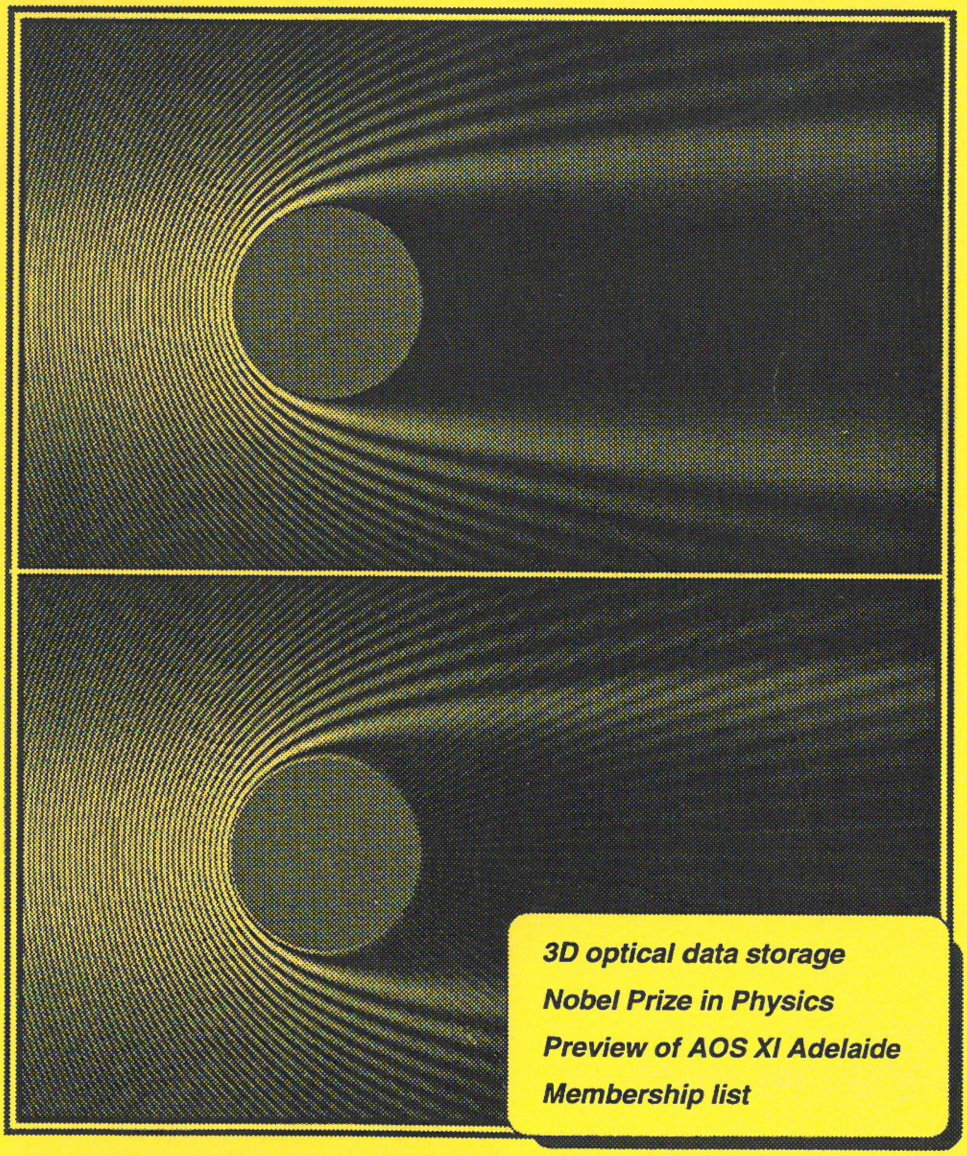
Australian Optical Society

NEWS



3D optical data storage

Nobel Prize in Physics

Preview of AOS XI Adelaide

Membership list

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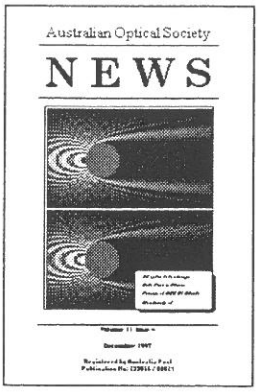
AOS NEWS



COVER:

Diffraction of a Gaussian beam by a copper wire, for two orthogonal beam polarisations. The field ampltude is shown in grey-scale. The beam is incident from the left, where light is reflected by the metal cylinder and interferes with the incident wave, producing standing waves.

In the lower figure the field can be seen to wrap around the cylinder and produce "whispering gallery" modes.

The rigorous solution to diffraction by a cylinder is important for modelling fibre-sizing instruments, and investigating the accuracy of scalar theories.

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President's Report

The Visibility of Optics

The theme of my first President's Report this time last year was that we as opticists should have a special advantage in communicating our branch of science to the general public, because most people have an elementary mechanistic feeling about phenomena such as light propagation, vision, colour, and so on. However, as in many other areas of science, much of what we all take for granted today is a relatively recent development.

The textbooks say that the Arabian mathematician Alhazen is thought to be the first person to have recognised clearly that the light that we see travels *from* the object *to* the eye, rather than in the reverse direction as the ancient Greeks before him had supposed. Alhazen's work was first published as recently as 1000 years ago, and was not introduced into European scientific culture for another 400 or 500 years when it was translated into Latin during the Italian Renaissance. Alhazen's concepts were then taken up by artists in their use of perspective to make their pictures more realistic, but largely ignored by "scientists" of the day. Indeed, science had to wait another two centuries before Isaac Newton in 1704 published his classic book (based on his research of the preceding 40 years, some of it suppressed because it offended the philosophies other physicists of the day, notably Robert Hooke) that could be regarded as the birth certificate of modern optics. (Incidentally, putting on my chemist's cap for a moment, I read with interest recently that John Dalton - often regarded as the father of modern chemistry - discovered that he was colour blind and in 1798 wrote a systematic account of his observations, based on some of Newton's concepts and experimental methods.)

Now, almost 300 years later, we approach the end of a century that has been quite spectacular in terms of advances in optical science and technology. Armed at the outset with Maxwell's equations and many important experimental observations from the 19th century, this century began with the profound conceptual advances of Planck and Einstein, leading to myriad subsequent developments in theory, experiment and technological spin-off. Today we are accustomed in our daily lives to recent innovations such as colour television, compact discs, barcode scanners, laser printers, fibre-optic communications, computer-controlled fabrication of spectacles, high-resolution imaging from satellites, "Star Wars" weaponry, holography, advanced medical procedures (such as endoscopy or laser diathermy, angioplasty and microsurgery), instant photography (with Polaroid film now being challenged by digital media), and many more. These are all products of optical science and we face the challenge of bringing that fact to the public's attention in order to gain support for our pursuit of further advances. We also need to remind the Australian Research Council of the importance of optics as a central discipline at the frontier of physical science, so that it is retained as one of the ARC's Priority Areas for the forthcoming research funding triennium.

And what are today's optical frontiers that could lead on to tomorrow's commonplace technologies? I am sure that we shall hear about plenty of them at the Society's AOS XI conference in Adelaide on 10 - 12 December 1997.

For one notable frontier, we need look no further than the recently announced Physics Nobel Prize award to Steve Chu, Claude Cohen-Tannoudji and Bill Phillips - each well known to some of us in the Australian optics scene. The laser-based methods that they and others have developed to cool atoms to microKelvin temperatures are part of a wider range of optical techniques that rely on momentum transfer between radiation and matter, including optical tweezers that can manipulate biomolecules and selective deflection methods that enable isotope separation. Beyond these lie the dramatic recent advances in gas-phase Bose-Einstein condensation and the "hot" topic of atom optics. These provide interesting flashbacks to the first quarter of this century, when quantum statistics was in its infancy and the wave-particle duality emerged as a major conceptual triumph.

You can read more about the "laser coolers" in an invited article by Ken Baldwin elsewhere in this issue. Incidentally, I gather from Ken's opening paragraph that the Canberra media were more attuned to the announcement of their Nobel prize than were those in Sydney: the only thing I saw in the Sydney papers (and I knew when and what to look for, because I receive Nobel Prize news releases by email) was a few days later when some Russian scientists claimed that the Prize should have been theirs. So much for "the visibility of optics" when it comes to public awareness of the true frontiers. Perhaps we have not advanced all that far since the days of Alhazen or Newton, in terms of reception of new ideas!

— Brian Orr

AOS MEDAL

AUSTRALIAN OPTICAL SOCIETY

The Australian Optical Society is seeking nominations for the fourth award of this medal, which is for an outstanding contribution or contributions to the field of optics in Australia by a member of the Australian Optical Society.

Previous winners of the medal have been:

1995: Mr Bill James
James Optics, Melbourne;
1996: Dr Parameswaran Hariharan
University of Sydney and CSIRO;
1997: Professor Jim Piper
Macquarie University.

This Medal is the most prestigious award of the Australian Optical Society. It would normally be presented only to a nominee at an advanced stage of his or her professional career and with a strong and sustained record of authority, enterprise and innovation in the field of optics in Australia.

Nominations for the 1998 AOS Medal Winner should include brief personal details and a curriculum vitae emphasising the main contributions made by the nominee to Australian optics.

Two letters of recommendation should also be provided. Nominations may be made either by or on behalf of any eligible candidate. The selection panel reserves the option to seek additional information about candidates for the award.

It is hoped that the person selected to receive the medal will be able to do so at the 1998 AOS Conference, which is planned as part of the Australian Conference on Optics, Lasers and Spectroscopy (ACOLS'98) in Christchurch, New Zealand in December 1998.

The closing date for nominations is 15 May 1998. Nominations should be sent to the AOS Secretary:

Dr Clyde Mitchell
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Fax: (03) 9544-1128
E-mail: C.Mitchell@mst.csiro.au

OPTICS GRAPEVINE

News from the World of Optics

AUSTRALIAN OPTICAL SOCIETY

AOS XI

Adelaide

10-12 December, 1997

See the preview on p26-31

Editorial

In this issue I have included a preview of the AOS XI conference to be held in Adelaide, 10-12 December. I sincerely hope that you receive your copy before then!

