



## product focus

According to a report by an influential think tank the US Department of Defence 'needs to get serious' about laser weapons. Read the latest report in the **optics.org DSS Product Focus** along with articles on the replacement faulty IR detectors for the James Webb telescope, Canada's Chinook laser protection and how the UK Ministry of Defence is inviting proposals for laser directed energy weapons. Along with a round-up of some of the latest products available at the show. We have included booth numbers (*where available*) so you can visit booths and view products for yourself.

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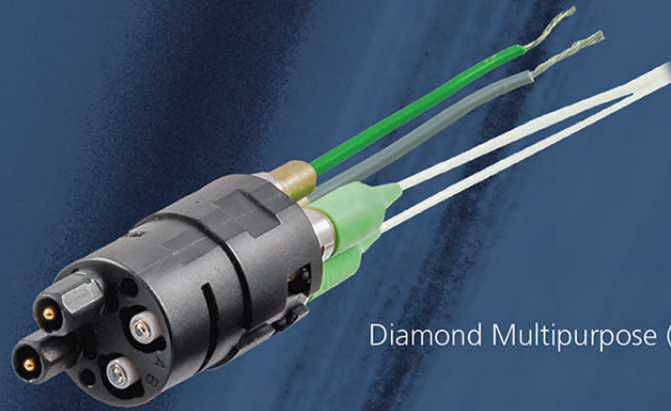


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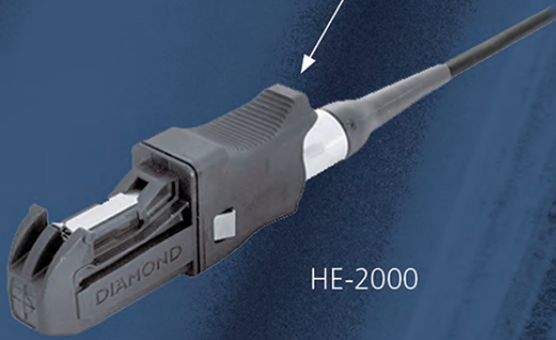
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# US 'must get serious' about laser weapons

Report from influential US think-tank calls for a more cohesive approach to development and deployment of directed-energy technologies.

The US Department of Defense (DOD) must change its approach to the development of laser weapons, if the technology is to live up to its promise as a game-changer for the country's military.

That's according to a report just published by the Center for a New American Security (CNAS) think-tank, which is urging a more cohesive strategic program to develop and deploy lasers and other directed-energy (DE) weapons, rather than the current and more disparate project-led approach.

Written by the Lawrence Livermore National Laboratory's deputy program director for defense, Jason D. Ellis, a policy

## Technological "orphan"

"The DE weapons area is a technological orphan – influenced by many and owned by none," writes Ellis, whose first recommendation is for the DOD to develop and communicate a department-wide strategic plan for DE weapons development.

He says that the US secretary of defense should identify and empower a champion within the DOD who can also be held accountable for DE weapons development. "Today, the department has lost a cohesive focus in the DE area," Ellis writes, noting that the DOD's current research and engineering strategy does not emphasize DE weapons.



Photo: CNAS

Jason D. Ellis, the LLNL deputy program director for defense who authored the CNAS report on laser and other directed-energy weapons.

Ponce, the Navy is more advanced in terms of real-world experience of a laser weapon.

"Ultimately, for DE weapons to become serious candidates for the department's new offset strategy, DOD must become serious about their development," states Ellis in the report's conclusions. "[The] DOD has made substantial technical advancements in both high-power microwaves and high-energy lasers over the past several years, and the state-of-the-art would arguably permit accelerated development options in key areas."

"But on their current course, existing and anticipated developmental activities for the full range of enabling and component technologies will not likely lead to fielded, operationally relevant DE weapon systems for the next several years," he adds.

## Increase laser weapon spending

Part of the answer is simply to spend more on the development of the technology. Ellis calculates that, out of a total DOD research, development and test budget of \$63 billion in 2014, just \$405 million (or 0.6 per cent) was allocated to DE weapons.

