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INTEGRATIVE MODULES FOR ELECTRONIC SYSTEMS. (Integrative Modules For Electronic Systems, Including Laser Diodes, Equipped With an Intensive Cooling System Based on Diamond-Copper Composite Materials)

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Abstract

Recent practical experience has shown that one of the key challenges in complex electronic devices – particularly those incorporating laser diodes – is ensuring reliable and efficient cooling. To minimise energy losses and increase the effective output, especially in modern lighting systems, active research is being conducted to develop integrated technical solutions that operate without additional structural components or extra energy consumption for cooling.

In parallel, new design approaches are being explored that enable increased light output while maintaining a minimalistic, compact construction and relatively low power consumption. These solutions aim to enhance the performance and energy efficiency of lighting devices without compromising design simplicity.

Keywords: *Integrative modules; Electronic systems; Laser diodes; Light output; Diamond spheres; Ductile material; Composite material; Pseudo-porous structure; Optical cable; Laser radiation; Flat-emitter lamp*

Introduction

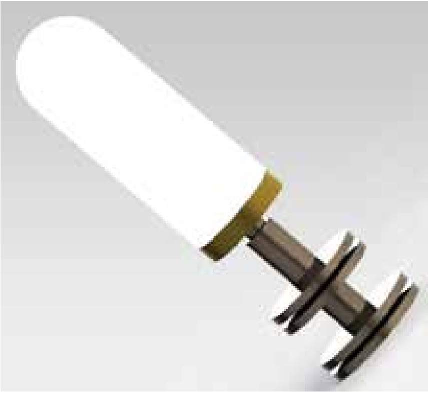
To eliminate energy losses and increase effective output – particularly in various lighting systems – active research is underway to develop integrative technical solutions that operate without additional structural components or extra energy consumption for cooling.

In parallel, new engineering approaches are being explored and refined to enable higher light output from lighting devices while maintaining a minimalistic and simplified design, operating at relatively low power and, consequently, low energy consumption.

The author of this publication considers the most effective solutions to be the integrative and comprehensive approaches proposed in the scientific and technological works and books of ***Rustam Mukhametov***, a well-known innovation specialist in this field.

What fundamentally distinguishes ***Rustam Mukhametov's*** proposals and developments from similar approaches by other authors is a broad platform for experimental computer modelling, made possible by his deep and diverse expertise in the methods of systemic and combinatorial computational modelling across adjacent innovative processes, including at the intersections of fundamental disciplines.

Figure 1. *One of the innovative developments for converting laser radiation into light emission within familiar and standard spectral ranges is presented*

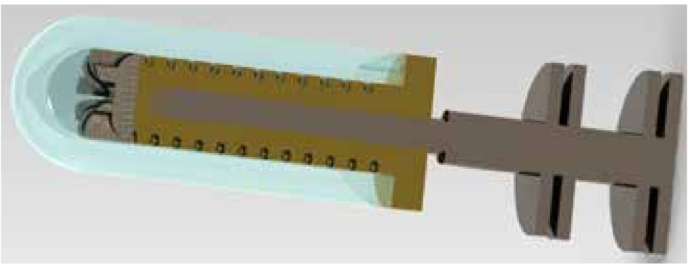


When analysing the advanced technologies presented in his innovative publications, ***Rustam Mukhametov*** formulates an exceptionally important thesis for solving the outlined problems – the combinatorial structure of each solution, meaning the harmonious integration and mutual reinforcement of traditional technologies and materials with innovative, primarily composite, technologies and materials.

A particularly significant aspect of ***Mukhametov's*** proposals is the consistent trend toward integrating and thoroughly adapting new materials and technological methods within the framework of established and proven technologies and materials. This creates a foundation for transforming properties and capabilities to a new, innovative level.

The next photo shows the axial cross-section of such a device, which is more convenient for detailed examination and analysis.

Figure 2.



As can be seen, the design of the innovative lamp integrates the functions of several fundamental structural components.

The lamp holder incorporates a vortex radiator whose shaft and discs are made of a diamond–copper composite, which serves as the key element of the lamp's cooling system.

Each component of this system is multifunctional. In addition to pure heat-transfer and heat-accumulation properties, the structure of these parts – formed from numerous micro-globules of the composite – simultaneously performs a critically important function of dissipating thermal flows. This is achieved due to the pseudo-porous structure of the composite.

Let us focus on the innovative structure of the diamond–copper composite (Appendix 1).