The December issue traditionally contains the membership list for the AOS, and this year is no exception (p40). Also included is a review of the 1997 Nobel Prize in physics, which was awarded this year to some of the pioneers of atom trapping (p17).

Duncan Butler

Nobel prize in physics

The 1997 prize in physics has been awarded to Professor **Steven Chu**, Stanford University, Stanford, California, USA, Professor **Claude Cohen-Tannoudji**, École Normale Supérieure, Paris, France, and Dr. **William D. Phillips**, National Institute of Standards and Technology, Gaithersburg, Maryland, USA. The prize was awarded for the recipients' contributions to laser cooling and trapping of atoms (see review p17).

An **Introductory Course in Computer-Aided Optical Design** is a one-week course by **Kidger Optics.** The course will be held in Sydney in March.

OSA manuscript tracking system

The Optical Society of America has started a manuscript tracking system on the World Wide Web. Manuscripts submitted to the OSA journals JOSA, Applied Optics, etc, can be tracked once the OSA manuscript number is known. This system is an excellent way to make sure your article is on track to publication. Some example results for a manuscript status inquiry are shown below:

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16 Sept.95      Sent to referee #1
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13 Oct. 95      Reminded referees
15 Oct. 95      Response recv  #2
16 Oct. 95      Response recv #1
21 Oct. 95      RR1 letter to Au
5  Jan. 96      Revised manuscript received
8  Jan. 96      Sent to referees
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The AOS on the World Wide Web
http://www.dap.csiro.au/OPTECH/Optics-Radiometry/aoshome.htm

A Tale of Two Conferences

Tanya M. Monro
School of Physics A29, University of Sydney, NSW 2006
Australian Photonics CRC, Australian Technology Park, Eveleigh NSW 1430

I recently returned from two conferences: the Optical Society of America Annual Meeting (Oct 12 - 17) and the Bragg Gratings, Photosensitivity, and Poling in Glass Fibers and Waveguides: Applications and Fundamentals meeting (Oct 26 - 28). The sponsorship provided by the 1997 AOS Postgraduate Student Prize helped to make it possible for me to make this trip. Here I present an overview of what were for me some of the highlights of these conferences.

The 1997 **Annual Meeting of the Optical Society of America** was held at the Long Beach Convention Center, California. The OSA Annual Meeting is a very general optics conference, which covers a wide range of topics from geometrical optics to Bose-Einstein condensation. Due to a nasty bout of food poisoning, the first talk I managed to see was an excellent review by Marty Fejer (Stanford, [Monday 2pm MNN1]) on the advantages of using Periodically Poled Lithium Niobate (PPLN, *pipplin*) waveguides for nonlinear optics experiments. Fejer reported the fabrication of PPLN devices with 7 μm wide domains.

Later that day, still a bit wobbly on my feet, I gave a talk titled `Self-written waveguides in photopolymers and photosensitive glasses' (MNN3), which got a good response. This talk was primarily about new theoretical work on self-writing processes. I was fortunate enough to have a postdeadline paper on my recent self-writing experiments accepted (PD13), and this paper was also well received.

An excellent overview of the possible applications of photonic band gap materials was given by Ekmel Ozbay (Bilknet University, Turkey WI4). Ekmel was the winner of the Adolph Lomb Medal, 1997, awarded for contributions to Optics made before the age of 30. Ekmel's talk focussed on the applications of photonic crystals in the microwave regime, and in particular to antenna and detector applications.

In postdeadline paper PD8, Koroteev et al. (Moscow State) presented a cute idea for using a cw femtosecond laser to write data in a 3-D optical data storage scheme. A prototype of this type of optical memory was constructed using alternate photosensitive layers and inert pure polymer layers for spatial separation (typical layer separation ≈ 30 μm). Information is written bit-by-bit using an electro-optically gated cw Ti:sapphire laser. The information can be read by using a CCD camera to detect the fluorescence excited using an argon-ion laser. Reading speeds of 10 Kbytes per second have been achieved using this prototype.

In the following paper, Davis et al. (Lucent, PD9) outlined a new, highly controllable technique for fabricating long-period fiber gratings using direct exposure to CO_2 laser pulses at 10.6 μm. The main advantages of this technique are that neither hydrogen loading or ultraviolet exposure are required. The technique uses an amplitude mask, rather that the more conventional phase mask approach, and Davis et al. find that this allows control of the grating properties on the scale of the grating period.

One thing I particularly noticed at the OSA Annual Meeting this year is that the optics job market seems to be booming. At the OSA employment center, many more jobs (both postdocs and industry positions) were advertised than last year. It is definitely a good time to be a finishing PhD student in the optical area.

After a week visiting the UK, I then went to Williamsburg, Virginia for the second conference: **Bragg Gratings, Photosensitivity, and Poling in Glass Fibers and Waveguides: Applications and Fundamentals (BGPP)**. The setting was beautiful; I spent a day wandering around colonial Williamsburg before the conference began. As it turned out, the weather was in cahoots with the conference organisers, because as soon as the conference started, so did the rain.

The BGPP meeting was co-located with the Glass and Optical Materials Division meeting (GOMD), and there were a number of joint sessions on such issues as the nature of defects in glass, particularly germanium-doped glass. These sessions were useful, although the jargon used by the GOMD audience was quite different to that used by the BGPP fraction, which led to some fun at question time. I was surprised by the large numbers of people attending the BGPP meeting, and it was clear that the organisers were surprised too, as many of the talks needed to be relocated to larger rooms.

The meeting opened with a good review by Linards

Skuya (Univ. Latvia, JSuA1) about the nature of optically active defect centers in silicon dioxide. He highlighted the fact that there is a powerful analogy between bulk and surface defects, and that a good understanding of bulk defects can be obtained by studying surface defects, which are much easier to control. He explained that the main problem currently in the study of defects is the difficulty of finding good structural models for the absorptions relating to the different types of oxygen vacancies.

This was followed by a review of topological modelling of glass by Linn Hobbs (MIT, JSuA2). He described how crystal structures can be generated using local rule sets. In particular, he demonstrated using computer simulations how the different polymorphic types of quartz can be generated. Amorphous structures such as glass can also be created using this technique, using information about bond-angle distributions.

One topic which surfaced repeatedly at this conference was long period gratings. (BSuB1, BSuB2, BSuD2, BSuD4 BMG17 and PD3) Long period gratings (period >> 1 μm) couple light from the guided core modes to the cladding modes of an optical fibre, and are often used to provide wavelength dependent losses in fibre systems. Because light is coupled to the cladding modes, long period gratings are sensitive to perturbations in temperature, pressure and refractive index. Although this leads to useful sensor applications, this sensitivity is not always desired. A number of techniques have been successful in reducing the temperature sensitivity of these gratings, including novel refractive index designs or doping the fibre core with B_2O_3, which has a negative thermal expansion coefficient.

Raman Kashyap (BT, BSuB5) gave a presentation about novel liquid and liquid crystal-cored fibre Bragg gratings. Here the grating is written in a photosensitive inner cladding layer. Such a structure has a negative temperature coefficient of Bragg wavelength shift, and also is potentially tunable by the application of an electric field. Also, the liquid used in the core region can be chosen to give very low insertion losses when coupled to standard single-mode fibre.

A new interferometer design was proposed for the fabrication of Bragg gratings, where the fringe period can be varied simply by altering the position of two mutually attached mirrors (Fonjallaz, BSuC3). Currently, this interferometer can produce gratings with resonant wavelengths between 900 nm and 1600 nm.

Another topic of great interest at the BGPP meeting was the fabrication of gratings using near-UV (330 nm) light (Starodubov et al. [BME1, PD1] and Grubsky et al. [BME3]). At this wavelength, gratings can be written through the polymer coating, and so the resulting fibre is much stronger, as it does not need to be stripped and re-coated, and also is much more efficient to make. With hydrogen loading, strong index gratings ($\Delta n > 10^{-2}$) can be formed. One postdeadline paper (Espindolam PD2) showed that gratings can even be written through the fiber coating at 257 nm.

At the opposite end of the UV range, germanium-doped waveguides were shown to exhibit photosensitivity at 157 nm, in the Vacuum-UV range (VUV). This was described in the paper by Herman et al. (Univ. Toronto, BME4). The principal motivation for using this wavelength is that relatively large index changes ($\Delta n \approx 10^{-2}$) can be achieved using low fluence in materials with low germanium-concentrations.

Phillip Russell presented an all-fibre Bragg-grating based acousto-optic modulator (PD4) which is capable of modulation efficiencies of up to 90 %. This is done by coupling forward and backward propagating Bloch modes in the grating, and operates in reflection. The high efficiency has been achieved by etching away the fibre cladding, and hence increasing the acousto-optic overlap.

In the Planar Waveguide Devices session (BTuB), a number of papers were given highlighting the advantages of photolithography techniques to form planar devices over more conventional techniques such as reactive ion etching. My talk on self-written waveguides (BTuB3) fitted in well here as an even less conventional technique!

I would like to thank the Australian Optical Society for awarding me the Postgraduate Prize, which made it possible for me to attend these conferences. Not only did I learn a great deal about current research in optics, but I also had the chance to meet people working in related areas. In addition, it gave me a chance to tell a much wider audience about my research, which has resulted in a few possible international collaborations.

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Three-Dimensional Optical Data Storage

Min Gu, D. J. Day and S. P. Schilders
Optoelectronic Imaging Group, Department of Applied Physics
Victoria University of Technology, PO BOX 14428 MCMC, Victoria 8001

Optical memory, or optical data storage, is a new field which has been listed as part of the optics priority research area by the Australian Research Council. In this article, we describe a three-dimensional optical data storage method based on the two-photon excitation process in a photo-polymer. In this method, a two-photon fluorescence microscope is used to read and write three-dimensional data.