When adjusted for inflation, that spend has declined nearly two-thirds from the 2007 figure, when major projects including the Airborne Laser were still being funded.

The ultimate scrapping of the Boeing-led Airborne Laser project, whose megawatt-scale chemical source relied on bulky and toxic materials, means that laser weapons are perceived by many as a colossal waste of money.

However, the class of weapons now under development is generally based around much more practical solid-state sources

*continued on page 4*



U.S. Navy photo by John F. Williams/Released.

The Laser Weapon System (LaWS), shown deployed on board the USS Ponce ship while it was in the Arabian Gulf in late 2014.

expert currently on leave at CNAS, the report makes a series of recommendations, including the call for a DOD "champion" to lead development of the technology.

Though small and only eight years old, CNAS is believed to have a growing influence in Washington, DC, and appears to have close links to President Obama's current administration. Its two founders have both served in government posts, while Hilary Clinton was among the speakers at its June 2007 launch event.

"While there is clear benefit in joint technology developments, a joint program office could potentially play a stronger role in driving focused programmatic outcomes in the context of identified time and budget constraints."

Ellis points out that while the US Navy has centralized responsibility for DE weapons to a single office, other services do not have such a clear center of gravity – perhaps because through the recent deployment of a 33 kilowatt laser gun aboard the USS

## US 'must get serious' about laser weapons

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that can be combined in different ways to deliver the power needed to disable or destroy targets. Despite the perception that lasers have always promised more to the military than they have delivered, Ellis believes that a substantial rise in developmental spending is now justified.

"If [the] DOD is to field operationally meaningful DE weapons, it should increase spending by two to three times for high-energy lasers," he says, adding that the department should both look to deploy existing laser technologies for near-term applications like drone destruction, and invest in the longer-term development of much more powerful sources to be used against higher-end threats like ballistic and cruise missiles.

### HELLADS potential

Looking positively at the technology currently available, Ellis says that although it does not necessarily offer any "unique

warfighting capability" just yet, there may still be some near-term opportunities to demonstrate the usefulness of laser and other DE weapons in the field.

He identifies the 33 kW fiber laser system tested by the USS Ponce and the 150 kW High-Energy Liquid Laser Area Defense System (HELLADS) being developed by the US Air Force and DARPA as two of the best near-term options, and adds that recent research by a team at the Lincoln Laboratory supports the idea that wavelength combining could be used to scale laser powers well beyond the 100 kW level, and towards the megawatt-class systems previously envisaged with chemical lasers.

"Based on the Navy's reportedly promising November 2014 Persian Gulf tests, the 33-kilowatt system establishes a reasonable foundation to proceed with development of a scaled-up 100-150 kW (or higher) system," Ellis writes.

"Rear Admiral Matthew Klunder, former chief of naval research, has argued that such a system could provide high-value counter-drone, counter-boat and combat identification capabilities."

"Once it has achieved this higher-power metric at acceptable beam quality, the Navy should consider limited-quantity procurement for operational deployment to a relevant operational theater."

Regards HELLADS, Ellis says that once the system demonstrates 150 kW output in the laboratory with an acceptable beam quality, it should be tested in an operationally relevant environment.

### "Get serious"

Ultimately, he says that the DOD needs to "become serious" about the development of laser weapons, if those weapons are to actually provide the US military with genuine superiority over its adversaries.

And while he adds that they should not be considered "silver bullets", Ellis says that laser weapons have finally demonstrated the kind of technical maturity that should see them integrated into naval, air and ground-force mission applications within the next decade.

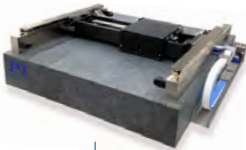
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Boeing completed its delivery of 15 specially adapted Chinook CH-147F helicopters to the Royal Canadian Air Force in mid-2014. The long-range helicopters are being fitted with laser countermeasure systems to protect from rocket attacks.

