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PHYSICIST'S FAMILY OF PATENTS IS A CRYSTAL-CLEAR VIEW INTO THE FUTURE

WRIGHT-PATTERSON AFB, OHIO – Vladimir Tassev, Ph.D., spent the better part of the last 25 years researching crystal growth for the Air Force Research Laboratory (AFRL), resulting in more than 15 years of projects related to the growth and study of novel nonlinear optical (NLO) materials for phase and quasi-phase matching (QPM) frequency conversion of laser sources for the mid and long-wave infrared (MLWIR) operation. However, it wasn't until recently that the physicist did something no one else thought could be done, leading to a family of patents. Focusing on protecting intellectual properties, the senior research physicist -- along with his articles and presentations -- has authored 16 US patents in the last six years with more pending applications. Twelve of these patents can be summed up as Optimized Heteroepitaxial growth of semiconductors:

US Patent #9,647,156 (2017), US Patent #9,777,402 (2017), US Patent #11,384,448 (2022), US Patent #11,390,963 (2022), US Patent #11,434,583 (2022), US Patent #11,535,951 (2022), US Patent #11,603,603 (2023), US Patent #11,761,115(2023), US Patent #11,761,116 (2023), US Patent #11,788,202 (2023), US Patent #11,795,574 (2023), and US Patent #11,795,575 (2023)

Tassev's work has also led to four additional patents related to the same research – two on the preparation of the orientation-patterned (OP) templates, US Patent #11,087,975 (2021) and US Patent #11,646,201 (2023), and two others dedicated to the growth and fabrication of QPM hybrid organic-inorganic structures: US Patent #9,960,568 (2018) and US #10,554,015 (2020).

"All these patents are related to the development of high-power widely tunable QPM frequency conversion laser sources operating in the MLWIR region that cover the two atmospheric windows of transparency between two and five microns and eight to 12 microns, although this approach can be successfully extended to the terahertz (THz) region", Tassev explained. "This includes, first, fabrication of OP-templates and, second, thick Hydride Vapor Phase Epitaxy (HVPE) on these templates to achieve large enough optical aperture for the following wave mixing frequency conversion processes."

This idea is based on combinations of materials, growth, and template preparation approaches. Combining materials can occur through either heteroepitaxy growth of one material – organic or inorganic -- on another (using semiconductors) gallium phosphide (GaP) and gallium arsenide (GaAs) or forming ternaries (using) gallium arsenide phosphide (GaAsP).

"For me", Tassev began, "the word 'combination' is very powerful. You combine two materials by growing one material over another and you surprisingly achieve a better quality than if you grew it homoepitaxially. Not to

TECH SNAPSHOT

PATENT NUMBERS:

US Patents 9647156, 9777402, 11384448, 11390963, 11434583, 11535951, 11603603, 11761115, 11761116, 11788202, 11795574, 11795575

TECHNOLOGY NAME:
Optimized Heteroepitaxial growth of semiconductors

INVENTORS:
Vladimir Tassev

TECHNICAL PROJECT OFFICE:
Air Force Research Laboratory

SOURCE:
US Patent and Trademark Office
www.uspto.gov

mention that, for some materials, heteroepitaxy is the only option to grow them. Combining two completely different materials such as an organic with an inorganic material is also possible."

Tassev's research found that, compared to the inorganic materials, the organics are remarkable materials from the point of view of nonlinearity. However, they are not that transparent in the infrared radiation (IR) and are not that resistive to heat as with traditional inorganic semiconductor materials.

"In a hybrid organic/inorganic structure, however, the material with better thermal conductivity (the inorganic) can play the role of the heat sink for the organic, while the organic with its better nonlinearity can improve the conversion efficiency of the device.", Tassev added.

"The thing is that nobody believed that the growth of one material on another was possible if their lattice parameters were so different, or that two materials could nicely complement each other in a ternary, or that one could grow by HVPE a high-quality on the rough surface of the OP-template hundreds of microns thick layers thick without the deposition of an additional smoothening the surface encapsulating layer," Tassev said.

While his research is ongoing, Tassev said the Air Force is already seeing the benefits. He believes that this is a breakthrough that will significantly accelerate the development of frequency conversion laser sources in the MLWIR and THz regions, leading to higher power, wider tunability, and coverage of frequency ranges never achieved before while being cost effective. These sources are in high demand for use with a wide variety of applications, starting with robust military applications such as infrared countermeasures (IRCMs), enhanced laser radar for ranging and target recognition, or long-range IR communication.

"This would be used in security with remote sensing and spectroscopy of chemical and biological species and offer less intrusive body scanning at airport security checkpoints and ranging to fine medical applications like breath analysis and biopsy-free cancer cell detection," Tassev said.

He also gave the example of a missile targeting an airplane. This technology could lead to redirecting the missile by feeding its targeting system new coordinates. This would be done in a relatively short amount of time when every second counts. When Tassev realized the many possibilities from this technology, he and the AFRL immediately began taking steps to protect the intellectual property, done through Air Force Materiel Command's (AFMC) Legal Office (LOJAZ).

"When you work in research, you must protect your ideas. You're also protecting the time, effort, and money invested in them. In today's world, people know everything. What we don't know is where the information is going, who's going to use it, and how," he said. "There are no ideas that should be neglected. However, ideas without realization have no value. It is critically important for the inventor to work closely with the patent attorney."