1. Introduction

In optical data storage, a laser beam is focused by an objective onto a recording material to produce a spot where physical or chemical properties of the material are changed (Figure 1). Information such as images, words, data, music and so on is modulated with the laser beam, so that an array of spots, determined by the logic state of the information, is formed in the recording material.

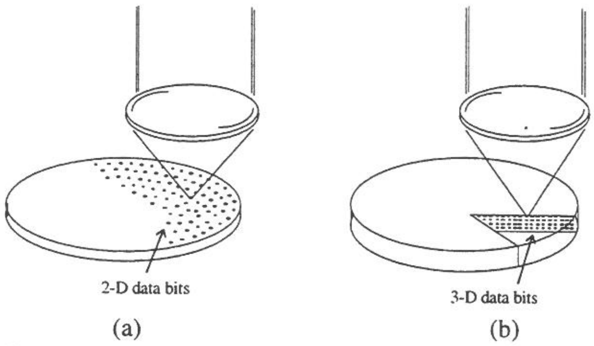

Figure 1: Schematic diagram for (a) 2D, and (b) 3D optical data storage.

Essentially, the size of the focal spot and the resolution of recording media determine the storage density. According to the diffraction theory of light in a "far-field" region (such as the focal region of a lens), the shorter the illuminating wavelength the smaller the spot size. In conventional two-dimensional optical data storage, where bits are recorded on the surface of a medium (Figure 1a), the best storage density achieved so far has been 0.1 Gbit/cm^2 for a given visible wavelength. This density is close to the limit imposed by diffraction by a circular objective lens. In order to break this limit, one can perform optical data storage in the region where the effect of diffraction is not dominant. This idea has led to a new method for optical data storage involving a near-field probe [1]. However, this method poses difficult engineering problems, mainly due to the close working distance required to circumvent diffraction effects.

An alternative way to achieve a high storage density in the far-field region is to record information in 3D space. Currently, there are two classes of methods for doing this. The first is based on 3D volume holography and the second is to record the bits information in a 3D array. The latter method, called 3D bits optical storage hereafter (Figure 1b), has an advantage of high signal-to-noise ratio, and the corresponding system is small in size. It is expected that a 3D storage density as high as Tbit/cm^3 can be achieved.

For 3D bits optical storage, a localised physical and chemical reaction is needed at a certain depth of a volume recording material. A number of materials including photochromic materials [2], photorefractive crystals [3], photopolymerizable materials [4], and photobleaching materials [5] have been employed for 3D bits recording. If a visible-wavelength laser beam is focused deeply into a material, light scattering is so strong that the intensity in the focal spot reduces appreciably. Accordingly, information cannot be efficiently recorded at a deep position of a volume material. To solve this problem, we have used a two-photon (2-p) process excited by an infrared ultrashort pulsed laser beam. In this article, we describe a 3D optical data storage method using a photobleaching material. In this method, 3D data are recorded as a photobleached pattern under 2-p excitation and read by a 2-p fluorescence microscope.

2. Two-photon fluorescence microscopy

The two-photon (2-p) process occurs when two incident photons are simultaneously absorbed by a sample to excite an electron transition from the ground state to an excited state (Figure 2). The excited electron first jumps to a metastable state and then returns to the ground state by radiating a photon having energy approximately twice as large as that of the incident photons. Because two-photon absorption is a nonlinear process, an ultrashort pulsed laser is required to produce a high peak power.

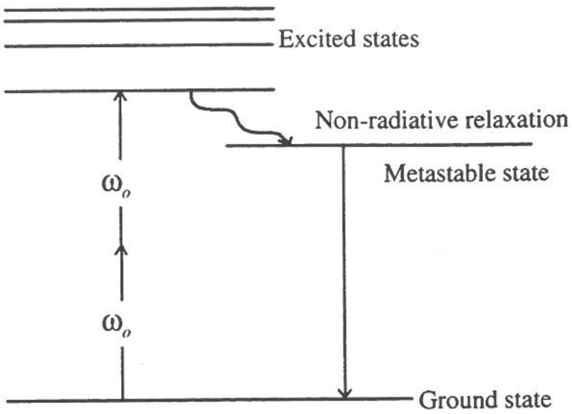

Figure 2: Energy diagram of the two-photon excitation process.

If the fluorescence light from a sample under 2-p excitation is imaged, this imaging technique is called two-photon fluorescence microscopy [6]. Figure 3 shows a pattern recorded in a photobleaching polymer matrix using a two-photon fluorescence microscope.

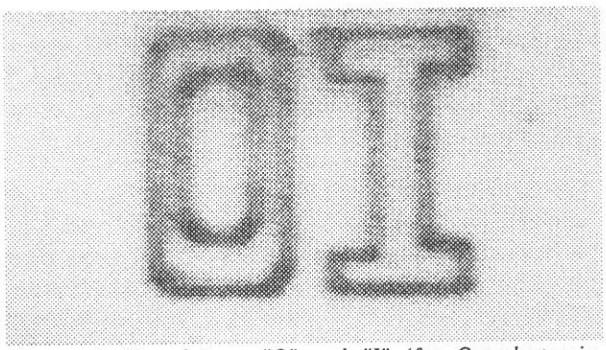

Figure 3: Two letters, "O" and "I" (for Optoelectronic Imaging), recorded in a photo-bleaching polymer using two-photon excitation. Image size: 30µm x 20µm.

With 2-p absorption, one can achieve a virtually ultraviolet (UV) photon excitation without using a UV source. This will help to reduce the light scattering and perform imaging through a thick sample, which is necessary in 3D optical storage. In general, a small confocal pinhole is needed to perform 3D imaging of a thick sample, which is called confocal microscopy [7]. Due to cooperative 2-p excitation, the fluorescence intensity is proportional to the square of the incident intensity, leading to a diffraction spot of an objective smaller than that by single-photon excitation. This property means that 3D imaging is possible without a confocal pinhole [6]. If one does use a confocal pinhole in 2-p fluorescence microscopy, then axial resolution can be improved by approximately 40% [7]. Another advantage in 2-p fluorescence microscopy is that the generalised (ie. away from the focal spot) photobleaching associated with single-photon excitation is avoided. Because of these advantages, 2-p fluorescence microscopy has become an important tool in biological studies.

If, on the other hand, photobleaching does occur in a 2-p material, it happens only in a small region near the focal spot of a high numerical-aperture lens. This novel feature indicates that the photobleaching property under 2-p excitation can be used for 3D bits optical data storage if bleached spots can be kept for a long time. Thus information may be recorded in a material as a series of photobleached patterns or spots. A photobleached spot cannot produce any fluorescence when it is excited by the laser beam of the same wavelength as employed in the recording process. Therefore a recorded 3D photobleached pattern can be read out using the same 2-p fluorescence microscope as used in recording. For example, the black region in Figure 3 corresponds to the photobleached area while the bright region is generated by the fluorescence under 2-p excitation.

In Figure 4, a schematic diagram of a 2-p fluorescence confocal microscope is depicted. The incident laser beam is from an ultrashort pulsed laser. The laser beam is focused onto a small pinhole (P_1) which acts as a point source needed for confocal microscopy [7]. The beam is collimated by a lens (L_1) and then focused by a high numerical-aperture objective (O) onto a recording material controll-ed by a computer (C). A modulator (M) is inserted in front of the laser and controlled by the same computer, so that the information to be recorded is modulated with the laser beam. In the recording process, the laser peak

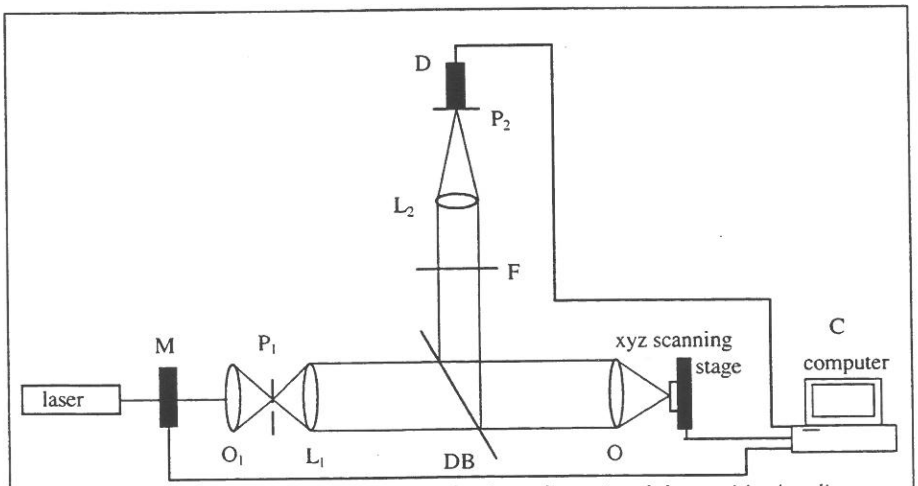

Figure 4: A two-photon confocal microscope for three-dimensional data writing/reading.

power should be high enough to reach the threshold of the 2-p photobleaching process. A recorded 3D bleached pattern is read by measuring the fluorescence under 2-p excitation by the same laser, in which case, the peak power of the laser should not be so high that no 2-p photobleaching occurs near the focal region. The collected 2-p fluorescence is reflected by a dichromic beamsplitter (DB) and focused onto a detector (D). Because the wavelength of the 2-p fluorescence is approximately half the wavelength of the excitation laser beam, a short-pass edge filter (F) is inserted to reject the residual signal of the excitation beam. Although it is not necessary to use a pinhole in front of the detector to read a recorded 3D pattern, using a pinhole (P_2), ie using a confocal geometry, does provide a tool for reading a recorded data of a higher density.

