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product focus

SPIE Defense, Security+Sensing
2013 Edition

In this issue of the optics.org **Product Focus** we look at the US Navy's deployment of their first laser weapon. Fiber lasers 'perfect' for directed energy systems? And a Q&A from some of the leading experts in the directed energy systems community.

You can also review some of the latest product launches from both exhibitors and non-exhibitors alike. We have included booth numbers *(where available)* making it easy for you to check out the products for yourself.

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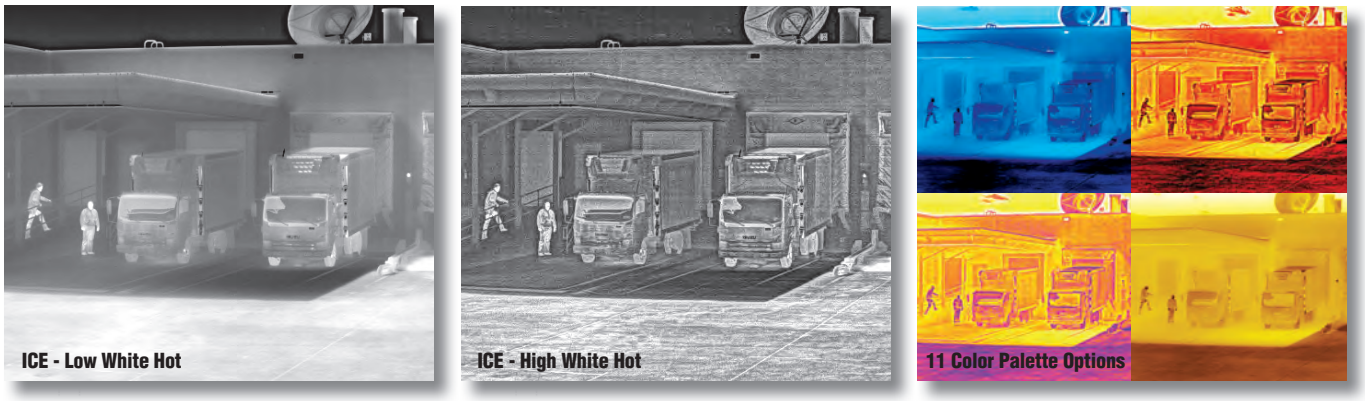

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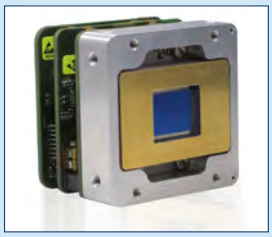

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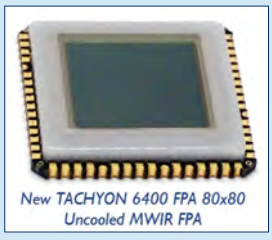

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US Navy to deploy laser weapon ahead of schedule

Following years of development, a high-power solid-state laser is set to sail aboard the USS Ponce next year.

The US Navy says that it will deploy a high-power solid-state laser on board one of its ships next year, in the clearest evidence yet that so-called "directed energy" weapons are regarded as militarily useful. The move follows recent US Navy demonstration of a fiber laser system capable of destroying an unmanned aerial vehicle (UAV)

A statement from the Navy quoted the chief of naval research, Rear Admiral Matthew Klunder, as saying: "Our directed energy initiatives, and specifically the solid-state laser, are among our highest priority science and technology programs. The solid-state laser program is central to our commitment to quickly deliver advanced capabilities to forward-deployed forces."

Such weapons, which would effectively use a power supply in place of bullets and missiles, have long been desired by armed forces, and the US Navy is now set to install such a weapon on board the USS Ponce transport craft in 2014, two years ahead of schedule.

