make the best and most efficient use of the resources available. In a time when financial difficulties appear just about everywhere, such an opportunity seems to be an indispensable ingredient.

LHC meets the condition in an excellent way. Although the energy is less than one-half of that of the SSC, the machine's discovery potential remains very high, especially since no definite thresholds for new physics are known at present in the energy gap between SSC and LHC. Maybe more important is the fact that the interesting events are not the collisions between the accelerated protons, but rather those between their constituents, namely quarks and gluons. These particles have a broad energy distribution inside the protons, with a tail at the high-energy end, so lower proton energies can partly be compensated for by higher collision rates. The cost of the LHC is very favourable since space had been left in the LEP tunnel to accommodate the LHC magnets. LHC thus guarantees a full exploitation of the initial investment. In addition, the whole injection system made up of several of CERN's accelerators is in place and meets all the requirements, not only for protons but also for heavy ions. Finally, the cryogenic system installed for LEP as well as other parts of the infrastructure can also be used. It therefore seems only reasonable that CERN Council confirmed in December that LHC is the future project for CERN; a positive decision to go ahead is envisaged for later this year.

The incoming Director-General of CERN of course now has the delicate task of finding ways to finance the project without a significant increase in contributions from CERN Member States. This raises the question of Non-Member State participation. There is full agreement that the LHC experiments should in principle be open to all physicists, but it is understandable that the Member States will request adequate contributions towards the construction of LHC, and maybe also for its operation. Since full membership seems to be unrealistic for some countries, new models for participation will have to be developed, especially for the USA and Japan. Since the LHC instead of "the SSC will be the flagship for the world's high-energy physics program" (O'Leary) let us hope that these problems can be settled in the near future.

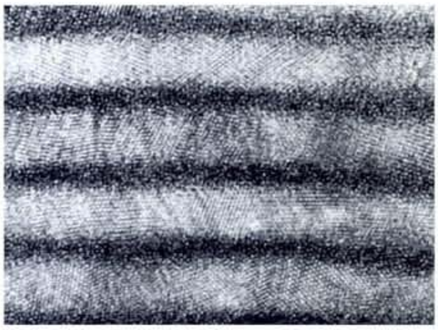
The operation of LHC is planned to start in 2002. In the meantime, several opportunities are offered to physicists and there is therefore no reason for defeatism because of the SSC decision. There is a strong hope that Fermilab's TEVATRON will soon discover the top quark (a determination of its mass would provide a very important input for the Standard Model). LEP is presently undergoing an upgrading to higher energies with the aim of measuring precisely the mass of the W-boson, another important parameter for the theory, and of studying other features of the Standard Model. HERA at DESY has only just started its research programme and exciting results can be expected. A B-factory has recently been approved for SLAC in the US, the approval of a second is imminent in Japan, and in China and Russia discussions for the construction of tau-charm factories are continuing. Elementary particle physics is still a flourishing field and we all hope that *New Scientist* will be proved right when it wrote "... the death of the SSC will leave the scientific community sadder but wiser — and perhaps fitter for the future".

EUROPHYSICS INDUSTRIAL WORKSHOP

Exploiting X-rays at the Nanoscale Continues to Challenge

The convivial organization of the EIW entitled *Nanometre-scale Methods in X-ray Technology* (the 9th in the EIW series) held on 11-13 October 1993 in Veldhoven allowed a remarkably fruitful exchange of ideas concerning the various challenges facing those exploring and using the interaction of X-rays with solids at the nanometre scale. One only needs to consider some of the major applications of multilayer mirrors to understand the significance of the field. These mirrors are playing an increasingly important rôle in imaging and spectroscopic applications for X-ray solar and stellar astrophysics [Christensen, Danish Space Research Institute], soft X-ray spectroscopy of laser plasmas [Platonov, IAP, Nishnii Novgorod] and X-ray fluorescence spectrometry [Urch, University of London; Vrebos, Philips Analytical X-Ray]. Several projects dealing with multilayer optics for soft X-ray projection lithography are also being pursued [Heinzmann, University of Bielefeld; Platonov; Louis, FOM Rijnhuizen; Artyukov, Lebedev Physics Institute, Moscow]. They emphasize the preparation of high-reflectivity multilayers and laterally structured reflection masks.

Considerable theoretical and experimental work is also devoted to laterally structured thin films, crystals and multilayers. High-resolution XRD at both glancing incidence and large angles has been used to study crystal truncation rod scattering from surface gratings etched in semiconductor materials [van der Sluis, Philips Research Labs; Baumbach, ILL, Grenoble; Tolan, University of Kiel]. New devices based on multilayer surface gratings have been designed, and manufactured. Successfully tested are thick zone plates [Vinogradov, Lebedev Physics Institute], Bragg-Fresnel multilayer lenses, lamellar multilayer gratings, and beam splitters prepared using technology derived from microelectronics for the microstructure fabrication. A major effort has been made at the same time to explain the performance of these devices on the basis of dynamical theory [Erko, IPMT, Chernogolovka; André, University of Paris].