3. Research on 3D optical data storage at VUT

Research work on 3D optical data storage at Victoria University of Technology (VUT) started at the beginning of 1997 and is being conducted in the Optoelectronic Imaging Group (OIG) within the Optical Technology Research Laboratory (OTRL) in the Department of Applied Physics. To perform 3D optical storage experiments, a 2-p confocal fluorescence microscope, depicted in Figure 4, has been set up on an optical table for flexible operation. An ultrashort pulsed laser (Tsunami, Spectra Physics) was coupled into the microscope. The pulsed width of this laser is approximately 80 fs. The laser wavelength is tunable from 695 nm to 1000 nm with an average power of up to 600 mW.

It should be pointed out that our microscope is an object-scanning system, which avoids off-axis aberration. A recording material is fixed on a scanning stage (50 nm resolution). For the results shown in Figures 3 and 5, the peak power in recording and reading processes was approximately 7 mW and 0.7 mW, respectively. The numerical aperture of the objective was 0.75.

The recording material was a solid polymer matrix doped with a new dye which has a high cross-section for 2-p excitation (the details of the dye are not described here for reasons of confidentiality). The strong 2-p photon absorption peak of the polymer was found at the wavelength of 798 nm and the corresponding fluorescence was measured approximately at 500 nm. Two letters *"O"* and *"I"* recorded as a bleached pattern in such a polymer are displayed in Figure 3. To explore the possibility of 3D data storage in the polymer, we recorded two letters *"V"* and *"U"* at different layers along the depth of the polymer. A typical result is shown in Figure 5. The distance between two adjacent layers was 10 µm. This result clearly demonstrates the feasibility of 3D bits optical storage in a photobleaching polymer under 2-p excitation.

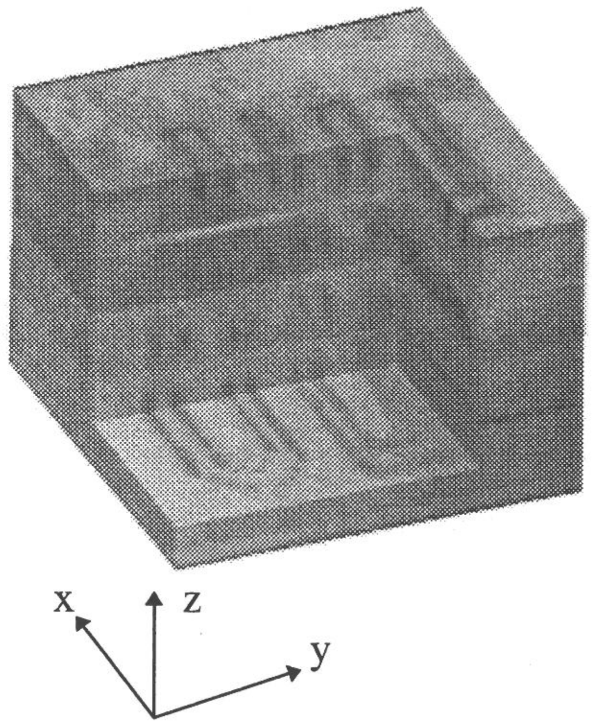

Figure 5: *Two letters, "V" and "U" (for Victoria University), recorded at different layers in a photo-bleaching polymer using two-photon excitation. Image size: 20µm x 20µm x 40µm.*

4. Conclusion

3D bits optical data storage is currently an active research area around the world. In principle, a 3D recording density of $Tbit/cm^3$ is possible in a volume material (however, the current densities are far below this limit). Future work in this area at VUT is being carried out in the following aspects:

1). Development of a super-resolving imaging system. To obtain a $Tbit/cm^3$ recording density, the diffraction spot of an objective should be reduced. To achieve a spot smaller than the normal Airy spot, we are designing a super-resolving spatial filter based on the principle of apodization [8].

2). Compensation for spherical aberration. Because of the mismatching of the refractive indices between the recording and immersion materials, spherical aberration occurs in the recording and reading processes. This aberration can increase appreciably the size of the diffraction spot of the objective for recording and reading. A new method for compensating the spherical aberration in a practical system is being designed.

3). Development of re-writable materials. One of the advantages of the 3D optical storage method based on 2-p photobleaching is security: recorded patterns must be read using the same wavelength as used in the recording process. However, 2-p photobleaching patterns are not erasable. To achieve a re-writable mechanism, other physical and chemical processes of materials in the focal region should be explored. One process may be based on the photochromic effect and the other is the photorefractive effect. If these two processes occur under 2-p excitation, a re-writable, or erasable 3D optical storage method can be developed. At present, inexpensive polymer materials which can exhibit these two effects are being developed at VUT.

We expect that once the research work described above is carried out, a novel optical system, which will produce a storage density of Tbit/cm^3 in an inexpensive photo-polymer, can be applied to practical 3D bits optical data storage. Such a high recording density in polymers will be extremely important and useful in widespread fields ranging from scientific research to industrial applications; from video and audio devices to special facilities for super-computers and information super-highways.

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1997 Nobel Prize in Physics Goes to Atom Coolers

by Ken Baldwin

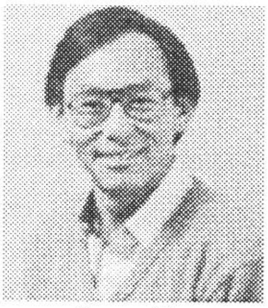
Its not often that you wake up in the morning to newspaper headlines announcing the award of a Nobel prize to three colleagues in your field.

Past experience shows that Nobel prizes are usually awarded to people who have generally done their work many decades before. The last time a Nobel prize was awarded in an optics related area was in 1989, when Dehmelt and Paul were recognized for their work in a similar field (the development of ion traps), along with Ramsey who invented the oscillatory fields technique which has been applied to atomic clocks.

It is refreshing to see that this year the Nobel Prize in Physics has gone to three pioneers of laser cooling and trapping of atoms who have done much of their work in the last decade and a half. The joint recipients were [1], Professor **Steven Chu**, Stanford University, Stanford, California, USA , Professor **Claude Cohen-Tannoudji**, École Normale Supérieure, Paris, France, and Dr. **William D. Phillips**, National Institute of Standards and Technology, Gaithersburg, Maryland, USA

The 1997 Nobel Prize Winners

Claude Cohen-Tannoudji



Steven Chu

William D. Phillips

The first two are well known to the Australian optics community. Steve Chu visited Australia in 1991 as a plenary speaker at the ACOLS conference held at the ANU in Canberra. More recently he attended the International Quantum Electronics Conference (IQEC) '96 in Sydney.

Similarly, Claude Cohen-Tannoudji was a plenary speaker at the ACOLS '93 meeting at Melbourne University when he visited Australia as a Frew Fellow of the Australian Academy of Science. While we have been trying to persuade Bill Phillips to visit Australia for a number of years, now his schedule will make this even more difficult in the near future!

A new field in optics

Since the early '80s, these researchers have made an enormous contribution to both the realisation and the understanding of the way that light forces can be used to cool atoms to unprecedented low temperatures. The new methods of investigation they developed have contributed greatly to increasing our knowledge of the interplay between radiation and matter. In particular, they have opened the way to a deeper understanding of the quantum-physical behaviour of gases at extremely low temperatures.

As importantly, their work has spear-headed the development of a new field of optics. Known as "atom optics", it is the direct analogue of light optics - except for matter [2]. Atom optics realises the true complementary nature of light and matter, with atoms being manipulated - both as particles and as de Broglie waves - through their interaction with "optical" elements made from light or matter.

These techniques have led to applications such as the design of more precise atomic clocks for use in navigation and global positioning systems. Chu, for example, has constructed an atomic fountain in which laser-cooled caesium atoms are launched upwards from an atom trap like jets of water. When the atoms turn at the top of their trajectory and start falling again, they are almost stationary. There they are exposed to microwave radiation that measures the caesium clock transition with great accuracy. Using this technique, it is believed that it will be possible to build atomic clocks with a hundredfold greater precision than at present.

Another significant development is the creation of atom interferometers. Here the de Broglie wave of an individual atom is split coherently, then sent along two different pathways before being recombined to measure

the phase difference experienced while travelling along the two interferometer arms. Such devices can be used to make very precise measurements of accelerations, gravitational forces, electric and magnetic fields, and atomic interactions.

Doppler cooling and optical molasses

The simplest light force exerted on matter is the radiation pressure force, which arises from the transfer of photon momentum to the atom when it absorbs the radiation. The atom ultimately re-radiates isotropically, and thus receives a net momentum gain in the direction of propagation of the photon, typically changing the atomic velocity by a few cm/s. If the light source is a counterpropagating laser that is detuned below the atomic resonance (to allow for the Doppler shift), then after many such absorption emission cycles (lasting typically much less than a microsecond), atoms can be slowed with massive decelerations (up to 10^5 times that of gravity!). This type of cooling was named Doppler cooling.

Doppler cooling forms the basis for a powerful method of cooling atoms with laser light. The method was developed further around 1985 by Steven Chu and his co-workers at the Bell Laboratories in Holmdel, New Jersey. They used six laser beams opposed in pairs and arranged orthogonally in three dimensions. Sodium atoms emerging in a beam in vacuum were first stopped by an opposing laser beam and then conducted to the intersection of the six cooling lasers. The light in all six laser beams was slightly red-shifted from the sodium resonance transition. The result was that whichever direction the sodium atoms tried to move they were able to absorb photons with the appropriate Doppler-shifted frequency and pushed back into the centre of the intersecting laser beams.

At the intersection of the laser beams, atoms move as though they are in a thick liquid, so the name "optical molasses" was coined. To determine the temperature of the atoms cooled in the optical molasses the lasers were switched off and the atom cloud was allowed to expand ballistically. It was found that the resulting velocity distribution corresponded to a temperature of about 240 μK. This corresponds to a sodium atom speed of about 30 cm/s, and agreed very well with the theoretically calculated temperature - the Doppler limit - which is essentially defined by the linewidth of the atomic transition, since the scattered photons (on average) differ in energy by the linewidth. The Doppler limit was then considered the lowest temperature that could be reached with laser cooling.