Recent developments in Europe have included a 50 kW system based on fiber lasers developed by Rheinmetall, and a 40 kW system from MBDA Germany that was able to shoot down towed artillery from a distance of 2 km. In the US, a 10 kW system built by Lockheed Martin recently shot down small-caliber rockets, but for true military utility, an output of more than 100 kW is usually stated as the benchmark power requirement.

Speaking at last year's SPIE Europe Security + Defence symposium in Edinburgh Mark Neice, director of the Albuquerque-based High-Energy Laser Joint Technology Office, had hinted at the advances being made, saying that "within the next couple of years we will demonstrate significant military utility of this laser weapons capability".

Credit: US Navy/John F. Williams.

The Laser Weapon System, shown here temporarily installed aboard the guided-missile destroyer USS Dewey last summer in San Diego, California.

Cost/benefit analysis

Klunder highlighted that the use of a laser in place of traditional "kinetic" weapons could have economic benefits as well as tactical ones, saying: "This capability provides a tremendously affordable answer to the costly problem of defending against asymmetric threats, and that kind of innovative approach is crucial in a fiscally constrained environment."

"Our conservative data tells us a shot of directed energy costs under $1," Klunder told the Sea-Air-Space exposition. "Compare that to the hundreds of thousands of dollars it costs to fire a missile, and you can begin to see the merits of this capability."

According to the US Navy, the decision to deploy the laser onboard USS Ponce ahead of schedule is the result of rapid progress in its research efforts.

It is involved in a variety of such projects, including the Maritime Laser Demonstrator that is under development with prime contractor Northrop Grumman, while the US Army has also funded several similar programs. Last September, the US Navy issued a broad area announcement for proposals to develop a laser weapon with a view to deploying the technology in 2016.

Future "is here"

Although the US Navy's latest announcement is light on technical details, it says that the Office of Naval Research (ONR) and Naval Sea Systems Command recently performed demonstrations against remotely piloted aircraft.

By using technology investments made through other Department of Defense (DoD) agencies, researchers have been able to increase the ruggedness, power and beam quality of lasers, more than doubling the range of the weapons in the process, the US Navy announced.

"The future is here," said Peter A. Morrision, program officer for ONR's Solid-State Laser Technology Maturation Program. "The solid-state laser is a big step forward to revolutionizing modern warfare with directed energy, just as gunpowder did in the era of knives and swords."

Although improvements to high-power laser combining, system efficiency and beam propagation through the atmosphere at large stand-off distances are still required before laser weapons achieve true military utility, the technology is advancing rapidly, and is expected to yield a variety of options not previously enjoyed: from non-lethal disabling and deterrence all the way through to target destruction.

"We expect that in the future, a missile will not be able to simply outmaneuver a highly accurate, high-energy laser beam traveling at the speed of light," Klunder said. Following the USS Ponce demonstration, the Navy says that it and the DoD will continue to research ways to integrate affordable laser weapons into its fleet.