Photo: Boeing.

# Canada's new Chinooks get laser protection

Laser-based directional infrared countermeasure systems from Northrop Grumman designed to protect fleet from rocket attacks.

A new fleet of Chinook CH-147F helicopters flown by the Royal Canadian Air Force (RCAF) is to be fitted with the latest generation of laser countermeasures from defense giant Northrop Grumman.

The directional infrared countermeasures (DIRCM) system, developed with key partner Selex ES, uses a modulated laser to track and confuse heat-seeking missiles, sending them off their intended course.

Earlier generations of countermeasure systems have tended to be relatively bulky, and only suited to large, fixed-wing aircraft, but the development of smaller designs mean that helicopters and much smaller aircraft now use the technology.

For example, the most recent "Miysis" DIRCM technology developed by Selex ES features a multi-band laser and weighs

only 16 kg. It is designed for smaller types of helicopter and is even said to be suitable for some unmanned drones.

In its Miysis literature, Finmeccanica-owned Selex ES, which is headquartered in Edinburgh, Scotland, writes:

"One of the greatest threats to airborne platforms is that posed by Infrared Man Portable Air Defence Systems (IR MANPADS). These readily available missiles are inexpensive, highly portable and have been used lethally during the last 40 years in both military conflicts and by terrorist organizations.

"MANPADS have become increasingly resistant to standard countermeasure such as decoy flares and, as such, the most effective defence from MANPADS is to directly attack them with a high-power,

multi-band laser DIRCM system. Modern MANPADS can engage low-signature threats from any aspect, meaning that DIRCM systems must now provide all-aspect protection."

Last year, Chinook maker Boeing said that it had completed delivery of the 15th and final CH-147F helicopter to the RCAF ahead of schedule. This particular version of the Chinook has been adapted with a new fuel system so that it can fly twice as far as normal, and cover the huge areas required by the Canadian authorities.

As well as its long-standing partnership with Selex ES, Northrop Grumman also has close ties with the California-based quantum cascade laser (QCL) technology specialist Daylight Solutions, having bought an equity stake in the company back in 2011.

The QCL-based approach is behind the development of common infrared countermeasures (CIRCM) systems that are even smaller and more versatile.

Other platforms in use include a range of options from Israel's Elbit Systems, some of which have been adopted recently by the German Air Force in its Airbus A400M military transport planes, and by an unspecified army in Asia to protect its Blackhawk helicopters.

<http://optics.org/news/6/3/42>

# Laser-based aircraft defense system approved for global sale

US Department of Defense green-lights BAE Systems' anti-missile protection system.

British multinational defence, security and aerospace company BAE Systems has announced that its Advanced Threat Infrared Countermeasures (ATIRCM) system has been approved for export by the US Department of Defense. The company commented, "This approval paves the way for sales to allied nations around the world, giving them access to this life-saving technology."

ATIRCM utilizes BAE Systems' Common Missile Warning System to detect an incoming missile and communicate the missile's position relative to the aircraft. ATIRCM then locates and tracks the incoming threat and emits a high-energy laser beam to defeat the missile's infrared seeker, effectively blinding its guidance system and preventing it from homing in on the aircraft.

Bill Staib, director of threat management solutions at BAE Systems, commented, "In today's environment with the proliferation of surface-to-air missiles, a proven aircraft survivability system to counter advanced threats meets an immediate need. We are seeing tremendous international interest for this system, which has proven to be both highly effective and reliable since its launch in 2009."

Developed in partnership with the US Army and currently deployed on military

helicopters, ATIRCM has proven to be highly effective in protecting both rotary and fixed wing aircraft. Deployed on mission critical US Army helicopters in Iraq and Afghanistan since 2009, the latest Army report states that ATIRCM's reliability surpasses the Army requirement "several times over".

