PHLburg Technologies, Inc.

1275 Drummers Lane
Suite 101
Wayne, PA 19087

Telephone: 610-688-6800
Fax: 610-975-5800
Website: phlburg.com

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Dear ,

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MESSAGE FROM NEIL B. GODICK

Prime Minister Vladimir Putin had some tough words for lazy bureaucrats: cut the red tape or be fined. The fine is approximately one month's salary.

The premier's anti-bureaucracy drive started earlier this year. With this announcement officials have to take administrative responsibility for their work or face potential fines for laggard efforts.

"Officials still keep sending citizens around in circles. There will be administrative responsibility for the violations. We need to break the vicious circle. There are still refusals, formal write-offs, requests to bring in unnecessary paperwork," Putin told ministers at a cabinet meeting.

Under new amendments the government is introducing, officials demanding unnecessary paperwork will be held personally responsible and could be fined. And, officials who refuse to consider citizens' complaints about them within a 10-day timeframe could be fined.

The number of Russians who think that Russia's sovereignty has brought positive results has grown over the recent years. This was announced by the Levada Center.

The percentage of respondents, who believe that independence is good for the country, has doubled since 2000, from 28% to 59%, while the number of critics reduced from 57% to 29%.

The proportion differs depending on the age, education, place of residence and income of the respondents.

We do not intend for the following reports to solve any need our readers may have. We do intend to keep everyone current on technology developments in Russia. If you would like any additional information on any of the developments reported – send us a note.

Cuprous oxide nanoparticles from electrodes

A research group from Daghestan State University (DSU) has developed a method to electrochemically synthesize cuprite nanoparticles.

Cuprous oxide Cu_2O (cuprite) is a very promising material for solar power engineering. In their basic state, cuprite electrons, like all semiconductors, fill up the valence band. Upon excitation, they pass into the conduction band. Electrons cannot have an energy level that is intermediate for both bands. For cuprite, the forbidden gap width is 2.0 to 2.2 eV. Visible light photons have an energy level from 1.6 to 3.1 eV. During interaction with electrons, photons can transfer to the electrons an energy that is sufficient for transfer to the conduction band. This results in, cuprite efficiently converting solar radiation to electricity. In combination with its low cost, this makes Cu_2O a very promising photovoltaic material.

During electrolysis, when copper electrodes are used for the anode and cathode and saturated sodium chloride solution for the electrolyte. The copper electrode starts dissolving and a reddish Cu_2O sediment is formed. It is these copper materials that were used by the researchers. They focused on experiments involving additional conditions for this synthesis. Cuprite was synthesized at various hydrogen pressures. In each case, scanning electron microscopy and X-ray diffraction analysis data confirmed high-purity Cu_2O particle formation. However, in response to a higher pressure, their specific surface area decreases. This occurs as the average particle size increases from 8 to 36 nm. This measurement is quantitatively determined by chrome dye adsorption.

Cu_2O particles have good photocatalytic properties. Active oxygen-containing agents that destroy dye molecules are formed in their presence. Experiments on photocatalysis were conducted on blue chrome azo dye. Exposure to UV rays or daylight made the dye solution lose its color. As the external oxidizer (oxygen) pressure increased, so did the discoloration rate. The value obtained for the discoloration rate dependence on oxygen pressure changes in the 0.4 MPa region. This indicates accompanying divalent copper oxide film formation on the nanoparticle surfaces.

Through these experiments, the researchers selected the most effective methods for obtaining photoactive Cu_2O nanoparticles. They also studied the external pressure effect on the nanoparticle dimensions and their photocatalytic properties.
#2011-06-167

2D Fermi gas production technology

RAS Institute of Applied Physics (Nizhniy Novgorod) recently completed a study of 2D Fermi gas of atoms.

