History and modern applications of nano-composite materials carrying GA/cm² current density due to a Bose-Einstein Condensate at room temperature produced by Focused Electron Beam Induced Processing for many extraordinary novel technical applications.

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Abstract The discovery of Focused Electron Beam Induced Processing and early applications of this technology led to the possible use of a novel nanogranular material “Koops-GranMat®” using Pt/C and Au/C material, which carries at room temperature a current density > 50 times the current density which high TC superconductors can carry. The explanation for the characteristics of this novel material is given. This fact allows producing novel products for many applications using Dual Beam system having a gas supply and X,Y,T stream data programming and not using GDSII layout pattern control software. Novel products are possible for energy transportation, -distribution,-switching, photon-detection above 65 meV energy for very efficient energy harvesting, for bright field emission electron sources used for vacuum electronic devices like amplifiers for HF electronics, micro-tubes, 30 GHz to 6 THz switching amplifiers with signal to noise ratio >10(!), THz power sources up to 1 Watt, in combination with miniaturized vacuum pumps, vacuum gauges, IR to THz detectors, EUV- and X-Ray sources. Since focusing electron beam induced deposition works also at low energy, self-cloning multibeam-production machines for field emitter lamps, displays, multi-beam-lithography, - imaging, and - inspection, energy harvesting, and power distribution with switches controlling field-emitter arrays for KA of currents but with < 100 V switching voltage are possible. Finally the replacement of HTC superconductors and its applications by the Koops-GranMat® having Koops-Pairs at room temperature will allow the investigation devices similar to Josephson Junctions and its applications now called QUIDART (Quantum interference devices at Room Temperature). All these possibilities will support a revolution in the optical, electric, power, and electronic technology.

Contents
The lecture reports on many subjects.

Discovery of Focused Electron Beam Induced Processing [1].
Early applications of this technology [2] for Micro-data recording [1] and high resolution Projection Lithography[4].

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Discovery of the novel nanogranular material in 1994, now called “Koops-GranMat®”, which carries at room temperature a current density up to 3 GA/cm².

Explanation of the novel nanogranular material “Koops-GranMat®” having a Bose Einstein Condensate at room temperature due to the deposition process and the materials growth process. A recently published paper by L. Butov and Remeika, from UCSD allowed to calculate the temperature at which the Bose Einstein Condensate in Koops-GranMat® can form.

Koops-GranMat® is not a superconductor, but carries 100 times higher current density than those. In High TC superconductors the repelling force of 2 electrons is balanced by the antiparallel spins with their attractive power and which are in general composed from large crystalline compounds, which contain many acoustic and optical phonons. Superconductivity is only achieved by cooling the material to the temperature, where the resistance drops from a finite value to zero (TC) to allow the formation of the Cooper-Pairs. Koops-Pairs are formed in the condensate of Koops-GranMat®. This, however, is free from optical phonons due to geometry quantization in the nanocrystals, even at room temperature.

Novel products for energy transportation, -distribution, and -switching are recently presented and patented. Photonic crystals can be built with this deposition method to be used as WDM Filters for the optical net.

Very sensitive photon-detection at room temperature above 65 meV energy allows IR cameras without a cooling device, and also very efficient energy harvesting. At red light Koops-GranMat® has an efficiency which is 3 times that which Si solar cells have in the entire white spectrum.

If applicability for powerful electron sources for nano-electronics is requested, all heated cathodes are excluded, diamond delivers at room temperature sufficient current for radiation insensitive electronics. Koops-GranMat® surpasses all other characteristics by very high currents and current density, and, which is most important, low required extraction voltage. Maximum currents of 1 mA from one tip are obtained at 24 V (Au/C) and 70 V(Pt/C). Such voltages can be handled in nano-electronics wiring patterns with 1 µm pitch.

Bright field emission electron sources are used for miniaturized vacuum electronic devices, a miniaturized vacuum pump and vacuum gauges, like an "Orbitron” pump. Amplifiers for HF electronics, micro-tubes, 30 GHz to 6 THz switching amplifiers with signal to noise ratio (S/N) < 10(!) are possible, since the cathode to Grit capacitance is 0.24 AF (240 FF). Very powerful THz sources with a high Signal to Noise ratio are possible.

Table 1: Characteristics for IR-sources in the 0.2 to 10 THz range

| Frequency THz | Wavelength µm | Resonator E0 µm | 1 Electron pulse at 100 V travels µm | S/N at 1 mA DC |
|--------------|---------------|----------------|------------------------------------|---------------|
| 0.2          | 1500          | 750            | 15                                 | 173           |
| 0.5          | 600           | 300            | 6                                  | 77,5          |
| 1            | 300           | 150            | 3                                  | 54            |
| 5            | 60            | 30             | 0,6                                | 24,6          |
| 10           | 30            | 15             | 0,3                                | 17            |
EUV- and X-Ray sources can make use of the material which cannot get hot due to the nanocrystalline metal/carbon compound structure used for the cathode and the anode. There only Rutherford scattering can act and escaping electrons can be retarded not to heat the tube wall [16].

Focused electron beam induced deposition works also using low energy electrons and allows by FEBIP Self-cloning the multibeam-production of SEM’s for massive parallel beam machines [17],[18]. Other mass producible objects are: Field emitter lamps and displays, photosensitive areal devices for energy harvesting, power distribution with switches controlling field-emitter arrays for KA of currents but with < 100 V switching voltage.

“Nano Granular material” protects Koops-GranMat® and other material combinations and their many applications forms. Applicant Dr. Hans W. P. Koops containing a) European Patent Application No. 12 183 564.9 (KOO 7532 EP -. Katscher, Habermann patent attorneys Darmstadt), b) National applications: China, USA, Germany under process [19].

Finally: Koops-GranMat® having Koops-Pairs at room temperature and it’s applications can replace all uses of HTC superconductors cooled to 40K. E.g. cooled SQUIDS by at Room Temperature operating QUIDART (Quantum Interference Device At Room Temperature), Magnets, Q-Bit-computers etc. Patents filed 2014 in Germany.

Koops-GranMat® is discovered in 1994 at FTZ German Telekom Research Centre as a novel material which is capable to replace cooled superconducting materials, and can revolutionize energy transport, detection, Field-Emitter lamps and displays, GHz to THz switching electronics, THz radiation power sources, and X-Ray sources.

Conclusions
The applications of Koops-GranMat® can revolutionize the electronic technology in a dramatic way, with the capability of 100 times of what super-conducting materials can do, but with the advantage to allow miniaturized tube electronics for GHz to THz applications and powerful miniaturized X-ray tubes which operate at room temperature and have no need for expensive cooling systems.

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