The original process of manufacturing composite globules begins with the formation of synthetic diamond spheres 5–7 microns in diameter (the size may vary depending on the geometry of the component and its operating conditions).

These spheres are then coated with copper using a proprietary innovative technology (Appendix 2).

The coating thickness is selected to ensure that when the lamp component is formed in a mold, the diamond spheres retain sufficient ductile material for the metal to undergo liquid-flow deformation, filling the spaces between the synthetic diamond spheres.

As a result, a pseudo-porous structure is formed in which diamond spheres– the best known thermal conductor while being fully electrically non-conductive – are uniformly distributed. Such a structure allows heat to dissipate instantly and spread evenly across the cross-section of the radiator discs.

An optical cable is placed in the spiral grooves of the lamp body. A laser beam from the laser module is directed into this cable. The optical cable is wound in a spiral and placed within the grooves at a diameter that causes the cable to emit light across its entire cylindrical surface, which is significantly more efficient than end-face emission.

To separate the laser radiation from the lamp's output light, a layer of phosphor – calibrated for a specific emission spectrum – is applied to the optical cable.

Thus, the final emission of the lamp is completely non-toxic and, due to the emission area being thousands of times larger than the end face of an optical fiber, a laser diode operating at only 1–2 watts produces a light output equivalent to 60–75 watts.

The presented models demonstrate that, based on the general principles of innovative design proposed by **Rustam Mukhametov**, it is possible – within the framework of traditional geometries and structures, for example an ion-exchange filter – and using natural and completely safe materials, to achieve practically ideal results with unique parameters and properties, including:

- complete elimination of chemical reagents in the process;
- use of natural ion-exchange conditions;
- enormous potential for unique exchange capacity, including for the purification of liquids contaminated with radioactive substances.

Figure 3. *The presented models demonstrate that, based on the general principles of innovative design*

Under such design trends, the fundamental requirements for the design approach itself change, allowing extensive use of computer modelling methods and techniques to achieve an optimal and ideally calibrated final result.

Figure 4. *The presented models show that, when based on the general principles of innovative design*

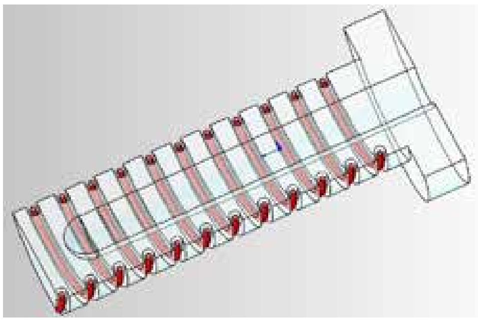
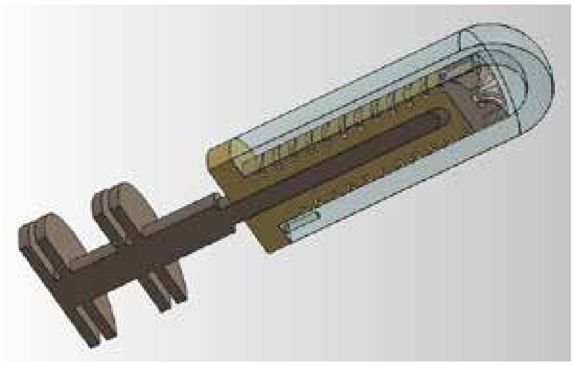
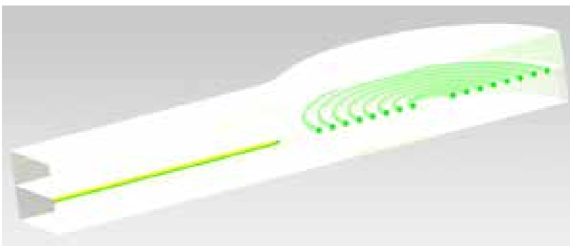


Figure 5.



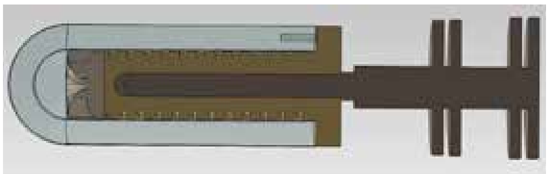
The generation of light from a curved optical cable – bent to a specific radius – has many possible alternatives. One such example is shown in the next photo: a cross-section of an emitter in which the cylindrical surface of the optical cable begins to emit light once a certain bend radius is reached.

