SECURITY

Network of Virtual Eyes in the Sky and on the Ground Secure the 2004 Olympic Games

With wars in Iraq and Afghanistan, and terrorist attacks in Russia and the Middle East, security was on everyone's mind at the 2004 Summer Olympic Games (Athens, Greece), resulting in a record security budget exceeding $1.5 billion, with much of it spent on optical security hardware and training. Science Applications International Corporation (SAIC; San Diego, CA) won the $312 million large-scale Athens security project for the 2004 games in competition against defense giants such as Lockheed Martin (Sunnyvale, CA) and a joint U.S.-French bid from Thales (Neuilly sur Seine, France) and Raytheon (Waltham, MA). SAIC provided much of the security infrastructure for the 2004 games, installing a computerized surveillance and screening system for 600 Olympic sites around Athens and training some 90,000 people.

The surveillance/security system gathered images and audio from an electronic web of more than 1000 high-resolution and IR cameras, 12 patrol boats, 4000 vehicles, nine helicopters, a sensor-laden blimp, and four mobile command centers. The system, which included components already used by U.S. and British government intelligence agencies, covered all of greater Athens, nine ports, airports, and all other Olympic cities. SAIC drew upon the expertise of several other key optical and electronic security companies as part of its consortium, including Siemens AG (Munich, Germany), General Dynamics Corp. (Falls Church, VA), Honeywell International Inc. (Morristown, NJ), Elbit Systems (Haifa, Israel), and several others. The original contract specified a 28 May delivery date, but due to construction delays, it was delivered just weeks before the opening ceremony.

As part of the surveillance package, SAIC turned to Airship Management Services (AMS; Greenwich, CT) to supply an airship equipped with the latest high-tech surveillance devices for a counterterrorism initiative at the Olympic Games. AMS appointed QinetiQ (Hampshire, UK), formerly part of the United Kingdom's Defense Research and Evaluation Agency, which recently was partially privatized, to equip its airship with surveillance equipment for Athens. Patrolling the skies at an altitude of 3900 to 12,000 ft. for 16 hours a day, the high-tech blimp was equipped with chemical detectors and L-3 Wescam's (Burlington, Ontario, Canada) high-resolution MX-15 cameras.

Providing ultra-high stabilization and image resolution in a highly compact size for unmanned aerial vehicle operations, the MX-15 imaging turret can contain up to six sensors, a 640 × 512 third-generation indium antimonide forward-looking IR detector with a high-magnification four-step zoom, a color CCD daylight zoom camera, a color CCD spotter camera, a day-and-night camera with spotter, a laser illuminator, and a laser designator (see figure). The MX-15's large aperture/high-resolution optics and less than 10 micro-radian stabilization enable precision long-range standoff target recognition and identification. The MX-15, in any configuration, comes equipped with an onboard inertial measurement unit, which incorporates solid-state fiber optic gyro technology for high sensitivity and reliability, and makes tracking easy by enabling the turret to follow the subject with hands-free simplicity, locking all sensors on a precise latitude/longitude position and aiming the turret at that fixed point regardless of aircraft movement or obstructions within the line of sight. —*Phillip Espinasse*

GEORGE SPYROU, AMS

These two AMS airships are equipped with MX-15 cameras, which were used in the 2004 Summer Olympic Games security operations.

LASER PHYSICS

Scientists Measure Oscillations in Visible Light Pulses

Researchers in Germany say they have measured the electrical field of visible light for the first time, an achievement that could eventually lead to new tools for high-energy physics.

Ferenc Krausz reported the work in the 27 August issue of *Science* magazine. Along with colleagues from the Max Planck Institute for Quantum Optics (Garching, Germany), Bielefeld University (Bielefeld, Germany), and the Vienna University of Technology (Vienna, Austria), he shot electrons at a pulse of 750-nm laser light and measured how the light affected the electrons.

The electromagnetic field of visible light varies at a rate of 10^{15} oscillations each second; no instrument exists to measure field fluctations with that temporal accuracy. To measure changes that take place in about a femtosecond, they needed something they could characterize in attoseconds, an order of magnitude lower than existing systems.

The team uses tightly controlled 250-as pulses in the extreme-UV (EUV) to soft-x-ray range of the spectrum. The EUV pulse knocks electrons off atoms of neon gas, and the team scans those electrons across the visible laser pulse. As the electrical field of the light pulse oscillates, it changes the energy level of the electrons, speeding them up or slowing them down. The researchers measure the changes with an electron spectrometer and use that measurement to get a picture of how the electrical field is changing.

"In principle it's quite simple," says Krausz. "Electrons that are set free get a kick from the laser field."

The system works, says Eleftherios Goulielmakis of the Max Planck Institute, because the electrons come in pulses of 250 as, while the electric field oscillates at 2.5 fs.