## Military-relevant exports discussed at Photonics West

The topic of potential changes to US export restrictions on military or defence-related photonics technologies was considered, last month, at a roundtable discussion at SPIE's Photonics West 2015. The US Government requires all manufacturers, exporters, and brokers of defense articles, defense services or related technical data to be ITAR-compliant (International Traffic in Arms Regulations).

The meeting aimed to collect input on areas of concern. Both US and non-US organizations working with ITAR related issues participated. Industry representatives and others interested in the impact of the USML rule changes were invited to attend the roundtable, held in San Francisco on 10 February.

As event organiser, SPIE noted, "Publication of the proposed regulation for this category in the Federal Register is expected in



Graphic: BAE Systems.

ATIRCM uses BAE Systems' Common Missile Warning System to detect a missile.

early 2015, with an open community comment period to be announced in the Federal Register. Category XII is important not only to the military and industry, but also to research universities that accept Department of Defense funding and manage the unique challenge of complying with all categories of controls."

There are 10 Category XII subcommittees addressing technologies including: cryocoolers; image intensified tubes and cameras; EMCCD devices and cameras; lasers; optics; readout integrated circuits; SWIR FPAs and cameras; uncooled FPAs, camera cores, cameras, and systems; cooled cameras; guidance, navigation and gyros; and stabilized platforms/gimbals.

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# UK Ministry of Defence invites laser weapon proposals

Mid-April event to outline needs and discuss options with potential suppliers.

The British Ministry of Defence is planning the development of a prototype high-power laser directed energy weapon. An event to brief potential commercial developers is scheduled for 15 April in Portsmouth West, UK.

The meeting of potential suppliers for the development, called the Laser Directed Energy Weapon Capability Demonstrator, will be organized by the Defence Science and Technology Laboratory, which will be managing the estimated £100 million project.

A brief description of the likely project requirements reads, "In order to achieve its strategic aims within the constraints imposed in terms of budget and operating environment, the UK needs to invest in the emerging technologies either to exploit them or to establish their limitations.

"The potential of laser-based weapons systems has been identified as an opportunity and offers significant advantages in terms of running costs as well as providing a more appropriate response to the threats currently faced by UK armed forces.

"The aim of the Laser Directed Energy Weapon Capability Demonstrator is to enhance the UK's understanding of the capability of a laser based weapon system. The project will consist of system studies and hardware trials, culminating in a number of practical demonstrations.

In order to be considered for this potentially lucrative contract, interested parties' demonstrations will need to establish the following:

- The ability to detect, acquire and track targets at range and in varying weather conditions, with sufficient precision.
- The ability to generate and precisely control a high energy laser.
- The control of the irradiance of the laser.
- The ability to manage the power and cooling demands whilst enabling operation of the laser over extended period of time.



Photo: Lockheed Martin.

Lockheed Martin ATHENA laser weapon system destroys a truck target by disabling the engine from 1 mile away, demonstrating its military effectiveness against enemy ground vehicles.

- The control requirements and, in particular, managing the risks such that the lasers are safe to operate.

The contracting authority said it initially anticipates that a single contract will be awarded, but it also acknowledges that "a broad range of capabilities is required to meet this research requirement, so it is not expected that a single supplier would be able to fulfil this requirement in its entirety."

## Lockheed Martin laser firepower demo

The UK MOD's announcement coincided with defense and aerospace systems developer Lockheed Martin reporting the successful demonstration of its 30kW fiber laser weapon system disabling the engine of a small truck during a recent field test, illustrating the rapidly evolving precision capability of laser-based weapons.

Known as ATHENA, for Advanced Test High Energy Asset, LM's ground-based prototype system burned through the engine manifold in a matter of seconds from more than a mile away. The truck was mounted on a test platform with its engine and drive train running to simulate an operationally-relevant test scenario.

Keoki Jackson, chief technology officer, commented, "Fiber-optic lasers are

revolutionizing directed energy systems. We are investing in every component of the system – from the optics and beam control to the laser itself – to drive size, weight and power efficiencies. This test represents the next step to providing lightweight and rugged laser weapon systems for military aircraft, helicopters, ships and trucks."