The atoms in the above experiment are cooled, but not captured. Gravity causes them to eventually accelerate and fall out of the optical molasses in about one second. To truly capture the atoms, a trap is required with a relatively deep potential well in which the atoms can be contained.

Atom traps

Magnetic fields had already been used at the beginning of the 1980's by Bill Phillips and his co-workers in a method for slowing down and completely stopping atoms in atomic beams. Phillips had developed what was termed a Zeeman slower, a coil with a varying magnetic field that exactly compensates the Doppler shift of the slowed atoms, thereby keeping them in resonance with the laser. Thus the atoms could be retarded by a red-detuned laser beam opposing the atomic propagation direction.

With this device Phillips had, in 1985, stopped and captured sodium atoms in a purely magnetic trap. Enclosure in this trap, however, is relatively weak, for which reason the atoms within it must be extremely cold to remain inside. When Chu managed to cool atoms in optical molasses, Phillips designed a similar experiment and started a systematic study of the temperature of the atoms in the molasses. He developed several new methods of measuring the temperature, including one in which the atoms are allowed to fall under the influence of gravity, the trajectory of their fall being determined with the help of a measuring laser.

A highly efficient trap was constructed in 1987 called a magneto-optical trap (MOT). It uses six laser beams in the same sort of array as in the optical molasses experiment, but with opposing right- and left-hand circularly polarised light. In addition, two magnetic coils with opposing currents produce a radial magnetic field gradient with a minimum at the point where the beams intersect. The magnetic field shifts the atomic energy levels by the Zeeman effect, thereby keeping atoms in resonance only with the polarised laser light opposing their motion over a range of velocities. The force thereby developed is greater than gravity, and pushes the atoms into the middle of the trap. The atoms are then truly contained, and can be studied or used for experiments.

Doppler limit broken

In experiments on atom traps Phillips found in 1988 that a temperature as low as 40μK could be attained. This value was six times lower than the theoretically calculated Doppler limit! The reason for this was that the Doppler limit had been calculated for a simplified two-level atomic model that had previously been considered sufficiently realistic. However, Claude Cohen-Tannoudji and his co-workers at the ƒcole Normale Sup•rieure in Paris had already studied theoretical models of more complicated cooling schemes. What happens in these schemes can be likened to the character Sisyphus of Greek legend who endlessly rolled a stone up a hill, but on reaching each crest finds

that the slope beyond is also an uphill one. This comparison led to the process being termed Sisyphus cooling. Chu and his colleagues also developed a similar model independently at the same time.

The explanation for Phillips' result lay in the more complicated structure of the atomic energy levels which interacted with polarisation gradients in the laser light field. Atoms moving in these polarisation gradients were constrained always to move in the direction of increasing potentials, and constantly lost energy. The reality is that such gradients are nearly always present for non-idealised atoms in such multiple-laser cooling systems, with the result that the Doppler cooling limit is almost invariably broken.

The limitation to the Sisyphus cooling process lies near another fundamental limit - the recoil velocity that an atom gains when it emits a single photon. The recoil limit corresponds to a temperature which for sodium atoms is 2.4 μK, while for the somewhat heavier cesium atoms it is about 0.2 μK. In collaboration with Cohen-Tannoudji and his Paris colleagues, Phillips showed that cesium atoms could be cooled in optical molasses to about ten times the recoil limit, i.e. to about 2 μK.

It first appeared from these experiments that it was generally possible to reach temperatures only about ten times higher than the recoil limit. In a later development both Phillips and the Paris group have shown that with suitable laser settings it is possible to trap the atoms so that they appear at regular intervals in space, forming what is termed an optical lattice. The atomic positions in the lattice occur at multiples of the light wavelength from each other. Atoms in an optical lattice can be cooled, as has been shown, to about five times higher temperature than the recoil limit.

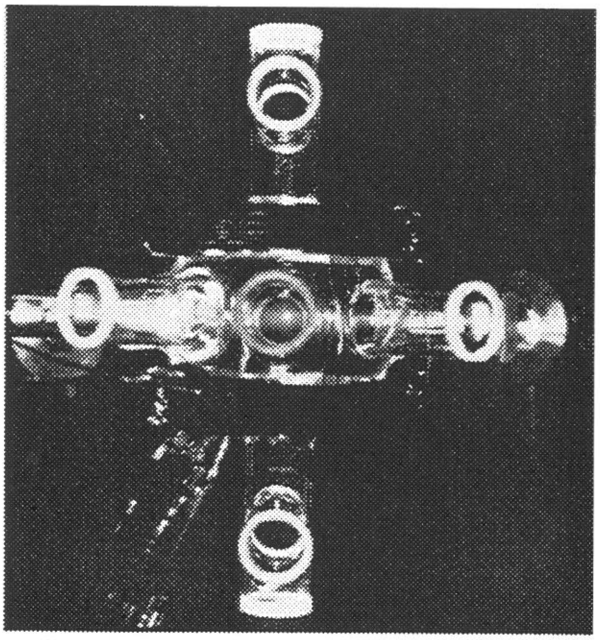
Recoil limit also broken

The reason that the recoil velocity sets a limit to laser cooling is that even the slowest atoms are continually being forced to absorb and emit photons. These processes give the atom a small but non-negligible recoil velocity and hence the gas has a very low but finite temperature. If the slowest atoms could be made transparent to the photons in the light field, then perhaps lower temperatures could be reached. One mechanism through which a stationary atom can be caused to assume such a "dark" state in which it does not absorb photons, was already known. But the difficulty was to combine this method with laser cooling.

Claude Cohen-Tannoudji and his group between 1988 and 1995 developed a method based on placing atoms into dark states at zero velocity which prevents the atoms from being further perturbed by the light field. He and his colleagues showed that the method functions in one, two and three dimensions. All his experiments use helium atoms, for which the recoil limit is 4 μK. In the first experiment two opposed laser beams were used and a one-dimensional velocity distribution was achieved which corresponded to half the recoil limit temperature. With four laser beams a two-dimensional velocity distribution was achieved, corresponding to a temperature of 0.25 μK, sixteen times lower than the recoil limit. Finally with six laser beams a state was attained in which the whole velocity distribution corresponded to a temperature of 0.18 μK. Under these conditions helium atoms crawl along at a speed of only about 2 cm/s!

Laser Cooling and Trapping in Australasia

Australia and New Zealand have traditionally possessed considerable strengths in atomic and optical physics, so it was natural that laser cooling and atom optics would develop rapidly in this environment [4]. Following the first experiments involving the ANU and the University of Melbourne in 1988, a number of centres have established research activity in these areas. An atom trap using sodium atoms was developed at ANU, cesium atom traps were established by CSIRO and the University of Melbourne and later at ANU and Otago, and a rubidium trap was built at the University of Queensland.



A millimetre size ball of trapped sodium atoms glows at the intersection of six laser beams in the magneto-optic trap in the Physics Department at ANU.

An ion trap at CSIRO in Sydney is also being used (along with laser cooling methods) to develop a highly accurate frequency standard. Other atom optics experiments are also established at Melbourne, Griffith and Auckland Universities, with theoretical studies

taking place at all these locations as well as at Macquarie University.

Future Developments from Laser cooling and Trapping

Intensive development is still in progress on the fundamentals and applications of laser cooling and the trapping of neutral atoms. These techniques have recently led to yet another milestone in physics - the demonstration of Bose-Einstein condensation [5] - a phenomenon that has attracted great interest. The realisation of BEC has yielded a new state of matter - the macroscopic quantum state - and has produced the coldest known temperatures in the universe (in the nanoKelvin range). These developments have also yielded a rudimetary atom "laser" [6], which may be used in future for precision interferometry or to act as a coherent atomic source for various applications. This discovery - by other teams of atom coolers - may lead to further Nobel prizes in the future.

Dr. Ken Baldwin is a Fellow at the Research School of Physical Sciences and Engineering at the Australian National University where he heads a research program in atom optics. He is grateful to Dr. Peter Hannaford for helpful suggestions with the manuscript.

Further reading

[1] For further information on this (and past) years Nobel Prize winners, consult the Nobel web page (on which this article is partly based) at:
http://www.au.nobel.se/announcement-7/physics97.html and http://www.nobel.se/cgi-bin/laureate-search?physics=on&silent=on

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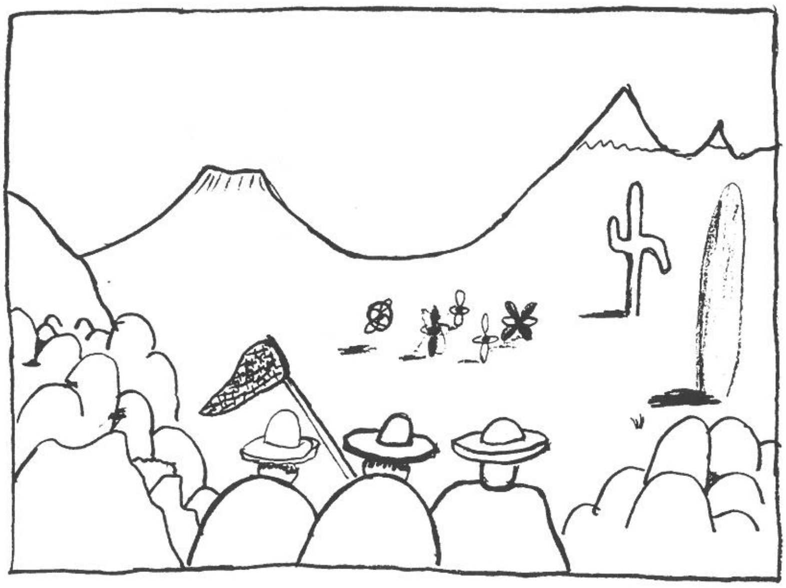

A GROUP OF ATOM TRAPPERS MOVE IN ON SOME SLOW-MOVING CESIUM ATOMS

AUSTRALIAN OPTICAL SOCIETY LINKS TO KINDRED SOCIETIES

The **AOS** maintains its own site on the World Wide Web, at:

http://www.dap.csiro.au/OPTECH/Optics-Radiometry/aosinfo.htm

We also have links to the sites and services of other kindred societies, particularly the following.