"This experiment provides, for the first time, a direct access to the exact value of the electric field of ultrashort laser waveforms and opens the way for further studies and control of atomic and molecular processes," Goulielmakis says.

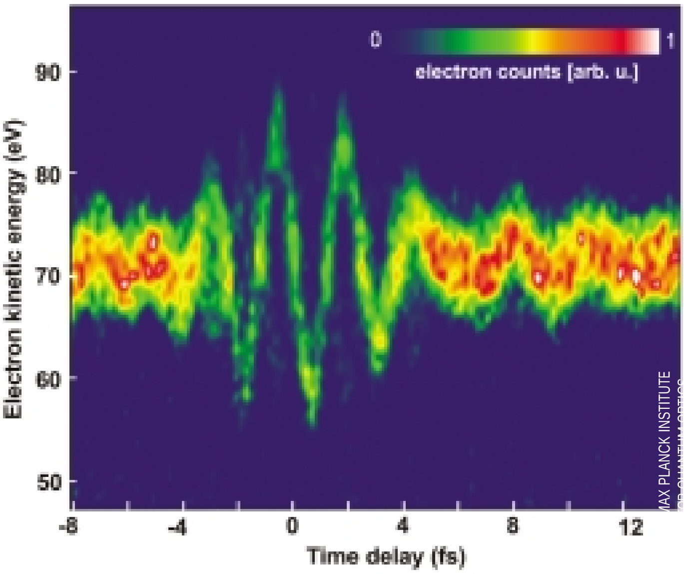
Key to the whole setup is the ability to produce laser pulses with exactly the same waveform from one pulse to the next, Krausz says. The team achieved that last year, and earlier this year showed it was able to control and characterize the 250-as EUV pulse (see ***oe**magazine*, May 2004, p. 18).

"This maybe becomes important for any applications in which you have to know how the field values evolve with time," Krausz says.

Eventually, this work could lead to the development of laser-based particle accelerators for studying high-energy physics, he says. Synchrotron-based accelerators have to be kilometers long and cost hundreds of millions of dollars to build. In principle, Krausz says, a laser-based accelerator would only have to be a few tens of meters long, and thus cheaper and less complex, but it would also have to be very precise in how much energy it imparts to particles.

"People are working on laser accelerators already now, but they are unable to produce particles with very well-defined energy," he says.

The work will also allow researchers to see how electrons move around in an excited atom. Krausz says this could yield insight into the physical processes at work, much the way chemists learn things by watching how atoms move within molecules, but at a finer resolution. If scientists can learn about how atoms emit x-ray photons as they relax back to their ground state, that might let them develop compact x-ray lasers, for instance, Krausz says. —*Neil Savage*



The kinetic energy of electrons varies up or down depending on the time at which they interact with the oscillating electrical field of the light pulse.

LIGHT AMPLIFIERS

Cr^{4+}-Doped Glass-Ceramics Could Lead to Ultra-Broadband Amplifiers for Telecom

A chromium (Cr^{4+})-doped transparent glass-ceramic developed by researchers at Kyoto University (Kyoto, Japan) could lead to a new class of ultra-broad amplifiers for wavelength division multiplexing (WDM) applications.

Although the gain bandwidth of rare-earth-doped amplifiers is usually significantly less than 100 nm in near IR, depending on the host material, 3d-transition metal ions exhibit broadband emission in this area of the spectrum. Solid-state lasers such as alexandrite (Cr^{3+}) and titanium-doped sapphire are widely tunable between 1.1 and 1.6 µm. This means that if Cr^{4+} can be stabilized in a host material, activated material would be an excellent candidate for a new broadband amplifier for WDM.

"Tunable laser operations have been achieved in crystals such as Cr^{4+}:YAG [Cr^{4+}:yttrium aluminum garnet] and Cr^{4+}:forsterite, but for light amplifiers, glass hosts are most favorable because they can easily be processed into fibers," says Setsuhisa Tanabe, spokesman for the Kyoto group. "Unfortunately, the luminescence efficiencies of Cr^{4+} in glass are much lower than in crystals. So we focused on gehlenite [$Ca_2Al_2SiO_7$], in which Cr^{4+} can be stabilized. Cr^{4+} in gehlenite shows a broadband luminescence between 1.1 µm and 1.4 µm, centering at 1.24 µm," explains Tanabe.

The team prepared a bulk glass of $50CaO$-$40Al_2O_3$-$10SiO_3$-$0.05Cr_2O_3$ composition as the starting material. The glass was melted in a platinum crucible in air at 1873K for one hour, annealed, and then cut into 10 × 10 × 3-mm samples. These were heat treated in two steps. The first step caused homogenous nucleation, while the second grew crystallites. Tanabe divided the samples into three batches, and differed the heat treatment for each. He based the heat-treatment conditions on differential thermal analysis of each sample.