Figure 6. *The next photo shows the structural layout of the lamp in a transverse longitudinal section*



Here, the individual technical components are clearly visible, each carrying its own functional and conceptual significance and performing specific technological and design-related roles.

Figure 7. *The design incorporates numerous innovative elements*

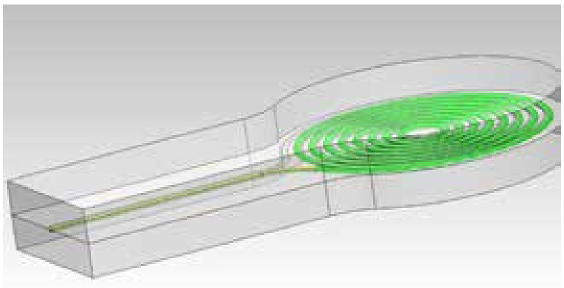


The proposed configuration contains many advanced features and, most importantly, is fully suitable for serial and large-scale production. Moreover, this lamp configuration – its combination of technological principles and structural materials – allows the integration of future technical solutions that may emerge as laser technologies, composite material engineering, and new energy-efficient cooling and control systems continue to evolve.

Figure 8. *The photo shows a mini-lamp in which a mixture of phosphors is applied to the end of an optical fiber according to a specific three-dimensional geometric pattern, providing white-spectrum light emission*

The diameter of the optical fiber is only 120 microns, which makes it possible to create micro-miniature light sources for use in highly compact optoelectronic systems.

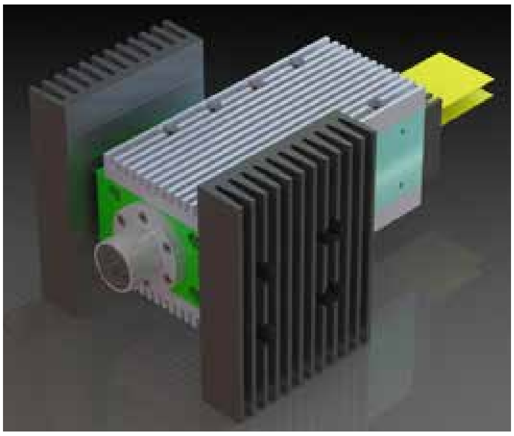
Figure 9. *The photo shows a flat-emitter lamp connected to a single optical fiber*



This system, in addition to its overall energy efficiency, makes it possible to achieve the required illumination level over a specified area with minimal cost and maximum simplicity.

The same configuration also allows for applying virtually any combination or mixture of phosphors to the spiral (flat spiral) section at the end of the optical fiber, enabling the generation of precisely defined light-emission parameters.

Figure 10. *The photo shows a laser-diode module based on the principles of active cooling achieved through the dissipative effect of components manufactured from a pseudo-porous diamond–copper composite*

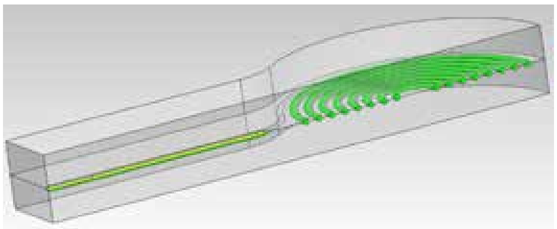


One of the innovative integrative features of the presented design is the use of thermoelectric coolers in combination with heat-conducting and heat-dissipating structural elements of the module housing.

The thermoelectric coolers are positioned between the external radiators and the module body. The heat-conducting elements direct thermal flows from the printed circuit board to the walls of the housing, where the thermoelectric coolers are mounted. The base surfaces of the radiators are pressed against these coolers, and additional module components requiring constant cooling may be mounted on the radiators when necessary.

Practical results have shown that reliable cooling ensures maximum stability of the laser output parameters, which in turn significantly expands the range of possible output configurations of the module. When required, this also enables the division of the laser beam among several optical fibers, each supplying a separate lighting device.

Figure 11. *The models of such devices are shown in the photo*



As can be seen from the models, despite their simplicity and manufacturability, the supporting disc of the laser diode (highlighted in red in the models) provides complete protection of the diode from overheating due to multiple contributing factors. As noted earlier, this significantly increases the operational stability of the module and reduces overall energy consumption for illumination.