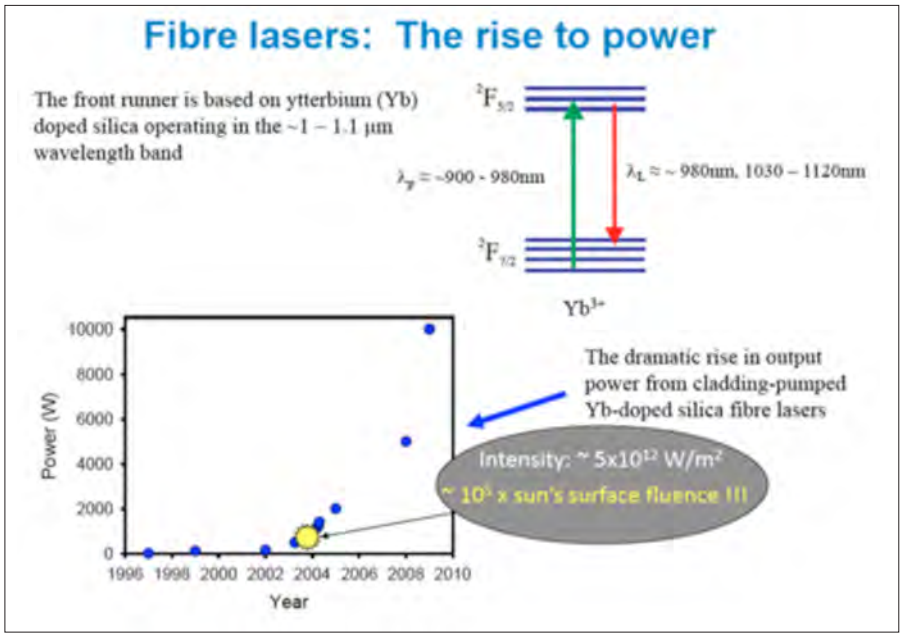
Article by Mike Hatcher

Fiber lasers 'perfect' for directed energy systems

Military-focused directed energy conference learns of potential of higher power fiber sources.

The tenth annual Directed Energy Systems conference, organized by Defence IQ and held in London earlier this month, heard almost two dozen presentations on all of the key areas in the development of DES.

Defence IQ said of this year's event, "Directed Energy Systems has continued to build and expand upon the key issue of moving DE technology out from the laboratory and into the field, for both lethal and non-lethal systems."



Fiber lasers based on Yb-doped silica based around 1µm have seen their powers rocket.

Speakers came from a wide range of academic, strategic, military and technological sectors. One of the notable academic presentations focused on the growing importance of fiber lasers for DES by Prof. Andy Clarkson from the Optoelectronics Research Centre at the University of Southampton, UK, who was presenting on behalf of an unavailable Prof. Sir David Payne.

Clarkson described fiber lasers as the "perfect building block" for directed energy systems – as they are electrically powered, efficient, modular, reliable with their civilian technology backbone. He said, "Power levels for narrow-line width fiber MOPAs (master oscillator power amplifiers) are currently around a few kilowatts. With the development of new rare earth doped fibers, such as those with ytterbium and holmium, fiber lasers have the potential to scale to higher powers."

He told the conference that even in relatively recent years fiber lasers had not been considered as suitable sources for directed energy systems because their outputs had not been great enough. However as kilowatt developments by the likes of IPG Photonics have led to fiber lasers starting to deliver multi-kilowatt outputs, these sources were creating a stir because of their ease of construction, economy and increasing power conversion efficiency.

"In the past decade alone, cladding-pumped fiber lasers based on ytterbium-doped silica operating in the 1.0 to 1.1µm wavelength have seen their powers grow from a few watts towards 10kW and beyond, delivering energy intensities well above 5x1012 W/m2.

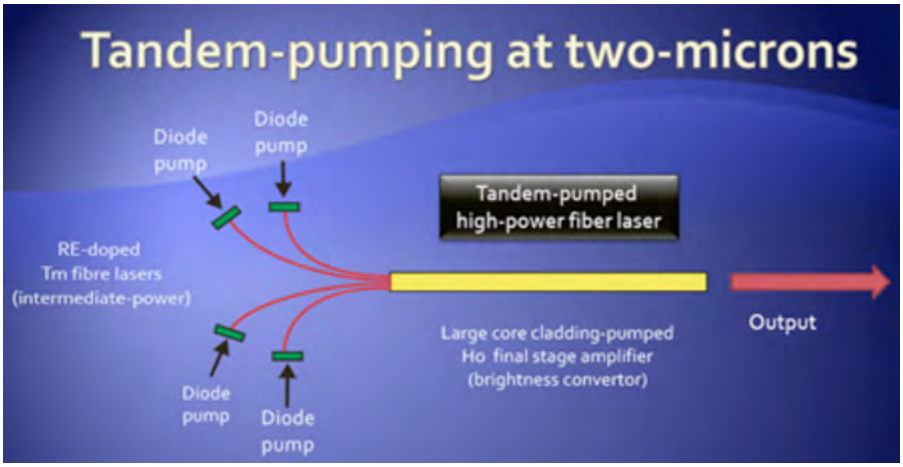
Such lasers have initially found many applications in materials processing including the fabrication of medical stents and the production of laser-treated turbine blades.