The study involved lithium atoms. These exist in two isotopic forms,

^{6}Li (six nucleons in a nucleus) and ^{7}Li (seven nucleons in a nucleus). The former isotope atoms belong to fermions, the latter's atoms to bosons. For the study, fermions were used. It should be emphasized that this difference between particles (fermions or bosons) becomes apparent only at ultra-low temperatures. At room temperature both isotopes' atoms behave in the same way. It was possible to reach a temperature that was only 10 billionths of a degree above absolute zero. At Stage 1 the atom mix temperature was lowered by creating a lithium atom cloud inside a vacuum chamber. Then exposing it to laser rays coming from six sides and converging at the same point. A laser radiation frequency level must be selected, at which its interaction with atoms will result in their kinetic energy reduction.

The atom mix was cooled to 150 microkelvins. For the next stage a different cooling technique is used, which conditionally could be termed *evaporation*. This process proceeds in a potential well containing a great number of atoms. By lowering the well walls, the fastest atoms' escape beyond the well walls. This is similar to the liquid evaporation process during which the fastest molecules leave the surface. *Evaporated* atoms carry excessive energy away with them, while atoms remaining in the well on the average become cooler.

The developed and implemented preparation method for 2D Fermi atom (lithium atoms) mixes involves producing a special electric field configuration forming a spatial *lattice* from potential wells. Adjoining wells are separated by very high *walls*. Atoms' movement in the direction perpendicular to the walls is matched by a definite energy levels system. Atoms also move in parallel to the walls. This movement is matched by yet another energy level system. There will be no perpendicular movement only if atoms take the lowest energy level that is possible for this direction.

Exceptionally important is producing a well-functioning device that can be used for Fermi atom gas preparation and study. The group is engaged in further research and does not plan to limit it to 2D systems only.
#2011-06-168

Superpower laser

Historically, all attempts to achieve super-high laser radiation intensities required finding solutions for two problems. One involves medium breakdown that inevitably accompanies an increasingly energetic beam. The other is the necessity for pulse duration minimization which, all other things being equal, means increased radiation power.

A method for strengthening radiation without medium breakdown was found in 1985. It was based on dispersion – dependence of the wave propagation rate on the electromagnetic field oscillation frequency. In a specially designed dispersion system, separate components (matched by different frequencies) propagated at different rates. As a result, the original pulse was spatially *stretched*, while its intensity decreased by several orders of magnitude. A stretched pulse could be strengthened without fearing an optic breakdown. Then it was compressed to the original size.

For pulse duration, new materials became the success factor in producing superpower lasers. In 1986, titanium-sapphire crystals were discovered. Their distinguishing feature was a wide frequency range where the signal could be strengthened. This made it possible to form extremely short duration pulses. In 1997 researchers from RAS Institute of Applied Physics built the first Russian laser with titanium-sapphire as the working medium. They reduced the pulse duration to 70 femtoseconds in a laser with a beam energy as high as 70 mJ. This laser's output power was 10^{12} W, i. e. 1 TW. In 2006 the same Institute developed and launched a substantially more powerful laser complex with an output power slightly over 500 TW.

The Russian Academy of Sciences financed the titanium-sapphire laser development (1997) while the sub-petawatt laser complex (2006) was built with the Russian Federal Nuclear Center at Sarov and *Rosatom's* active participation. The nuclear industry's interest in superpower laser is explained by the tempting prospects for laser thermonuclear fusion – the main alternative to the *Tokamak*-type thermonuclear reactor. In the tokamak a deuterium-tritium plasma is retained for a relatively long time (about a second). Laser thermonuclear fusion calls for substantially shorter periods (about 10^{-10} second) at significantly higher deuterium and tritium concentrations. These parameters are achievable by heating targets containing deuterium and tritium for a short time using super-high intensity laser radiation.

RAS Institute of Applied Physics is developing significant upgrades to the 2006 device. The power output is being increased tenfold, to five petawatt ($5 \cdot 10^{15}$ W). The laser is named PEARL (PEtawatt pARametric Laser). At this point PEARL is among the world's five most powerful lasers.
#2011-06-169

Protection against bending

The tragic events at Fukusima-1 NPP are another demonstration to the world that man-made disasters pose a real threat, and provisions for every eventuality must be made. Other accidents that are less widely publicized occur regularly. These are train crashes, sudden roof cave-ins, bridges falling into rivers and many others. To prevent them, potentially hazardous facilities must be equipped with control systems that will signal when deformation sets in. At their own initiative, scientists at the **Chair of Optoelectronic Devices and Systems (Saint-Petersburg State University of Precision Mechanics and Optics)** have been developing such systems for thirty years.