Optical Society of America (OSA)
Look at the range of information available through OSA's OpticsNet: http://www.osa.org
SPIE - The International Society for Optical Engineering
SPIE maintains the following Web site: http://www.spie.org
FASTS - Federation of Australian Scientific and Technological Societies
Many items of interest concerning Australian science and technology policy and related political developments are accessible via the FASTS Web site: http://www.usyd.edu.au/su/fasts/

Australian Institute of Physics (AIP)
The AIP home page, with links to AIP state branches, is at : http://www.physics.usyd.edu.au/aipaust/index.html
The AIP also maintains a helpful electronic bulletin board through the efforts of John O'Connor [Email: phjoc@cc.newcastle.edu.au] at the University of Newcastle. See below for further details.

Australian Institute of Physics - Physics Mailing Lists
A series of mailing lists have been created to service the communication needs of physics in the Australian community. This can facilitate the communication of material to members of the physics community interested in receiving information in designated areas. The lists are not just for listeners - if you find useful information then share it.

* *How do I subscribe to a list?*

To subscribe to a particular list called PHYSICS-XXXXX (where XXXXX is replaced by one of the topic areas listed below - e.g., PHYSICS-OPTICS, PHYSICS-LASERS-AND-QUANTUM-OPTICS, etc.), send an email message to the address:

MAILSERV@CC.NEWCASTLE.EDU.AU

and include in the body of the text the line:

SUBSCRIBE PHYSICS-XXXXX [address]

The [address] is an optional parameter specifying your email address. If no address is specified, the "From:" address in your message will be used (i.e., your address).

* *How do I cancel my subscription to a list?*

If at some stage you no longer wish to receive messages from that mailing list, then send an email message to <mailserv@cc.newcastle.edu.au> and include in the body of the text the line:

UNSUBSCRIBE PHYSICS-XXXXX [address]

* *How can I get help?*

If you are unsure of what you can do, send a message containing the word "help" to <mailserv@cc.newcastle.edu.au>.

* *How do I send a message to be broadcast to people on a particular list?*

To send an email message to everyone on list PHYSICS-XXXXX, send or forward the message to:

PHYSICS-XXXXX@CC.NEWCASTLE.EDU.AU

and it will immediately bounce out to all subscribers to the list.

* *How do I contact people in the optical physics community?*

Please subscribe to the list PHYSICS-OPTICS, and use it to receive and send information of general interest to opticists.

Please note that, unless the optics community starts to use this service more regularly, it is likely to be withdrawn!

* *What other AIP mailing lists are there?*

Apart from PHYSICS-OPTICS, there are another two dozen AIP mailing lists.
Ones that may of particular interest to AOS members include those with XXXXX replaced by:
PHYSICS-LASERS-AND-QUANTUM-OPTICS, PHYSICS-OPTICS, PHYSICS-PLASMA, PHYSICS-SOLID-STATE, PHYSICS-THEORETICAL

AUSTRALIAN
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provide
HIGH QUALITY OPTICAL COMPONENTS
AND LASERS
FROM EASTERN EUROPE

- **Dielectric Mirrors** (starting from $25 for 25 mm)
- **Laser Cavity optics**
- **Plate Beamsplitters** (starting from $25)
- **Retardation Plates** (starting from $55)
- **Thin-Film Polarisers** (starting from $75)
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- **Custom Pulsed Holography Systems**
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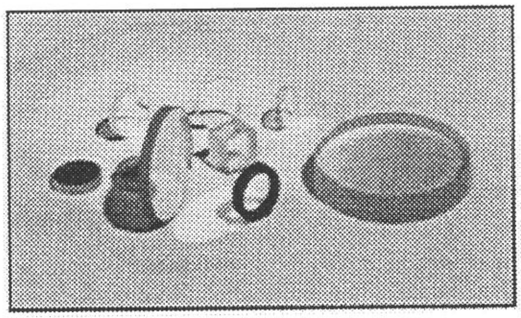

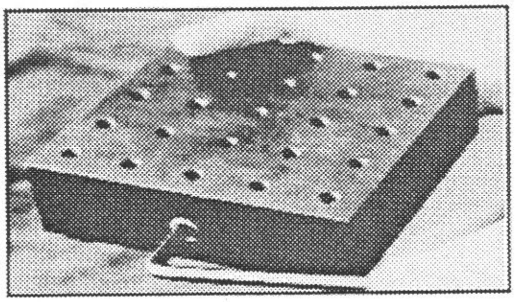

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Single longitudinal mode, single shot.

Output energy..5 Joules
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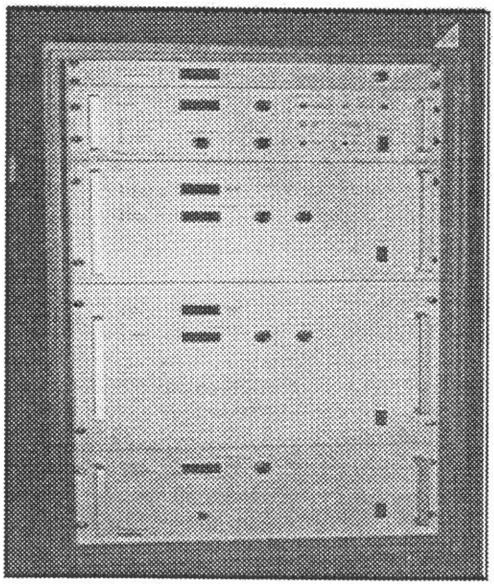
Repetition rate:
pilot mode..0.5....2 pps
general mode.................................1 pulse per 5 min.
Coherence length.....................................more than 3 m
(typical 5 m)
Pulselength (1/e)......................................more than 25 ns
(typical 35 ns)
Beam diameter..less than 18 mm
Laser head size..1100x450x250 mm
Laser head weight.....................................30 kg

INCLUDES:
- 3 Power suppliers
- Water / water heat exchanges
- Cables, internal water pipes
- Accessories



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Specialists in standard and custom lasers for Holographic applications

AOS XI - Conference Preview

*This a **provisional** list of presentations (both oral and poster) to be delivered at the AOS XI conference in Adelaide. This list was compiled on the 13th of November, and does not contain all of the modifications requested at that time. The presentations have been divided up into several topics which are intended to make the list readable. These topics are **entirely independent** of the final sorting for AOS XI, and, since they are based only on the talk titles, are probably of limited value in determining the content of a presentation. Please also note that author lists have been truncated in certain instances to save space.*

3D Data storage

Two-photon-absorbed photopolymerization for three-dimensional microfabrication .... *O Nakamura, S Maruo and S Kawata*
Three-Dimensional Optical Memory in Two-Photon Bleaching Material .... *D.J. Day, S.P. Schilders and Min Gu*

Atom optics

A detailed study of velocity selective coherent population trapping using a bright atomic beam .... *D. Milic et al*
A Magnetic Waveguide for Cold Atoms .... *S. Nic Chormaic, J. A. Richmond, B. P. Cantwell and G. I.Opat*
A variable feedback tunable diode laser for atom optics .... *P. Fox, M. Walkiewicz, P. Farrell & R. Scholten*
Applied atom optics: a bright metastable helium atomic beam .... *M Hoogerland, D Milic, W Lu, K Baldwin and S Buckman*
Atomic Coherence Effects on an Optically Pumped Rubidium Vapour in Static magnetic field .... *JW Jun and HS Lee*
Atom Lithography for the Production of Nanoscale Structures .... *W. Lu, K.G.H. Baldwin, M.D. Hoogerland and S.J. Buckman*
Correct description of pumping and damping for an atom laser .... *J. Hope, G. Moy and C. Savage*
Magnetostatic optics for ultracold atoms .... *AI Sidorov, DC Lau, GI Opat, RJ. McLean, WJ Rowlands et al.*
Manipulating Microkelvin Cooled Caesium Atoms using evanescent light fields....*B.D. Cuthbertson, D. Gordon, J.H. Eschner et al*
Mirrors and diffraction gratings for matter waves .... *Chris Westbrook*
Nonlinear dynamics of a laser-guided atomic field .... *B. C. Sanders, Weiping Zhang, S. Dyrting, Weihan Tan*
Optical detection of atomic superfluid state in a degenerate Fermi gas .... *W Zhang, RG Hulet and CA Sackett*
Quantised circular motion of a trapped condensate in laser fields .... *K-P Marzlin and W Zhang*
Transverse Laser Cooling of a Rubidium Beam .... *M. Walkiewicz, P. Fox and R. Scholten*
Spinning a Bose-Einstein condensate by Laguerre-Gaussian laser beams .... *K-P Marzlin and W Zhang*
The Theory of the Atom Laser .... *G. Moy, C.M. Savage,*
Using the Quantum Coherence Between Bose-Einstein Condensates .... *C.M. Savage, J. Ruostekoski and D.F. Walls*
Laser induced Fluorescence from Single Atoms in Several Wave Packets .... *J. A. Richmond et al*
Ground state and quasiparticle Excitations of a double BEC .... *D Gordon and CM Savage*

Detectors

A wide band photo-thermoelectric contactless YBCO:BiSb thick film bolometer : design considerations *M.M.Kaila and G.J.Russell*
Optical radiometry with a trap detector .... *J. L. Gardner*
Optical wide band thick film YBCO bolometer .... *M.M.Kaila, J.W.Cochrane, G.J.Russell*

Fibre optics and waveguides

Characterisation of D-fibre and Tapered Fibre Sensors using scanning near field optical microscopy and atomic force microscopy ... *Shane T. Huntington et al*

