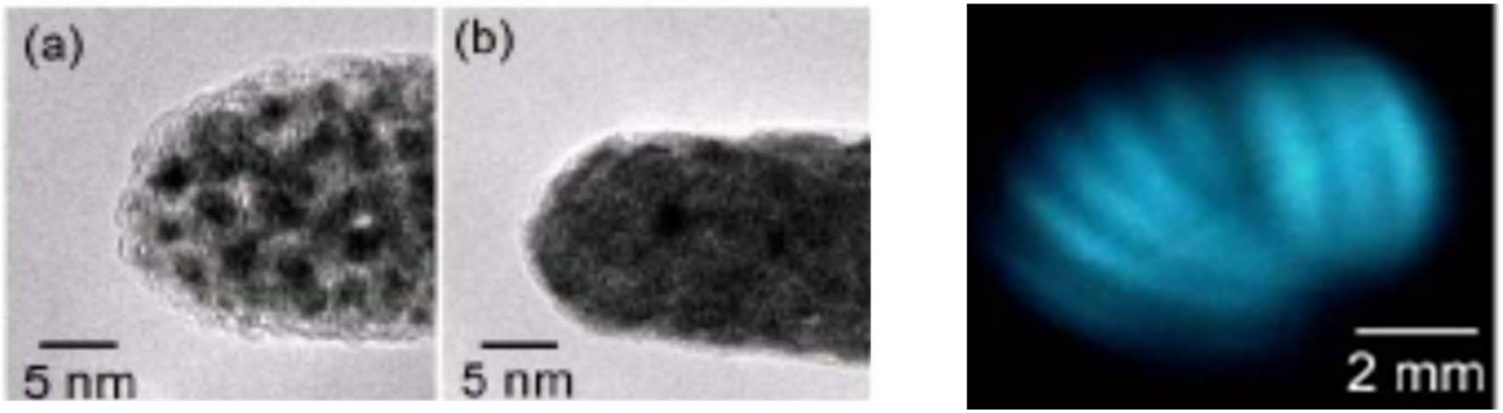
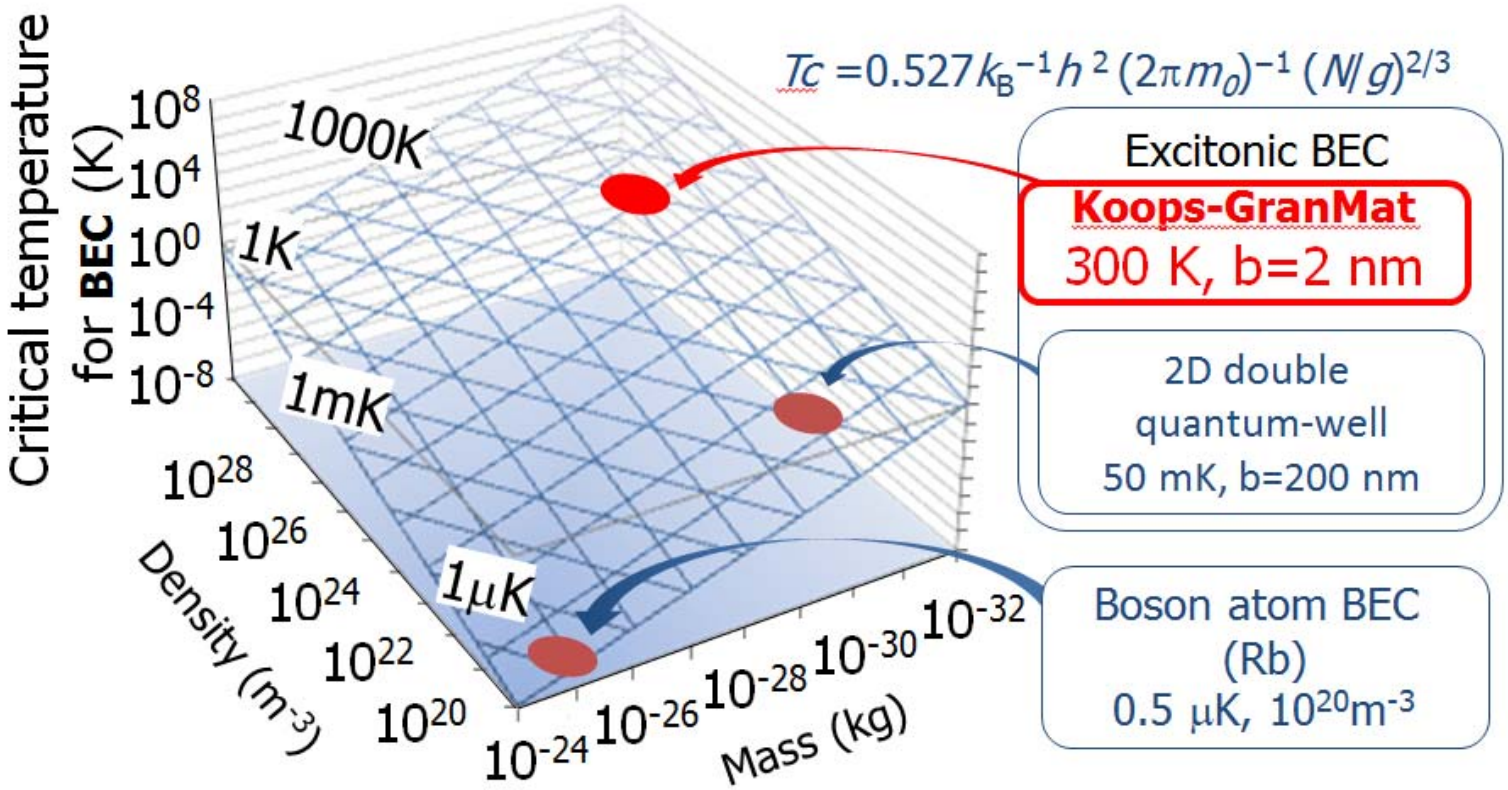