One device they developed is a measuring engine with a deformation detection system that rolls along railroad tracks. Sensors generate optical radiation and determine railroad bed displacement from its design position.

First the team developed quality control systems for straight railroad sections. Now they are developing the same for curved sections. Jointly with researchers from the Railroad Transport Institute, they produced an optoelectronic system to measure railroad track positions (**RU2387561**). The operating principle is based on the ability to determine the tracks' spatial position relative to immovable geodetic network reference markers on the railroad. The system includes several optoelectronic position sensors joined in a local network. The system can reliably determine the railroad bed position and its displacement from the design level. The measuring engine with the system passes over a selected railroad section. The system takes measurements in two mutually perpendicular directions and also inclined plane measurements. If a deformation is determined, the machine goes over the section again and corrects the rails.

A third-generation optoelectronic dock deflectometer that processes video images of markers placed on structural elements is being developed. The third-generation optoelectronic dock deflectometer will process images of markers placed on structural elements. Such deflectometers can also be used to determine a house's roof status.
#2011-06-170

Profitable waste: producing energy from biomass

Any organic waste is subject to microbial decomposition. In oxygen's absence, organic waste turns to biogas. Technically pure methane released from biogas can be fed into a gas pipeline network or directed to a gas-piston / gas-turbine plant to generate electricity and heat.

***Aspekt* Company (Moscow)** has determined optimum parameters for microbial colony development resulting in increased specific biogas yield. This is achieved by increasing the fermentation temperature from 35 to 55 °C. *Aspekt* has developed a novel biogas purification method to separate methane from biogas with minimum power expenditure.

There are three basic biogas purification methods: (1) liquid and solid chemical absorption and impurities' absorption, (2) membrane separation, and (3) freezing-out (cryogenic method). The first method often uses liquid chemical CO_2 absorbents – monoethanolamines and diethanolamines. They absorb carbon dioxide but do not interact with methane. The result is virtually pure methane, but the liquid phase has to be changed. To remove absorbed carbonic acids, it must be heated. This technology loses out on its energy consumption. Similar substantial energy losses are characteristic in the cryogenic method. To freeze carbon dioxide, you have to expend considerable power that is generated by the plant thereby reducing its overall efficiency.

Aspekt's biogas separation technology uses the membrane-absorption method. This technology combines absorption and membrane separation methods' advantages. As in the classical chemical absorption method, carbon dioxide is *captured* by the liquid absorbent. However in this case there is no direct contact between the phases, the liquid and gas are divided by a membrane. The technology does not require a higher biogas pressure to feed it to the membrane. The gas flows from the bioreactor by gravity under a pressure that is slightly higher than atmospheric.

Carbon dioxide passes through the membrane more easily than methane. As the biogas stream moves along the membrane, carbon dioxide diverted through the membrane to the absorbent's mobile liquid phase and the *nonpenetrating* methane concentration in the biogas increases sharply. The membrane module has a layered structure (liquid / gas / liquid / gas) and is assembled in an airtight reservoir. If the membrane system is placed at the bioreactor outlet, CO_2 will be extracted, and a desired methane purity level can be achieved. Later carbon dioxide is blown off and fed to hotbeds via pipes. The combined biogas purification method avoids additional power inputs, which in conventional conditioning systems are needed for chemical sorbent heating, gas mix cooling (in the cryogenic purification method) or higher biogas pressure (in the membrane method). The total power consumption by the plant itself is not more than 10 % of the total power it generates. The plant owes its high efficiency to the polymer membranes patented by RAS Topchiev INKhS.

The pilot membrane plant for biogas conditioning produces up to 100 m^3 biogas a day. The bioreactor's side products are organic fertilizers based on the liquid biomass processed by microorganisms. The fertilizers were tested in 2010. Wheat crops treated with the preparation had a 40 % yield increase. Corn treated with the preparation had an 80 % higher yield. This is comparable with treatment by mineral fertilizers.
#2011-06-171