The demonstration marked the first field testing of an integrated 30-kilowatt, single-mode fiber laser weapon system prototype. Through a technique called spectral beam combining, multiple fiber laser modules form a single, powerful, high-quality beam that provides greater efficiency and lethality than multiple individual 10kW lasers used in other systems.

ATHENA is based on the Area Defense Anti-Munitions (ADAM) laser weapon system developed by Lockheed Martin in Sunnyvale, California, which has been proven in demonstrations against small airborne and sea-based targets. It incorporates the 30-kilowatt Accelerated Laser Demonstration Initiative (ALADIN) fiber laser developed by the company in Bothell, Washington.

<http://optics.org/news/6/3/21>



# Elbit to provide Blackhawk countermeasures

Asian Army selects Israeli arms firm's 'mini MUSIC' infrared system to protect its Blackhawk helicopters.

The electro-optics division of the Israel-based defense company Elbit Systems has won a contract to supply its "mini MUSIC" infrared countermeasures system to protect helicopters flown by an unspecified Asian country's army.

The system, which is based around fiber laser technology, will be used on board Blackhawk helicopters – which Elbit says is a new application for the technology.

Adi Dar, general manager of Elbit's "Electro-optics-Elop" subsidiary, said: "In addition to being selected by a new customer, this award represents the inclusion of a new platform, the Blackhawk, to the broad portfolio of platforms already equipped with our unique DIRCM systems including our MUSIC version for small platforms such as helicopters."

Among the existing users of Elbit's various "MUSIC" family of directed IR



Credit: Sikorsky

*Black Hawk protection: Elbit's most compact and lightweight infrared countermeasure system is based around a fiber laser.*

countermeasure (DIRCM) systems – designed to protect aircraft from ground-launched heat-seeking missiles - are a variety of Israeli commercial aircraft, as well the Italian and Brazilian air forces.

The German Air Force was also revealed to be a customer last November, and is using the multispectral "J-MUSIC" DIRCM system

on board its Airbus A400 military transport planes.

Elbit says that the "mini" version is the newest of the various MUSIC systems. "These operationally proven systems integrate advanced fiber laser technology with an accurate, high rate thermal tracker and a small, highly dynamic mirror turret to provide effective, reliable and affordable protection to all types of aircraft, under all operational conditions," states the firm.

Features include a sealed mirror gimbal for high reliability, a thermal camera for accurate acquisition and tracking, and a hyper-hemispherical dome for maximum coverage.

Designed for use on smaller aircraft, it weighs only 19 kilos and boasts a power consumption of less than a kilowatt.

<http://optics.org/news/6/1/26>

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# IR detectors replaced on James Webb telescope

**Design flaws in original equipment see replacement of near-infrared detectors in three JWST instruments.**

Infrared detectors in three scientific instruments used by the James Webb Space Telescope (JWST) have been replaced, after the original sensors were found to have a design flaw.

According to a release from the European Space Agency (ESA), which is collaborating with NASA and the Canadian Space Agency on the giant project, new detectors have now been installed in all three instruments.



Photo: NASA.

*A detector from the NIRSpec Engineering Design Unit (EDU). The first generation of JWST's highly sensitive near-infrared detectors were found to suffer from a design flaw that resulted in a progressive degradation of their performance, according to ESA. They have now been replaced.*

One of those is the ESA's "NIRSpec" instrument, a spectrograph featuring two mercury cadmium telluride (HgCdTe) sensor arrays that are expected to provide unprecedented information about the chemical composition and age of distant stars and galaxies.

According to NASA, NIRSpec's detectors will support medium-resolution

spectroscopy over a wavelength range of 1-5 $\mu$ m, and lower-resolution spectroscopy down to wavelength of 600nm. The instrument also employs a MEMS-based microshutter array for aperture control, which has also encountered problems in testing.