Clarkson acknowledged that there were several problems and power limitations around fiber lasers, especially in relation to scaling up their powers significantly beyond 10kW. "Their typical long and thin design gives the following problems: a high core intensity, which can cause damage, and leads to nonlinear limitations for pulsed applications, and a likely 30kW peak power limitation. Scaling to very high powers with narrow linewidth can be very challenging."

However, various developers are working on different designs of beam combination to raise the overall power, including techniques such as: incoherent beam combining and spatial beam combining, which can increase power, but not brightness; wavelength beam combining; or coherent beam combining, all of which create significant thermal challenges.

An alternative strategy is to use "slightly multimode" fibers or a technique called tandem pumping, in which multiple diode pumps feed into a large core cladding-pumped ytterbium final stage amplifier (brightness convertor), which is a route to 10kW output.

Looking to the future and addressing several questions from conference delegates about the potential for ever higher power fiber lasers, Clarkson concluded, "Further power scaling of ytterbium lasers is likely to be challenging as we approach the fundamental limits of that technology and design. However, 2µm fiber lasers based on thulium and holmium look very promising as they offer further power scaling potential and operation in the 'eyesafe' wavelength regime."



Graphic: ORC

One strategy to boost fiber laser output is called tandem pumping, in which multiple diode pumps feed into a large core cladding-pumped ytterbium final stage amplifier.

Directed energy experts consider route to acceptance

The DE systems conference in London discussed the need for education to promote wider appreciation of laser weapons.

As the US Navy announces that a high-power solid-state laser is set to be deployed on aboard the USS Ponce next year, the debate over directed energy weapons and systems continues apace.

Last month, the tenth annual Directed Energy Systems (DES) conference, organized by Defence IQ and held in London, heard almost two dozen presentations on all of the key areas around the development of DES. Representatives from the military, academia and several commercial players agreed that in many cases the court is still out on approving laser-based weapons, although there are increasing signs that defensive and civilian deployments of directed energy systems are growing.

As with the previous year's conference (also attended by optics.org), the hot ticket was the concluding panel discussion, which involved a variety of voices from the directed energy systems community.

The theme this year was "Next steps - Moving DES from the Drawing Board to the Operational Field". The key speakers were: Col. Tracy Taffola (US Marine Corps Director, Joint Non-Lethal Weapons Directorate), Elizabeth Quintana (Senior Research Fellow, Air Power and Technology, of the Royal United Services Institute, UK), Dr Märten Risling, (Experimental Traumatology Unit, Karolinska Institutet, Stockholm, Sweden), and Dr Michael Cathcart, (Senior Research Scientist and Chief, Remote Sensing group, Georgia Tech Research Institute, Atlanta, GA).

The panel had to consider four key questions – all relating to the deployment of directed energy systems in military applications and what changes in government policy and in the understanding of wider society would be necessary for such changes to be effected and acceptable. In the following report, optics.org provides selected comments on the various questions under consideration.

Q1: Given the lack of deployment of the Active Denial system in Afghanistan what possibilities do we have for changing the mindset of policy makers on Directed Energy?

Tracy Tafolla: There have been a number of requests for active denial DES technology from division, brigade and battalion level – so that it could be deployed at these levels. One of the challenges that we face is misperception of what DE systems are – for example, upper echelon staff not having the information that they probably should have and speaking out about their personal feelings rather than the science and what we know about these systems.

In our recent Joint Non-Lethal Weapons Directorate annual report we go into some of the DES myths and we have done some myth-busting. We have had to do that because just as important as telling the story of what directed energy is, we have to tell people what it is not. That is a critical element that we're all going to have to face if we want to move forward.