Efficient Coupling of a Laser to a Waveguide Using a Taper Designed by Conformal Mapping .*A.E. Ash, M.W. Austin, & J.D. Love*
Fabrication of Optical Fibre Bragg Gratings using a Frequency-Doubled copper vapour laser .... *CJ Paddison et al*
Energy level processes in heavily-doped Er3+: fluorozirconate glasses .... *V.K. Bogdanov et al*
Fibre and waveguide Refractive Index Measurements with AFM Resolution .... *Shane T. Huntington et al*
Imaging concentration profiles in Pr3+ Nd3+ codoped ZBLANP Fibre .... *I.R. Mitchell et al*
Modelling of multiline Brillouin/erbium fibre lasers .... *D Yu. Stepanov and GJ Cowle*
Observation of self-written waveguides .... *TM Monro, D Moss, M Bazylenko, CJ de Sterke and L Poladian*
Optical fibre temperature sensing based on the fluorescence intensity ratio from neodymium Md3+ doped silica fibre*J.C. Muscat et al*
Production of wavelength-tunable chirped in-fibre Bragg gratings with a simple prism interferometer.....*M Vasiliev, DJ Booth et al*
Thermalisation of the 4F9/2 and 4I15/2 Levels of Dy3+-Doped Silica Fibre .... *Scott Wade, Gerard Monnom, et al*
Waveguide devices made with ion microbeam technology .... *M.L. von Bibra, M. Bromley and A. Roberts*
Grazing-angle scattering of optical waves in periodic Bragg arrays .... *D.K. Gramotnev*
Extremely asymmetrical scattering of optical waves in non uniform periodic Bragg arrays .... *D.K. Gramotnev and D.F.P. Pile*

Filters

Construction of high-quality narrow-band holographic filters .... *AY Tikhomirov, J. Munch, T Mckay and J.Staromlyska*
Faraday Anomalous Dispersion Optical Filter in Rubidium .... *D.L. Phelps, C.J.Vale, H McKee and P.M. Farrell*
Recent developments in tunable narrow band filters .... *C.H Freund, RP Netterfield, DJ Drage et al*
Liquid Crystal Tunable Lyot Filters: Design and Applications .... *J.Staromlynska, S.M. Rees and M.P. Gillyon*
Determining the properties of a Fabry-Perot cavity using radio frequency techniques .... *Karl Baigent et al*

Imaging and holography

Interferometry and coherence effects

Lasers

Laser ablation

Materials

Microscopy

Nonlinear optics

Optics in medicine

Optical instruments

Optical fabrication and testing

AOS XI *Provisional* Timetable for invited and oral presentations

Please note that the following timetable is only tentative at this stage. Check the conference web page for poster papers and updates to this timetable. Note that invited talks are 45 minutes and oral presentations are 15 minutes. The dimensions of the poster boards are 1800 mm (horizontal) x 1200 mm (vertical) with the bottom edge about 600mm above the floor.

Also, don't forget the associated workshops which will take place before the conference (on the Monday and Tuesday).
* *Quantum Coherence and Information Processing*
* *Propagation and Imaging Science*
* *Thermal Noise Limitations in Gravitational Wave Interferometry*

Wednesday

8:30		registration
9:00		Opening and pesentation of AOS Medal
9:15		1997 AOS Medal Lecture **Engineering gain -- developments in high-power, high-beam-quality copper lasers** Prof. Jim Piper, Macquarie University
10:00		Coherent Scientific Plenary Lecture **Mirrors and Diffraction Gratings for Matter Waves** Dr Chris Westbrook, Institute d'Optique, Orsay, France
10:45		coffee
11:00		**Magnetostatic Optics for Ultracold Atoms** Dr Peter Hannaford, CSIRO
	Atom optics	Lasers
	Using the Quantum Coherence Between Bose-Einstein Condensates C.M. Savage, J. Ruostekoski and D.F. Walls	**Power Scaling In Diode Array End-Pumped Lasers** Justin L. Blows, Judith M. Dawes, James A. Piper
	Spinning a Bose-Einstein condensate by Laguerre-Gaussian laser beams K-P Marzlin and W Zhang	**Efficient frequency conversion of a standard 1064nmNd:YAG laser to 580nm** H.M. Pask and J.A.
	Applied atom optics: a bright metastable helium atomic beam M Hoogerland, D Milic, W Lu, K Baldwin and S. Buckman	**High average power Q-switched second harmonic generation with diode pumped Nd:YAG laser** PK Lam, DE McClelland and H-A Bachor
12:30	lunch	
13:30	**Concepts of NMR in nonlinear and quantum optics** Dr Neil Manson, ANU	
	Quantum optics	Spectroscopy
14:15	**Adaptive single-shot phase measurements-the full quantum theory** H.M. Wiseman and R.B. Killip	**Light emission from fractional-dimensional excitons** A Thiligam
14:30	**Quantum aspects of laser noise** TC Ralph, CC Harb, BC Buchler, EH Huntington and H-A Bachor	**First observation of the He 1S - 2S transition: a new measurement of the ground state Lamb shift** Dr. Ken Baldwin
14:45	**Quantum state engineering of atoms** B.V.H. Varcoe, R.T. Sang, W.R. MacGillivray and M.C. Standage	**Time-resolved IR-UV double resonance laser spectroscopy of symmetry-breaking processes in acetylene molecules** Brian J. Orr, Mark A. Payne and Angela P. Milce
15:00	posters (concurrent trip to local laser industries 2hrs)	
19:30	Public Lecture **Trapped ions, Schrödinger's cat, and quantum computation** Dr. Dave Wineland, NIST, USA	

Thursday

8:30	**Modern Femtosecond Lasers: Spectral provision from X-rays to T-rays** Prof. Wilson Sibbet, St Andrews University	
9:15	**Optical Spatial Solitons in Saturating Nonlinear Media** Prof. Barry Luther-Davies, ANU	
	Lasers/Nonlinear Optics	Microscopy
10:00	**Ultra-short pulses generated by mode-locked lasers with either slow or fast saturable absorber response** Akhmediev N., and Ankiewicz, A	**Image improvement using adaptive optics on a confocal microscope.** P.W. Fekete, C.J. Cogswell, M.R. Arnison, J.O'Byrne
10:15	**Controlling Chaos in the Optically Pumped Far Infrared Ammonia Laser** R. Dykstra, D.Y. Tang, A. Rayner and N.R. Heckenberg	**Quantitative Optical Phase-Amplitude Microscopy** A. Barty, D. Paganin, K.A. Nugent and A. Roberts
10:30	coffee	
10:45	title to be announced OSA representative	
	Nonlinear Optics	General Optics - components
11:30	**Second Harmonic generation imaging using Femtosecond pulses.** R. Gauderon, P.B. Lukins, C.J.R. Sheppard.	**A Prototype Bimorph Mirror developed for the Anglo-Australian Telescope.** Huawei Zhao, Pal W. Fekete and John W. O'Byrne
11:45	**Collision of photorefractive spatial solitons** W.Krolikowski, B Luther-Davies, SA Holmstrom	**New birefringent optical coatings - will they replace or complement crystal optics** I.J. Hodgkinson
12:00	**A variable pulse length laser used for continuous tuning through nonlinear optical mechanisms** P. Klovekorn and J. Munch	**Global optimisation in optical thin film design** DG Li and AC Watson
12:15	**An Injection-Seeded Lithium Niobate Optical Parametric Oscillator: Operating Characteristics and Spectroscopic Applications** Glenn W. Baxter, Hans-Dieter Barth and Brian J. Orr	**Ion-assisted deposition of optical thin films** D. Drage and R. Netterfield
12:30	lunch	
13:30	**LIGO and the Optical Challenges in the Detection of Gravitational Waves** Prof. Barry Barish, Caltech/ Principal Investigator of LIGO	
	Nonlinear Optics	Interferometry - Gravitational waves
14:15	**Observation of self-written waveguides** TM Monro, D Moss, M Bazylenko, CJ de Sterke and L Poladian	**The VIRGO interferometer** Adalberto Giazotto VIRGO collaboration, Pisa
14:30	**Metastable chaos in the ammonia ring laser** R.G. McDuff, R. Dykstra, J.T. Malos, .R. Heckenberg	**Experimental demonstration of resonant sideband extraction in a Sagnac interferometer** DA Shaddock, MB Gray, H-A Bachor and DE McClelland
14:45	**Three-Dimensional Optical Memory in Two-Photon Bleaching Material** D.J. Day, S.P. Schilders and Min Gu	**LIGO optics fabrication** A.J. Leistner, J.Seckold, M.Suchting, R.Bulla, E. Pavlovic, P.Lennox, J. Schmidt, G. Davis and W. Stuart
15:00	**posters**	

Friday

8:30	**Invariant pattern recognition:scale and out-of-plane rotations** Prof. Henri Arsenault, Universite Laval	
9:15	Photoscreening the young and the elderly -- detecting refractive errors and mapping cataracts Prof Ian Hodgkinson, Otago University	
	Medical applications	General optics - imaging
10:00	**Laser-activated protein solder microsurgical tissue repair** K.M. McNally, A. Lauto, J.M. Dawes, R.I. Trickett, A.E. Parker and J.A. Piper	**Experimental and simulated studies on the performance of an ATR system against imagery containing extremely cluttered natural scenes** P Miller, M Royce, P Virgo, M Fiebig and G Hamlyn
10:15	**Dye-assisted diode laser ablation of carious dentine and enamel** K.M. McNally, B.R. Gillings and J.M. Dawes	**Effect of particle size and concentration on microscopic imaging through a turbulent medium** S.P. Schilders, X.S. Gan and M. Gu
10:30	coffee	
10:45	**Optics and lasers in the preservation of vision** Prof. Doug Coster, Flinders University	
	Nonlinear Optics	General Optics - interferometry
11:30	**Laser Frequency Correction Using Phase Sensitive Detection of Stimulated Photon Echoes** G.J. Pryde, M.J. Sellars, T.R. Dyke and N.B. Manson	**Multiple Beam Plane parallel plate shearing interferometry for differential interference contrast.** K. Matsuda, M. Roy, P.W. Fekete, T. Eiju, C.J.R. Sheppard and J.W. O'Byrne.
11:45	**Linear and nonlinear optical properties of poly(p-phenylenevinylene)(PPV) in a polymeric matrix** A. Samoc, M. Samoc, B. Luther-Davies,D. Fotheringham, R.M. Krolikowska and M. Woodruff	**A 300mm Aperture Phase-Shifting Fizeau Interferometer** P.S. Fairman, B.K. Ward, B.F. Oreb and D.I. Farrant
12:00	**"Constants of Motion" in Nonlinear Optics** Colin Pask	**Accuracy of scalar diffraction by a dielectric cylinder** Duncan Butler and Greg W. Forbes
12:15	**Imaging concentration profiles in Pr3+ Nd3+ codoped ZBLANP Fibre** I.R. Mitchell, B.P. Petreski, S.P. Schilders, P.M. Farrell, G.W. Baxter andM. Gu	**Ultrafast Ablation of Carbon with High-Pulse-Rate Nd:YAG laser** A.V. Rode, EG Gamaly and B Luther-Davies
12:30	lunch	
13:30	**Improvement of ground-based telescope resolution using micro-electro-mechanical deformable mirrors** Prof. Michael. Roggemann, Wright-Patterson/ Michigan Technological Univ.	
14:15	**posters**	