Of three samples, sample A was not heat treated at all; sample B went through a nucleation cycle at 1183K for 6.5 hours and a growth cycle at 1273K for one hour; and sample C also went through the nucleation cycle and then a growth cycle at 1373K for one hour.

"The heat treatment obviously changed the samples," Tanabe says. "The original sample was green. Once heat treated, sample B turned bluish green and sample C went deep blue. We subjected them to x-ray diffraction, which showed two kinds of crystals had formed—β-$CaAl_2O_4$ and gehlenite. That may mean that the temperature dependence of nucleation and growth rates of these two crystals are quite similar."

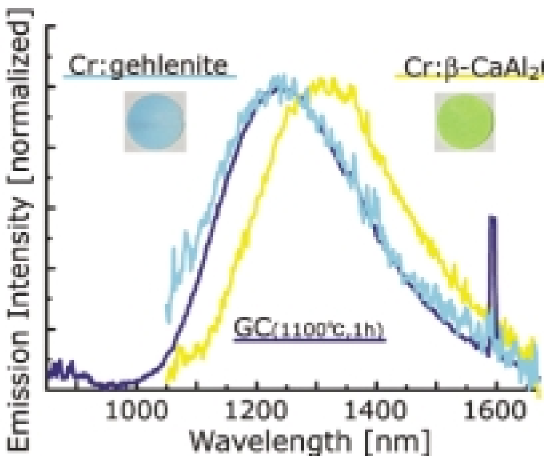


Figure 1 Emission spectra of Cr-doped glass and Cr:gehlenite glass ceramics, excited at 792 nm.

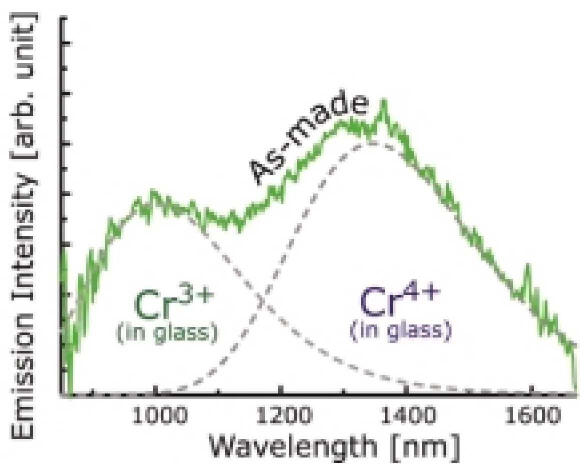


Figure 2 Deconvolution of the emission spectrum of sample A.

Tanabe and his group tested the emission spectra of the three samples and found that the heat-treated ones show a single emission band that peaked at around 1240 nm (see figure 1). The untreated sample A showed two emission

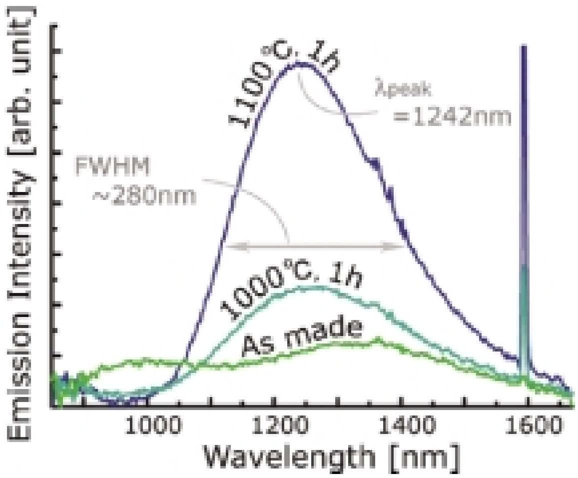


Figure 3 Comparison of emission spectra of Cr^{4+}-doped glass ceramics and polycrystalline samples.

bands that peaked at 1350 nm and 1000 nm (see figure 2). "In addition, heat treatment measurably increased emission intensity," Tanabe says. "We knew that polycrystalline Cr:gehlenite shows an emission band at around 1240 nm and that polycrystalline Cr:β-$CaAl_2O_4$ has a band at 1310 nm. This told us that the 1240-nm emission of samples B and C could be ascribed to Cr^{4+} ions in the gehlenite phase. That, we judged, confirmed that most of the Cr^{4+} and Cr^{3+} ions in the as-quenched glass were incorporated in the precipitated gehlenite crystallites as Cr^{4+} through heat treatment." (See figure 3.)