There is a desire for these kinds of systems and the advanced technology and capabilities that they bring. However, I don't know of any country right now that has an over-arching policy set endorsed by its political leadership and understood by the general public such that a commander feels that he's not going to be the first one out of the gate and then not be fully supported if he deploys a DE system and wondering he's going to face some sort of international tribunal.

Michael Cathcart: I will follow up the Colonel's comments and echo with the same kind of issues that we have seen at Georgia Tech. One of the things that we have been asked to develop are the associated educational aspects.

The idea was that in a post-accepting directed energy weapons world, we might be working with a system that is not known to the wider community, so the idea of our work is to provide an educational policy for the period from high school through to military service academies.

We use DE systems all the time – as rangefinders designators, but when you star putting a name to things and associating them with lethal injury, pain and so on is when you start bringing up the weapons-related issues and arguments. Currently there are still no senior personnel out there who are able to take that first decision. Who will be the first person to take that risk and push that button?

TT: There is an effort by combatant commanders and the services to force the Office for Security Cooperation's hand into providing guidance on DE weapons. Nobody wants to be sinking a lot of money into R&D programs if we are not going to be allowed to use them. Each country is going to be different. As we sit around the table in some of the NATO working groups in which I have been working with, I got the same feeling – that there is not great policy established anywhere on DESs. We are going to have to consider that at some point in time.

Question from floor: Is there greater acceptability for civilian deployment of DES than for military deployment?

MC: I believe that if that this technology can be seen in a law enforcement role initially then the public will see that beneficial potential more than they will with a military application.

Considering the jail trial (a millimeter wave crowd management prototype in a jail in Los Angeles) the politicians in LA got around making a decision on permitting the DE system by not issuing the radio frequency license. This avoided having to consider whether the anti-personnel millimeter wave technology was acceptable or not. But I think as people get familiar with the technology then they will like it a lot better – look at what has happened with cell phone acceptability after initial consumer concern about handset radiation.

Q2: What considerations and qualifications for human safety are needed in order togein general support for DEWs? and
Q3: How can we promote the work and possibilities of Directed Energy on a larger more public scale?

MC: One of the issues that Colonel Tafolla raised earlier is that it seems to be OK for a conventional weapon to blow someone's arm off but if you use a laser an blind someone then that is somehow more egregious.

Elizabeth Quintana: I think it depends who you are asking. There have been a lot of discussions about the use of unmanned vehicles in theater: why you want a robot coming through your house? Well I would rather have a robot coming through my house than a bunch of 18 year olds who are armed to the teeth and who are afraid that somebody will jump out on them, who will shoot the first person that twitches.

Generally, armies are professional and all that but at the same time doing a house search is a high adrenalin activity. I think people think about things as if it were happening to them and we are living in a free and open society and not a war zone. It's a very different situation and you might consider things in a very different way. The Afghan people might see things in a very different way to the way that we in the West do.

Any new weapons system, these days, is going to come under a lot of public scrutiny. Because we have the Internet and everybody is very happy to share information and, of course, there will always be people who put out scare stories. But it's true that you have to have consistent messaging, why it's important, why you might need to use these systems.

I thought the CSBA [US Center for Strategic and Budgetary Assessments] report in 2012 into Directed Energy Weapons, was very interesting – describing using a third-party as a way of getting the messaging out, on why governments might need to continue to invest in such systems. So I think promoting DES is going to be a constant messaging issue.

Märten Risling: You probably cannot convince all the people that it's safe to use RF systems because they are not visible. Many people have fear of radiation and microwaves. But if you take cell phones as an example of acceptable radiation, nowadays, the general public are not very concerned about these.

Then there is the issue of political leadership. For example, we had discussions in Sweden a few years ago about the use of tasers by law enforcement. The police really wanted to have them because they were not happy with the lethal firearms alternative, which they have to use a few times every year with maybe one lethal incident per year.