NEWS from WARSASH Scientific

Piezoelectric Microscope Objective Positioner

Warsash is proud to announce a new device from PI, that offers the ultimate in fast, accurate microscope focussing. The compact P-722 and P-723 PIFOC microscope objective positioners feature 350mm piezoelectric travel, a resolution of 1nm (open loop), the straightness of travel ≤ 5 arcsec and a fast settling times of only 20-30 ms.

The PIFOC is compatible with standard microscope objectives and can be mounted on almost any microscope by simply screwing the units between the turret and the objective. The optical path is increased by only 13mm (¥ path length microscope required). Standard threads are W 0.8X1/36", other threads are available on request.

The positioners are equipped with low voltage piezoelectric drives (0 to 100V) integrated into a sophisticated flexure guiding system. The force exerted by the piezo drive pushes a flexure parallelogram via an integrated lever mechanism. The wire EDM cut flexures and levers are Finite Element Analysis, modelled for zero stiction/friction and extraordinary guiding precision. The LVDT (Linear Variable Differential Transformer) displacement sensor equipped versions, can be operated in closed loop providing repeatabilities of 20 nm.

Applications for this Piezoelectric Microscope Objective Positioner include confocal microscopy, scanning interferometry, surface structure analysis, bio-technology, semiconductor test equipment.

Uniform Light sources

Labsphere, the world's leader in integrating sphere and diffuse reflectance technology have extended their wide range of uniform source systems. Used as radiometric standards, their product line has grown from standard white light sources to include high-intensity, colour and sensitometer sources. System hardware and software are designed to support applications in remote sensing, electronic imaging and thermal imaging.

Integrating sphere uniform light sources provide perfectly uniform scene illumination for imager calibration. Large aperture uniform sources are standard equipment for calibrating aerospace remote sensing radiometers and imagers. Smaller aperture sources provide illumination for correcting CCD camera response, back illumination in film digitisers and for front illumination in document scanners.

White light sources provide exceptionally uniform luminance over the full exit port diameter of the integrating sphere. Luminance ranges are from 5 to 125,000 foot-lamberts depending on the sphere size, with uniformity greater than 95%.

Red Green Blue colour sources allow the user to generate a virtually infinite variety of uniform colour output at the sphere exit port. Systems are ideal for calibration of colour instruments, architectural lighting studies, simulation of uniform spectra for colour displays, materials degradation research and human vision research.

Sensitometer Sources are designed for test and evaluation of photo-sensitive materials including colour, infrared and black and white films. System options accommodate white light applications, infrared applications and spectral analysis. Labsphere Uniform Source System demonstration software is also available.

Ultra High Resolution PZT Translator

The P-410 Plco from Physik Instrumente is a new series of closed loop Piezo actuators that combine the advantages of piezoceramic actuators and capacitive sensors in a small package. They provide the best combination of resolution , linearity, bandwidth and response of any linear actuator on the market today.

Plco translators were developed for research and production engineers who want higher resolution than the standard strain guage sensor equiped PZT where able to provide, but without the need for the sophistication of the Capacitive Sensor Equiped PZT flexure Stages.

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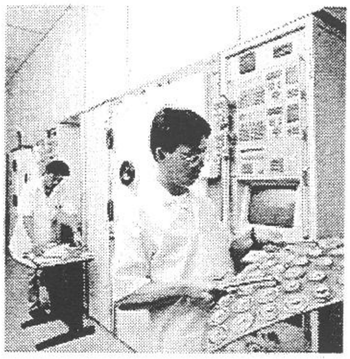
Advanced Thin Films



Coating applied using ion-assisted deposition (IAD) technology have advantages which will give your product the edge. Ions bombard the surface producing a dense film:

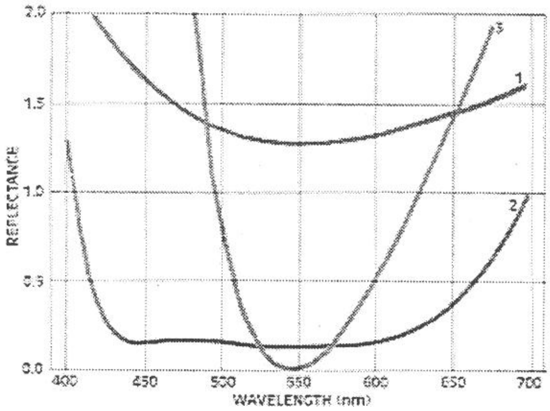
- High durability
- Consistent optical properties
- Smooth surface suitable for lasers

IAD produces tough films without the need to heat the substrate. Temperature sensitive materials can be coated :

- Plastics
- Infra-red optics
- Semiconductors
- Fire optics
- Large optics
- Crystalline material

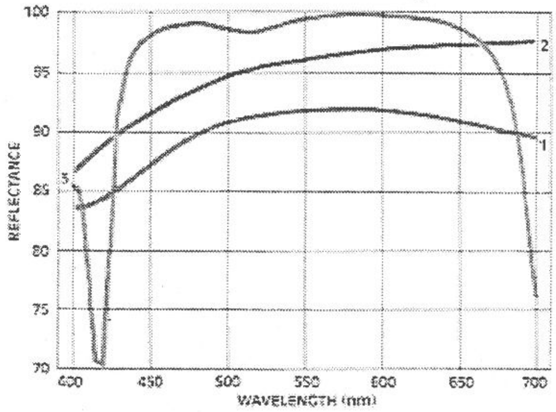
Consult Avimo's staff to discuss how IAD can benefit your products

ATF 1000 Series Anti-reflection Coatings



1. Single layer MgF_2; a historic standard.
2. Board band multilayer in the wavelength range of your choice.
3. V-coating; nearly zero reflectance at a specific wavelength.

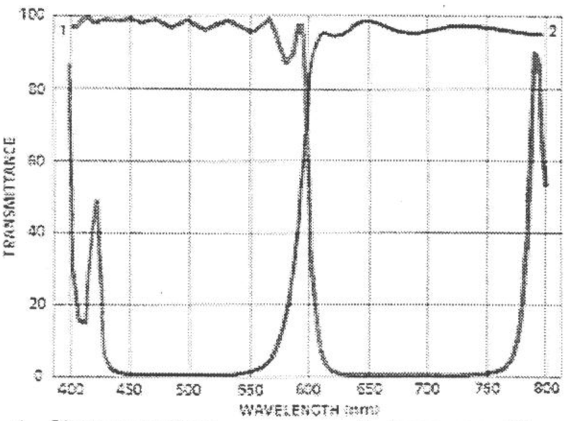
ATF 1000 Series Metallic Coatings



1. First surface aluminium protection with SiO_2.
2. First surface silver with multilayer protection.
3. Enhanced first surface aluminium.

Avimo metallic coatings are protected to withstand environmental extremes. Second surface reflective coatings are also available.

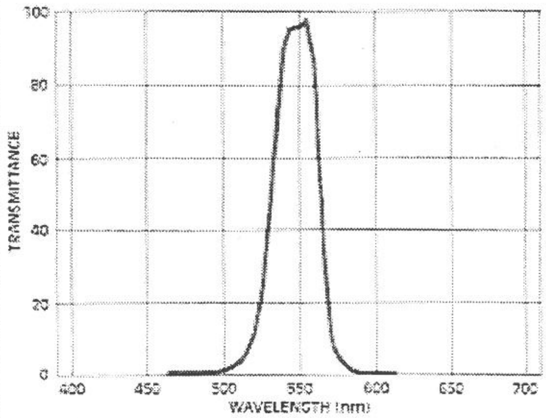
ATF 5000 Series Dielectric Edge Filters



1. Short pass filter. 2. Long pass filter.

The primary wavelength, the slope of the edge, the blocking properties and the transmitting properties can all be designed and controlled to suit your requirements.

ATF 6000 Series Dielectric Bandpass Filters



Avimo will design and produce filters to meet your requirements for central wavelength, the full width at half max and blocking properties.

As a "Center of Coating Excellence" for precision optics, Avimo has developed conventional physical vapor deposition as well as ion-assisted deposition (IAD) technology to produce high performance optical thin films. Choose from our lists of proven coating designs or have our thin film team design a coating to meet your specific needs. For further details, please contact :

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A Subsidiary of Avimo Group Ltd
14 Fifth Lokyang Road . Singapore 629763
Tel : 2655122 . Fax : 2651479 . E-mail : aeo@pacific.net.sg

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1997 AOS Membership List

The names that appear in this list are of those members who had paid their 1997 membership fee by the 14th of November, 1997, and who had also supplied a contact address. If you feel your name was incorrectly left off this list, or your contact details are incorrect, please contact the AOS Treasurer, Barry Sanders.

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