Fig: a: Pt/C deposit , b: Tip after RIE etching, right: fringe-like electron-emission pattern observed in field emission in the far field from a Pt field emitter fabricated by electron-beam-induced deposition.

K. Murakami, F. Wakaya, and M. Takai, "Observation of fringelike electron-emission pattern in field emission from Pt field emitter fabricated by electron-beam-induced deposition,"
J. Vac. Sci. Technol. B, vol. 25, no. 4, pp. 1310-1314, **2007**

Bose and Einstein published the formula for a Temperature of a Condensate in 1929 depending on the particles density and their mass.
With this formula one obtains for Rubidium atoms BEC at 0,5 µK. For 2 d double quantum wells of of Butov and Remeika: 50 mK, and for Pt/C-Koops-GranMat® 300 K, as it was observed

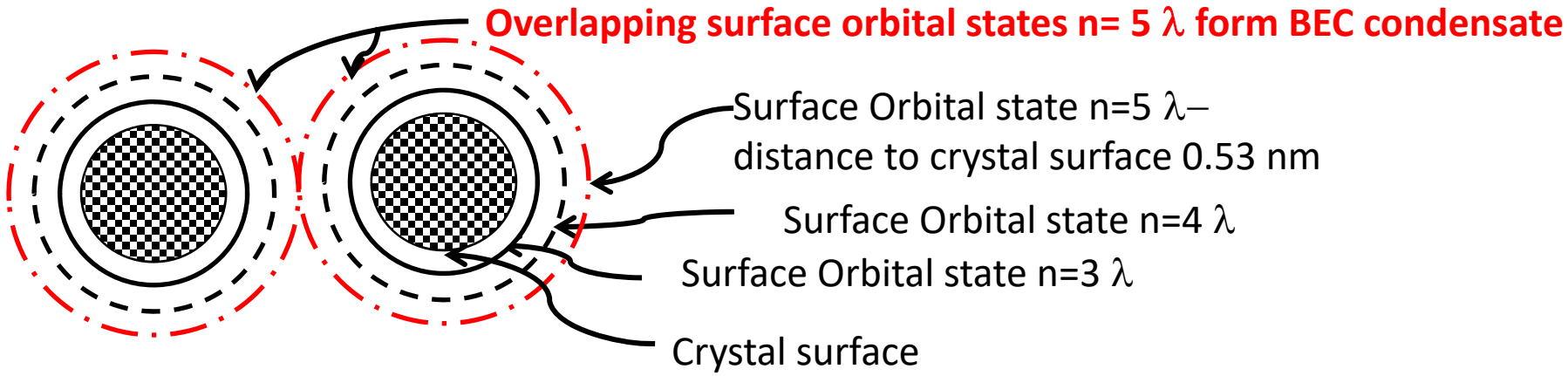


H. Koops, H. Fukuda, "Giant current density via indirect exciton orbit overlapping in polarized nanogranular materials" J. Vac. Sci. Technol. B 33, 02B108 (2015), http://dx.doi.org/10.1116/1.4904732