But the political leadership always hesitates when this issue comes up. There might be two components: if they make the decision to accept such technology then they will be scrutinized by the newspapers and media every time there is a misuse or problem with the system – with a focus on the politician who introduced it. Then the second considering is financial. So there's a complex problem to gain acceptability.

TT: We do so much work on potential human effects of DE weapons – to the point that it's almost more acceptable to shoot someone with a conventional lethal system than with a non-lethal system. We're always having to explain that battle.

There are other issues around DESs such as magazine capacity, and not having to resupply ordnance. So logistics footprint doesn't have to be the issue. We come to these forums and most people are supportive of the developments associated with DE weapons. But overall, it's going to require an education process that will go beyond the DES community.

EQ: I think the way that one looks at the way the nature of war has progressed even from Kosovo (1998-1999) to Libya (2011) – and consider the kind of targets that the military are looking at. In Kosovo, it was quite acceptable to hit power stations and bridges and similar constructions that were supporting the government. But in Libya such targets absolutely were not acceptable and these kind of DE systems – and cyber-warfare – are very popular because you can create effects without causing collateral damage. For the politicians it's actually quite an easy win provided that you can prove that you can create the military effect that they need.

Whether there's any longer-term damage, that needs to be managed, but, again, for a politician who wants to intervene, having a non-lethal weapon – and not dropping a conventional bomb – is quite attractive. Although it's more difficult on the laser side. Politicians are living under the glare of 24-hour news media so, in some ways, the use of DE technologies is very attractive – providing it's proportionate.

***Ret'd Admiral Massimo Annati** (from the floor):* I think we should differentiate our position if we are talking about equipment for riot control or that for conflict situations. It's certainly better to disable the power distribution in a country without having to physically destroy a power station. It's better to have a ship blacked out in the harbor than to sink it.

But in a riot control situation the difference is the need to spray people with irritant or hydrant rather than deploying a weapon that could cause them permanent damage.

So for systems that are an alternative to lethal weapons, yes, I think that everybody should support that approach but for riot control equipment – for police-like equipment there is a long way to go because there is more concern about its use than support.

Q4: Are we likely to find more success with non-lethal DE systems than with lethal?

MC: As you have heard at this conference, counter-RAM (C-RAM, counter-rocket, artillery, and mortar) by directed energy systems has so far been sort of successful. At the same time you heard from Col Tafolla's talk and others that the non-lethal side has some immediate applications but also that the military is looking for more success and wider acceptability.

TT: I think we can see success on both sides. Luckily for us, in most cases we don't require the same kinds of power (as does C-RAM). But we are still facing the same kinds of issues, whether it's thermal management of laser systems, or getting our propagating our signal out over the necessary range. With non-lethal developments, we face some added burdens that the lethal side doesn't have to face.

The problem can be likened to the old Star Trek question of whether you can set the phasers on stun or on full power. Whether you have a full spectrum system that you can range up and engage with something and have either a non-lethal effect or crank the power up and blow a hole right through a target.

Every military individual that I know out there will tell you that's what they want to have – a DE system that you can scale up rather than needing to carry a whole bunch of systems. We're not there yet certainly, but I think that we're going to find success with both [lethal and non-lethal], especially some of the laser systems and some of the higher power microwave systems that are coming on stream. It's just a matter of applying our resources as best we can.

But in the case of when I have choice of putting lead across the bow of a ship and causing death or using a non-lethal approach and causing damage, given that choice, most captains will take a non-lethal approach whether it be microwave or laser. One is not in competition with another.

Article by Matthew Peach

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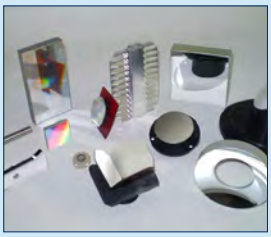

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