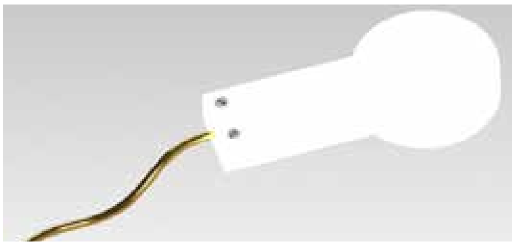
The models also illustrate the coding and decoding system, which enables identification of the optical fibers connected to the module and the corresponding lighting devices.

Figure 12.

This system provides additional functional capacity for implementing and monitoring various computational models of energy control and distribution. These functions fully depend on the purpose and operating conditions of the module, and the possibility of embedding the software component precisely at the most critical point is of particular importance for further development of the technology.

Moreover, this fundamental approach to applying new composite materials in new applications – materials with completely unique properties and characteristics – makes it possible to create advanced lighting devices and instruments with parameters required by modern technologies.

Figure 13. *The presented three-dimensional models show the heat-conducting elements, which simultaneously serve as the structural mounting components for the laser diode inside the module housing*

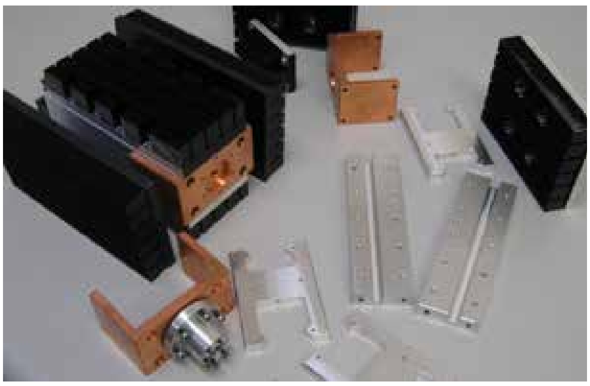


It is also important to note that, alongside the latest composite materials, nature provides exceptionally valuable natural materials.

The design principles described in the publications of **Rustam Mukhametov** allow the creation of a harmonious combination of long-established natural materials with proven engineering and manufacturing techniques.

The conceptual solutions proposed by **Rustam Mukhametov** enable further technological development – for example, transforming carbon – carbon composite fabrics into compressed solid components with entirely new properties, which open new innovative possibilities in lighting engineering and related technological fields.

Figure 14. *The photo shows the actual structural components of the innovative laser-diode module featuring a cooling system and a laser-diode holder made of a diamond – copper composite*



As can be seen in the photo, all other housing elements and components of the cooling system are manufactured from standard profiles and materials and do not require any special materials or specialised technological equipment; everything is produced using conventional cutting and measuring tools.

This may be considered an example of the integration and combination of innovative solutions for the efficient and safe conversion of laser-diode radiation into safe, high-intensity phosphor emission, with virtually complete heat dissipation and without thermal or optical losses.

All key output parameters of this integrated lighting system fully comply with current safety standards and regulations.

Appendices, references, patent and licensing information:

Appendix 1
United States Patent Application
20120040166
Kind Code: A1
Date: February 16, 2012
Title: Composite Material, Method of Manufacturing and Device for Moldable Calibration
Abstract:
Composite materials and methods and systems for their manufacture are provided. According to one aspect, a composite material includes a collection of molded-together multilayer capsules, each capsule originally formed of a core and a shell. After a plastic deformation process, the shell forms a pseudo-porous structure, with pore locations containing the capsule cores. The cores are made of a material – e.g., synthetic diamond – harder than the external shell, which may be formed of a ductile metal such as copper. The composite material exhibits high thermal and/or electrical conductivity and/or dissipation.

Appendix 2
United States Patent Application
20100224497
Kind Code: A1
Date: September 9, 2010
Title: *Device and Method for the Extraction of Metals from Liquids*
Abstract:
A volume-porous electrode is provided that increases the effectiveness and productivity of electrochemical processes. The electrode is formed of carbon, graphitic cotton wool, or carbon composites configured to permit fluid flow through the electrode volume in three orthogonal directions. The electrode conducts an electrical charge directly from a power source and also includes a conductive band connected to the surface of the electrode volume, ensuring a uniformly distributed high charge density. Apparatuses and methods employing the volume-porous electrode are disclosed for removing metals from liquid solutions using electroextraction and electrocoagulation techniques, as well as for electrochemical modification of a liquid's pH level.

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