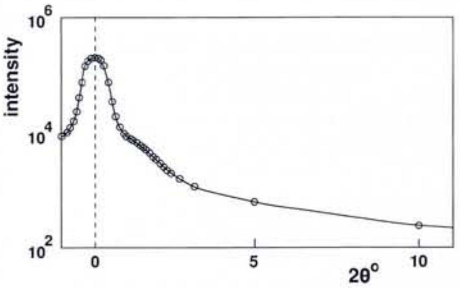


A nanoscale Co/W multilayer.

In general, the field of nanometre-scale methods in X-ray technology can be subdivi-

Out-of-Plane Scattering Offers Improved Characterization of Multilayers

Measurements over a large range of momentum transfers $Q_{||}$ parallel to the sample surface are required to separate out the various components of the diffuse X-ray scattering from multilayers, so that structural features such as interface roughness, amorphicity, and the degree of conformality between successive layers can be characterized. However, in the standard method of rocking the sample about the position of specular reflection, the range of $Q_{||}$ that can be achieved is limited by the sample surface. Secondly, the component of momentum transfer perpendicular to the surface varies so the observed scattering is affected by changes in the sample's transmissivity.



Low-angle diffuse scattering intensity, integrated over the exit angle, of an amorphous W/C multilayer for an angle of incidence of 1.48°. The intensity is plotted as a function of 2θ, where θ the angle between the incident beam and the detector in the plane of the surface, and sin θ is proportional to the momentum transfer $Q_{||}$ parallel to the surface.

A way around these problems was described at EIW-9 by Salditt *et al.* The new method is based on out-of-plane scattering, with a scattering geometry which is essentially the same as that used for grazing incidence diffraction (constant incident and exit angles on the sample; position sensitive detector moved out of the plane of reflection). Examining a multilayer sample comprising alternating layers of amorphous W (23.7 Å thick) and amorphous C (25 Å thick), they found that the intensity decreased continuously by over two orders of magnitude in the narrow-angle range (see figure). This behaviour can only be explained if, for the sample studied, at small Q diffuse scattering by rough interfaces is much greater than amorphous scattering. Some recent simulations of diffuse scattering by amorphous multilayers will thus need to be reconsidered, thereby illustrating the value of having an improved technique for identifying the various contributions to scattering in multilayers.

ded as follows: 1) new X-ray sources; 2) X-ray techniques for the metrology of nanostructures; 3) nanoscale devices for X-ray applications. The scheduling of the 22 formal presentations and the 25 posters followed this scheme, and plenty of time remained for informal discussion between the 70 or so participants, one-third of whom came from industry.

X-ray sources are clearly an essentially ingredient and the workshop considered progress in the design and construction of new types of sources devoted mainly to industrial applications in lithography. High-power excimer lasers are being tested for generating soft X-ray radiation at 13.5 nm [Bijkerk, FOM Rijnhuizen], while a compact synchrotron radiation X-ray source centred on the critical wavelength of 0.84 nm is now available commercially for routine operation [Kempson, Oxford Instruments].

X-ray Reflectometry Develop

In the area of submicron local analysis of microstructures, glancing incidence X-ray reflectometry (GIXR) is now well-established for determining thickness, surface roughness and, more generally, electron density profiles in thin films and layered materials. It can be regarded as complementary to thin-film characterization with X-ray diffraction (XRD), which was discussed by Fewster [Philips Research Labs, UK] and Temst [Katholieke University, Leuven]. Elaborate simulation codes for the analysis of experimental reflectivity curves have become available; they take advantage of Fourier transform techniques [University of Linz; Martin, Lab. Electronique Philips; Bridou, IOTA, Orsay; Voorma, FOM Rijnhuizen] and include refinements such as data correction for sample curvature [Bridou]. The power of the method is increased by adding complementary techniques such as X-ray fluorescence (XRF) and XRD to provide either non-destructive, near-surface analysis with a single instrument [van den Hoogenhof, Philips Analytical X-Ray; Zheludeva, Institute for Crystallography, Moscow]. Spectroscopic and kinetic ellipsometry has also been incorporated for use with *in situ* studies of ultra-thin film growth [Luken, ESRF, Grenoble]. The application of synchrotron radiation as the X-ray source permits an extension of the technique to energy-dispersive reflectivity measurements [Hoghoj, ESRF], and to soft X-ray reflectometry [Krumrey, ESRF] which is being used to calibrate optical devices. The latter illustrates the increasing number of possibilities for research and applications in the soft X-ray spectral range.

Interface Roughness a Key Issue

Complementary to GIXR is glancing incidence X-ray scattering — a relatively new method for surface, thin-film and multilayer characterization, and the subject of intense research, with the interpretation of experimental results based mainly on the distorted wave Born approximation (DWBA). The combination of glancing incidence X-ray reflectivity and scattering measurements should lead to an improved description of surface roughness in terms of the lateral correlation distance or the frequency spectrum [Sinha, Exxon, USA; de Boer, Philips Research Labs, Eindhoven]. The particular case of scattering by periodic multilayers, which have important practical applications, was being studied by many contributors with the view to determining a model for the replication of interface roughness on passing through the multilayers [Holý, University of Brno; Spiller, IBM, USA; Plotz, University of Linz]. A tool for understanding the physical origin of the X-ray scattering, which will allow a quantitatively unambiguous interpretation of the measurements, was introduced by Salditt [University of Munich] and is summarised in the insert.