Bill Brocklesby of the Opto-electronics Research Centre at the University of Southampton (Southampton, UK) says, "Cr^{4+} glass-ceramics are a very sensible research aim: The properties of the crystalline host combined with the mechanical properties of the glass form an ideal combination. The hosts developed by Tanabe look like the best transition metal candidates so far for use as an amplifier. The spectroscopic properties have to combine with favorable material properties, though, for a successful device.

"The spectroscopic properties of the Cr^{4+} ions as described seem ideal," Brocklesby continues. "The spectrum is broad and centered in a very interesting region of the communications bands. However, the presence of a significant quantity of Cr^{3+} is not ideal. The selective incorporation of the Cr^{4+} into the crystallites will help this problem. The material properties necessary to get to a successful fiber device are more complex, however. The melting temperature and annealing temperatures of the material do not preclude its use in fiber, but much material engineering is necessary to get from the present work to a successful device. Glass-ceramic fibers have been shown to have low enough loss for active device work, so this development of Cr^{4+}-containg material with good spectroscopic properties is very encouraging for the field."

—Charles Whipple

Robotic Mission May Save Hubble's Powerless Imaging Spectrograph

One of the Hubble Space Telescope's four major scientific instruments, the Space Telescope Imaging Spectrograph (STIS), has lost all power, and plans to repair it are in question.

Performing spatially resolved spectroscopy over wide wavelength (115 to 1100 nm) and spectral resolution ($\lambda/\Delta\lambda$), ranging from ~100 to 200,000, STIS is featured in nearly 30% of planned future science observations. With one of its two redundant electronics sets failing in 2001, STIS had been operating on its backup electronics, which suffered a component failure that has now taken STIS completely offline. The National Aeronautics and Space Administration's (NASA; Washington, D.C) cancellation of the original shuttle-based service mission four (SM4) has eliminated any potential for servicing Hubble in 2006. "We are actively working on the development of a capability to service Hubble without having to rely on the space shuttle, using a robotic system," explains NASA's David Leckrone. With a tentative date set for December 2007, the robotic mission would attach two modules to the aft end of Hubble, a de-orbit module containing new

The STIS instrument is pictured here in 1996 during its pre-launch integration and testing period at Ball Aerospace and Technologies Corp. (Boulder, CO), where it was designed and batteries, and an ejection module (EM) containing components needed to service and upgrade Hubble, as well as a robot and a remote manipulator arm. EM components would include a new set of gyros, the Cosmic Origins Spectrograph (COS) and Wide Field Camera 3 (WFC3), originally developed for flight to Hubble on SM4; whether the robot mission will also attempt to fix STIS is undetermined at this point, according to NASA officials.

NASA also selected teams from Johns Hopkins University (Baltimore, MD) and Arizona State University (Tempe, AZ) to perform two low-cost conceptual studies and investigate the possibility of flying COS and the WFC3 on another satellite that would provide some of the same capabilities as Hubble. This possibility could prove to be important in the long term if the robotic servicing mission does not materialize. —*Phillip Espinasse*

GLASS COATING |

Intelligent Window Coating Reflects Heat, Not Light

Conventional window tints provide a summertime solution for dealing with high air conditioning bills and hot stuffy cars, but these methods block heat by reducing the light transmission, which can reduce driver safety in some cases when used in automobiles. Using tungsten-doped vanadium dioxide ($W:VO_2$) as a coating, researchers at the University of Liverpool (Liverpool, UK) have developed a smart glass that transmits visible wavelengths of light but reflects IR light when temperatures rise higher than 29°C.

The fabrication process relies on a high growth rate atmospheric pressure chemical vapor deposition technique compatible with the float glass manufacturing process. Using vanadium oxytrichloride and tungsten hexachloride as vanadium and tungsten sources, respectively, and water as a reductant, the team passed vapor phase chemicals over a hot glass substrate with an oxide barrier layer to apply the coating.

The coating enables solar gain to be maximized during colder days; as the temperature rises above a critical point, the material changes its structure to reflect away IR radiation while maintaining its optical transparency. By doping VO_2's lattice during the deposition process, one can alter the coating's transition temperature. A content of 1.9 atom% tungsten gives a thermochromic transition temperature of 29°C, which is near ideal for intelligent window coatings. "In this way, air conditioning usage is reduced in hot weather without any increase in lighting costs, and the maximum benefit of the sun is felt during cold weather," explains Troy Manning of the research group.

Due to the coating's yellow/green color, the group is investigating color suppression with a dye or another oxide coating. This material will find use in glazing applications, and other potential applications exploiting VO_2's thermochromic transition such as optical switches for optical computers, IR modulators for missile guidance systems, IR goggles, cameras, and data storage. Existing thermochromic methods use polymers and hydrogels; however, these methods suffer lifetime and inhomogeneity issues.

—*Phillip Espinasse*