Pierre Ferruit, ESA's JWST project scientist, said in a statement from the agency: "Excellent detectors are crucial to the outstanding instrument performance needed when you want to look at the extremely distant and faint early stars and galaxies that formed when our universe was still young, and the new detectors secure this top priority."

## Microshutters replaced

The HgCdTe detectors are not the only components being replaced after the recent battery of equipment tests ahead of JWST's much-anticipated launch, now expected to take place in 2018.

One of the NIRSpec instrument's key attributes is its ability to analyze light from more than 100 different astronomical objects simultaneously, over a 9-square-arcminute field of view. That will give JWST a unique capability for a space telescope, and to do it requires thousands of microshutters, arranged into four different arrays.

The arrays comprise thousands of tiny windows that can be opened and closed individually so that only the light from each particular object of interest is allowed onto the NIRSpec detectors.

But after simulations that reproduced the kind of noise and vibration likely to be experienced on the launch pad took place in 2012, several thousand of NIRSpec's



Credit: NASA.

*Ralf Maurer, JWST NIRSpec Project Manager, discussing the (NIRSpec) instrument on NASA's NIRSpec video "100 points of light: Behind the Webb".*

microshutters were found to be jammed in the closed position.

To replace the faulty microshutters, ESA says that it had to open the instrument's outer cover, something that had to be done under strict cleanliness conditions to avoid contamination. Maurice te Plate, its system integration and test manager for JWST, said:

"In particular, the microshutters are very sensitive to material such as small polyester fibers that can get stuck inside and prevent them from fully closing. We just completed our final checks and we are now ready to install NIRSpec back in to the module."

NIRSpec was built at the EADS Astrium facility in Munich, Germany, over the course of nearly a decade, and was delivered to NASA's Goddard Space Flight Center in September 2013. Peter Jensen, ESA's JWST project manager, said of the latest developments:

"NIRSpec is in its final flight configuration. We have now completed the endeavor we started eleven years ago – it has not been easy, but through skill, persistence, and dedication, the team has made it."

<http://optics.org/news/6/2/35>



# Frequency comb gets infrared extension

Research team including Nobel winner Ted Hänsch raises possibility of chip-scale sensors extending through the mid-IR region.

A collaboration of scientists from Europe and New Zealand have used a silicon waveguide to extend the range of a frequency comb deep into the infrared spectrum – suggesting that the approach could lead to future chip-scale molecular detectors operating across the mid-IR “fingerprint” region.

across virtually the entire mid-IR range, and theoretically able to detect almost any molecular substance.

In the paper, Hänsch and his collaborators write: “By using waveguide designs where the buried oxide is removed, the entire silicon transparency window (up to 8,500 nm) could be covered.”