The DWBA theory accounts for the resonant phenomena which are observed in non-specular scattering from periodic multilayers, and it highlights their connection to X-ray standing waves (XRSW). XRSW generated during XRF measurements of crystalline or layered synthetic structures can be used to characterize ultra-thin layers deposited on these structures [van den Hoogenhof, Philips Analytical X-Ray; Zheludeva] or included in the bulk [Kovalchuk, Institute of Crystallography, Moscow].

Improving Multilayer Fabrication

The development of nanoscale X-ray technology is strongly related to progress in the design and fabrication of nanoscale devices based on layered synthetic microstructures. Some participants reported that the reflectivity of multilayers made by thermal evaporation is increased by ion bombardment of each layer immediately after deposition, and by optimizing the temperature of the mirror. Ion bombardment during deposition is also applied to produce graded refractive index profile multilayers by controlled atom mixing [Verhoeven, FOM Amolf; Louis, FOM Rijnhuizen; Schlatmann, FOM Amolf]. High quality Si/SiN and Si/SiO multilayers produced by reactive sputtering have shown selectivity and thermal stability better than those of the refractory-metal containing Mo/Si multilayers commonly used for EUV mirrors [Houdy, University of Evry]. Magnetron sputtering permits one to produce W/Sb multilayers with periods down to 1 nm, thereby opening the way for normal incidence soft X-ray mirrors in the crucial "water window" spectral range. A maximum normal incidence reflectivity of 13% at a wavelength λ of 4.47 nm has been achieved with a Fe/C multilayer deposited on a silicon wafer [Salashschenko, Nishnii Novgorod].

Industrial applications of soft X-ray projection lithograpy at $\lambda = 13$ nm will require sources that have average X-ray power levels which are at least an order of magnitude greater than those usually found today. Optimization of deposition techniques tends to focus on Mo/Si multilayers having a reflectivity above 60% at normal incidence. Achieving this value will not be easy because it is equivalent to only 10% less than the theoretical reflectivity of perfect multilayers [Platonov; Louis].

The proceedings of EIW-9 will be published in *Journal de Physique III* and it was decided to organize a follow-up meeting, probably in Germany in 1995. Finally the Co-chairmen recognize that the workshop would not have been possible without generous financial support from the Commission of the European Communities, Foundation Physica, Newport B.V., Philips Analytical X-ray, and Philips Research Laboratories.

D.K.G. de Boer, *Eindhoven*
J.P. Chauvineau, *Orsay*

EUROPHYSICS INDUSTRIAL WORKSHOPS

Thermal Microsensors: Their Bases, Principles and Applications (EIW-10)

25-28 April 1994

Treff Hotel Panorama, Oberhof, Germany
(40 km from Erfurt)

To promote a wider application by industry of the latest results of research and development.

Sessions: introduction; materials; technologies; applications (4 invited reviews, 30 contributions & posters).

Fee (incl. registration, accomodation, full board, hotel facilities, excursion):
- EPS Members and staff members of EPS Associate Members: DM 750.-
- Others: DM 900.-

Registration deadline: 11 March 1994

Information: J. Müller, Institut für Physikalische Hochtechnologie e.V. (IPHT), Postfach 10 02 39, D-07702 Jena
(tel.: +49-3641-85 25 37; fax: +49-3641-85 25 87).

Industrial Applications of Positron Annihilation (EIW-12)

10-12 March 1994

De Rosep Hotel/Conference Centre, Oisterwijk, The Netherlands
(near Tilburg)

To promote industrial applications of positron annhilation by bringing together industry and specialists from laboratories.

Sessions: Defects in metals; semiconductor materials; technical applications of PET; future developments (invited review talks, contributed presentations & posters).

Fee (incl. registration, accomodation, full board, proceedings):
- EPS Members and staff members of EPS Associate Members: NLG 1050.-
- Others NLG: 1300.-.

Information: Prof. A. van Veen, IRI, Delft University of Technology, Mekelweg 15, NL-2629 JB Delft
(tel.: +31-15-78 38 77; fax: +31-15 78 64 22).

PLASMA PHYSICS DIVISION

Call for Nominations

The term of office of the present Division Board has ended along with the mandate of its Members. The following Board Members are considered eligible for re-election:

J. Bakos (Vice-Chair), Budapest
C.-G. Fälthammar, Stockholm
M. Siegrist, Lausanne
F.W. Sluijter (Chair), Eindhoven
P. Sunka, Prague
F. Wagner, Garching

The Chairman seeks nominations for a new Board (which should have 12 elected members) and asks that they be sent before **16 March 1994** to Mrs. M.A. Coopmans-van Basten, Dept. of Applied Physics, Eindhoven University of Technology, Postbus 513, NL-5600 MB Eindhoven (fax: +31-40-44 52 53; email: ria @ vsrs.ni.phys.tue.nl).