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New Type of Disk Laser-New Paradigm of Technology Development

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Commentary

The US has announced the new program "SHIELD" (Self-protect High Energy Laser Demonstrator) which is a comprehensive program to create a 5th-6th generation fighter with a high energy laser on board to protect it from air to air and surface to air missiles. It includes the development by Northrop Grumman of a laser beam control system, the development of the actual laser by Lockheed Martin, and the integration of the entire laser weapons (LW) system into a single laser complex by Boeing. Due to the corona virus pandemic and technical difficulties, the US plans to receive these laser aviation systems by the end of the 2022 year only. Within the framework of the program, solid state (SS) LW complexes based on the technology of fiber lasers with spectral beam combining of radiation from single sources were successively created. It was consistently reported on the creation of lasers with an average power of 30 kW, then 60 kW, 100 kW and even 300 kW. The choice of a fiber laser as a unit for power summing is determined by the high quality of the radiation, its compactness, and low weight characteristics. To date, the weight factor of such LW complexes has been brought to a level of 5 kg/kW. This factor includes an estimate of the weight of the laser itself, its power source, the heat release system, and the entire platform that holds the system elements as a whole. Lockheed Martin plans to further bring this weight factor to a level of 2 kg/kW. These figures look very bright and promising for the development of tactical LW. The company plans to test a system with much bigger power, but it seems that created prototype of a 300 kW laser is very close to the physical limit for the fiber technology. For comparison, it should be said that LW complexes on gas, chemical and alkali metal vapors bases, which the US has already abandoned (GDL, CO_2, CO, COIL, HF/DF, alkali metal vapors) gave a weight factor in the range of 200-400 kg/kW, which means that a megawatt LW complex can hardly be placed even in a Hercules type aircraft carrier. And in order to achieve air supremacy, it is necessary to create and equip serial combat aviation with light and compact tactical LW complexes with a weight of several hundred kilograms. The weighting factor acquires special significance when considering the issue of equipping spacecraft with lasers, since this task is already on the agenda of the US Department of Defense. According to the accumulated experience of operating the LW complexes created in the past, the need to create in the future a very light and compact laser systems with an output power of several tens of Mw is confirmed. Therefore, only SS laser technology allows specialists to look confidently into the future. Only having a developed SS laser technology can we talk about the creation of a whole range of high energy LW systems that meet the assigned tasks for sure? Thus, the LW complex on a SS basis with a capacity of 10 megawatt, taking into account the weight factor planned for implementation -2 kg/kW would weigh within 20 tons, which looks like as a quite acceptable! Nevertheless, the technology used by the US for combining fiber laser beams is suitable only for creating tactical LW with a power of up to several hundred kW not more. It is especially true if we are talking about movable LW complexes. Obviously, a different design scheme of a SS laser is needed, which would allow further scaling of the energy of the LW complex while maintaining its characteristic weight factor. As noted above, a laser based on the outdated physical and technical foundations of the previous stage in the development of laser technology would weigh many tens of times more. Taking into account the above, it is important to draw a number of conclusions that affect the general understanding of the problem of LW creation in the world.

SS laser technology in the world has reached the level of maturity that allows the creation of high energy tactical aircraft with reasonable weights and dimensions. Laser complexes created on gas, chemical and alkali metal vapors bases are a matter of the past. It became clear that the light and compact LW systems cannot be obtained on their basis. Very similar situation take place in the case of liquid LW systems, they cannot be efficiently scaled up to the MW class complexes. Today, the technology of tactical LW systems, well developed in the US, is based on fiber and disk types of lasers, research on which was begun in Russia and subsequently significantly developed in the US. Nevertheless, due to a number of physical limitations, the creation of compact and lightweight LW complexes based on the indicated bases is limited by the tactical power level. This is the great limitation of these technologies, since not only the strategic level of average power and possible temporal structure of radiation, but also many new effective applications based on them are physically impossible.

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Conflict of Interest

Author declares there is no conflict of interest.

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