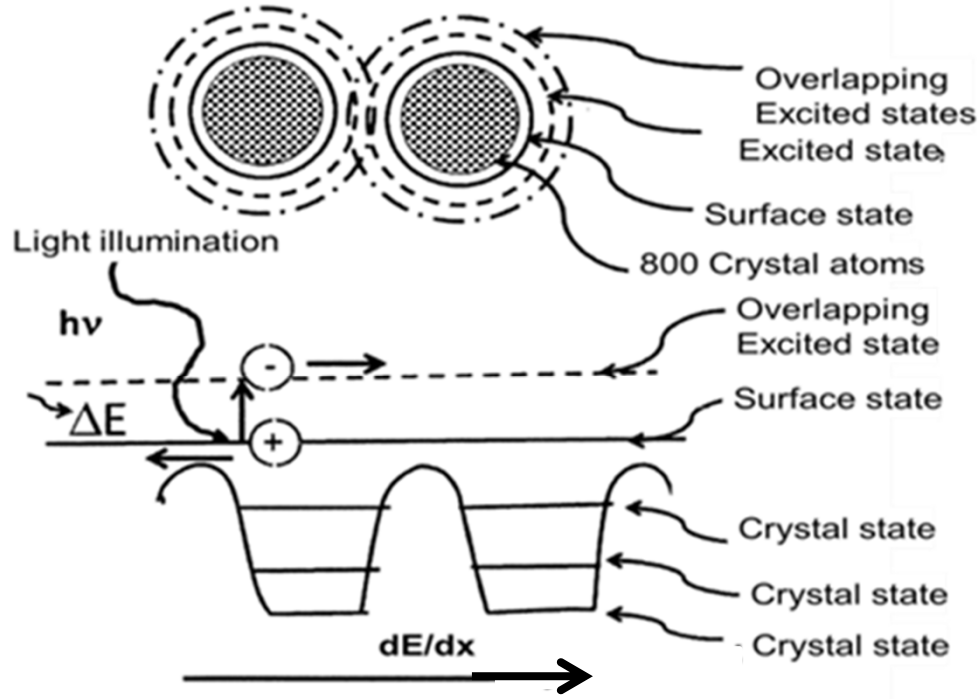
Bohr‘s stability conditions employed to orbital Eigenstates above the crystal surface gives a much smaller level splitting than the bandgap is in semiconductors (H.W.P. Koops, U. Koops 2009)

In Koops-GranMat one nano-crystal is composed from ca.1000 atoms in a single crystal form. The crystal is embedded in a Fullerene matrix which is also geometry quantized.
Overlapping Excitonic surface orbital electron states form the condensate .
Wavelength of electrons at Fermi level is ~ 2 nm (Pt/C)

Bohrs Eigenvalue in circular states at the crystal rim : Surface Orbital (n λ),
n = 3 at 2 nm diameter crystals



Nanocrystal Pt/C 2nm or Au/C 4 nm diameter, separation 1 nm
The energy difference between excitonic levels is 125 meV (Pt/C) and 65 meV (Au/C)



Principle of energy harvesting from the green-house emission using nanogranular compound materials. Since a 2 materials mixture is used, the 2 materials form a common Fermi–level. The Pt-material takes the electrons from the Fullerene crystals, which have therefore holes. The incoming radiation excites the electrons in the Fermi-Level to the level with the holes. There electrons and holes form Bosons in a very high density. They can be moved by an external dipole moment and finally deliver electrons to the outside world for work.

Nano-composit materials, e.g. Pt/C are sensitive in the IR light and can harvest all day and night the IR- light, which is emitted by the Green-House – gases in the upper atmosphere.

By switching on a field gradient at the rim of the Koops-GranMat® detector layer the energy stored in Bosons is at the end of the layer released as electrons to the customer.

This material unifies the radiation detector, the storage device, and the energy supply.

IR-Solar-receivers are useful in areas having a low density of population, but need to use expensive and desastrous Lithium containing batteries for electrical machines.

To move Bosons a field gradient is required, which can propel the dipoles of the Bosons to the end of the field gradient, where they can decay and deliver electrons.

The current supply can be controlled by adjusting the static field gradients or switching them on or off. The principle has been shown, in the experimental stage. Now a larger area layer of 1 cm² is under construction for demonstration.

Later presently existing glass coating machines, can be used by replacing the ion-sputter-sources with by field-emission array electron sources, which deposit the nanocrystalline detector layers from organometallic precursor gases to absorb the IR radiation and convert this finally to electrons or current.

Summary

Nanogranular compound materials offer a possible solution to absorb energy from the space in the earth atmosphere without interruption by day and at night. The green-house gas emission is the powerful source of 340 W/m² during day and night. Large area detectors and storage devices are possible, which are far more efficient than present Silicon solar energy panels, which need batteries.
The fabrication is possible by small changes in today's glass coating systems.

It will be a revolution for the earth energy budget without the need to burn coal or plants. All this energy comes in the end from the sun and the space.

Conclusions

- Koops-Gran Mat® with electron hole pairs are produced with FEBIP from organometallic precursors using slow step deposition and sequential epitaxy
- Electrical resistance measurements show no line resistance but a contact resistance which depends on the contact area
- Overlapping surface orbital Eigen-states form a Boson- condensate according to Bose's and Einstein's theory
- This transition of electrons and holes from Fermions to Koops-Pairs in a material properly produced with FEBIP allows to explain the Hyper Giant Conductivity Observed at Room Temperature in Metal/Carbon compound materials
- The theory of Bose renders the temperature for the formation of the Bose - Einstein condensate for Rb: 0,5 µK, 2D Litho: 50 mK and Koops-GranMat®: 300K

Koops-GranMat® requires no cooling and is superior to Metals, Superconductors and Graphene-applications.

It can revolutionize electronics energy transport and photonics

Acknowledgments

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„Imagination is more important than knowledge.
Knowledge is limited, imagination embraces the world“. AE

Thank you for your attention

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