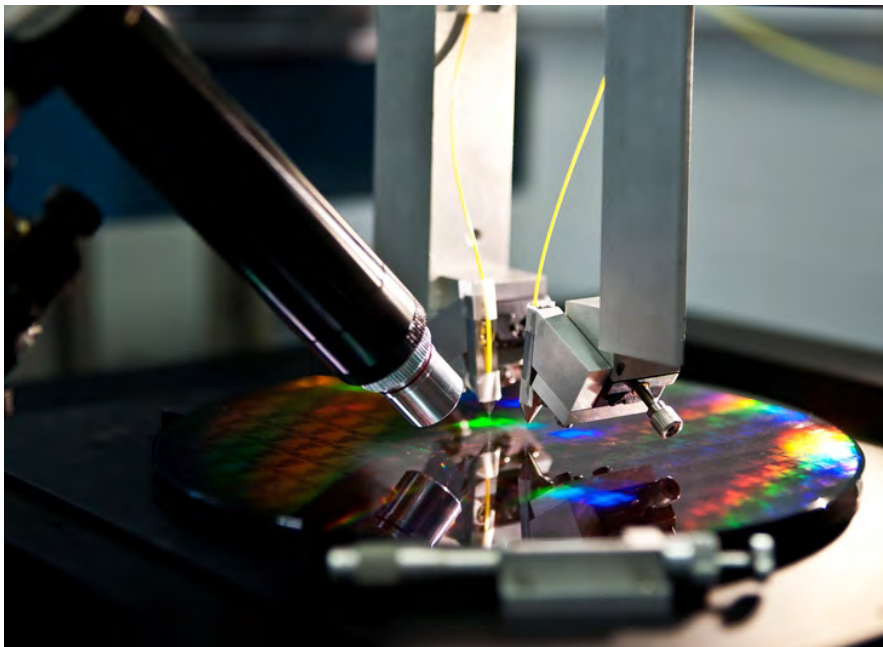


Photo: IMEC

*Silicon photonics under test at IMEC. Strong light-matter interaction in a broadly transparent silicon nanowire waveguide is central to extending the wavelength range of an OPO-pumped frequency comb into the mid-infrared spectrum.*

The research team, which includes Ted Hänsch – co-winner of the 2005 physics Nobel for his early work on frequency combs – has so far demonstrated octave-spanning operation from around 1500 nm to 3300 nm.

But in a paper that they have just published in the journal *Nature Communications*, they say that by altering the design of the silicon nanowire waveguide they could extend the wavelength range to 8500 nm.

That would open up the possibility of building cheap and compact high-resolution spectroscopic sensors operating

And although the current experiment relies on a bulky light source – an optical parametric oscillator (OPO) pumped by a Ti:sapphire laser – in the future that could be replaced with quantum cascade lasers or microresonators in a far more compact design. Thulium-doped fiber laser offer another way to generate the required supercontinuum source.

“Our work would then represent an essential building block paving the road for an octave-spanning frequency comb entirely generated on a chip,” the team suggests.

## ERC grant funding

As well as Hänsch and his colleagues at the Max-Planck Institute for Quantum Optics in Garching, near Munich in Germany, the team includes collaborators at IMEC and Ghent University in Belgium, CNRS in France, and the University of Auckland in New Zealand.

They have been working together thanks to grants from the European Research Council for three related projects, called “Multicomb”, “Miracle”, and “InSpectra”.

Of those, the five-year “Miracle” and “InSpectra” efforts, both co-ordinated by Ghent’s photonics research group, run until December this year, while the Hänsch-led “Multicomb” is funded through August 2016.

According to IMEC, one of the critical parts of the latest work was to fabricate a nanowire silicon waveguide that confines the pump light from the OPO into a tiny space. Strong light-matter interaction in the silicon waveguide, plus the material’s broad infrared transparency, produce the octave-spanning comb.

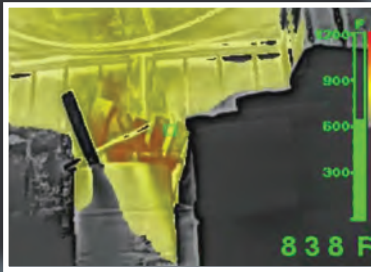
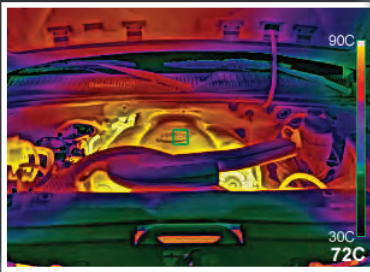
The key element – a 10 mm-long air-clad photonic wire – was made on a CMOS pilot line on a silicon-on-insulator wafer, with the device built on top of a buried oxide layer.

The absorption of that buried oxide layer limits the long-wavelength end of the transparency window to around 4000 nm. But by using a waveguide design where the buried oxide layer is removed, potentially the entire silicon transparency window – up to 8500 nm – could be accessed.

“The results are an important step towards a small-footprint chip scale mid-infrared frequency comb source,” reckons IMEC. “Such sources could act as sensitive cheap gas sensors in the mid-infrared. These would be important for example for environmental monitoring for measuring air pollution, or in medical diagnostics as a cheap tool for breath analysis.”

<http://optics.org/news/6/3/18>

[ picture this ]



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