BOLOGNA AND CAMBRIDGE UNIVERSITIES

AN ELECTRON MICROSCOPE TWINNING PHENOMENON?

Ugo Valdrè[1] and Peter Hawkes[2]

We cannot say that these universities are twinned in any formal sense, though they were founded within little more than a century of each other: Bologna in (nominally) 1088 and Cambridge in 1209. But the close scientific relations and interactions over a period of some 50 years in the domain of electron microscopy might suggest some form of twin relationship though not a true symbiosis. The true twinning phenomenon was essentially between the Metal Physics Group and Electron Microscopy Section of the Cavendish Laboratory and the Electron Microscopy Centre of the Istituto di Fisica of the University of Bologna. Here we recapitulate the events that led to the ultimate step: the dispatch of the drawings for the construction of the first British high-voltage transmission electron microscope from Bologna, where Ugo Valdrè (UV) had taken them for safe keeping, to the Churchill College Archives in the University of Cambridge.

The University of Bologna was the first Italian University to acquire an electron microscope, in 1949, and a Centre for Electron Microscopy (EM Centre) was part of the Istituto di Fisica (from 1989 Dipartimento di Fisica) under the direction of Professor Giorgio Valle (Trieste 1888–Bologna 1953), who launched this project. That first instrument (a CSF model) had electrostatic lenses and a maximum accelerating voltage of 60 kV, which imposed severe limitations.

Electron microscopy in Italy does, however, have a pre-history. The first electron microscope (EM) that arrived in Italy was a Siemens & Halske Übermikroskop ÜM 100; it was ordered in 1939 and installed only in Spring 1943 at the Istituto Superiore di Sanità (ISS, Advanced Institute of Health) in Rome. It was one of the very few EMs that left Germany during the Second World War, the Italian Fascist Government being allied with the Germans. It had an accelerating voltage that could be increased in steps of 20 kV from 40 up to 100 kV and a point-to-point resolution of 5 nm. At the beginning of October of the same year the German Military Command, at the request[1] of the Siemens Firm, took the most valuable components (practically the entire instrument, except the vacuum plant) back to Germany, before the retreat from Rome, on the ground that ISS had paid only the first instalment of its cost and that corresponded to the vacuum system. However, Prof. G.C. Trabacchi, the head of the Physics Laboratory of ISS, managed to convince the Officer in charge of the confiscation to wait till next day. During the night the technical personnel of ISS made measured sketches of the most important parts of the instrument in the hope that they would be able to rebuild it at the end of the war. Trabacchi was the very same person who had built the particle accelerator used by Enrico Fermi in his research. The work of constructing a new instrument started immediately but was delayed because of the irregular supply of electricity and difficulties in obtaining the necessary materials. However the new microscope was completed and put in operation at the end of 1946 (Bocciarelli & Trabacchi, 1946; Trabacchi, 1947).

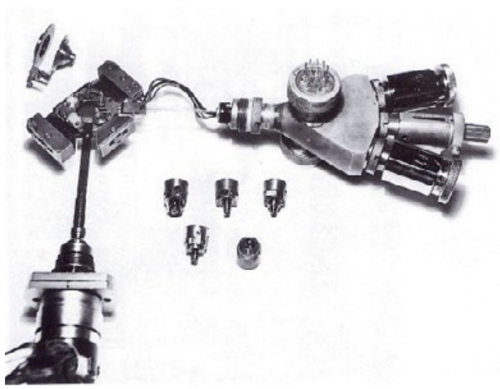

Fig 1: *This shows, upside down, the Elmiskop I (x.y) traverse stage with the triple drive for performing double tilting and rotation of the specimen and carrying electrical connections (permitting sample heating and temperature measurements, for example), the cold finger with a component of the decontamination stage and a selection of specimen holders (for double tilting, heating, rotation, Lorentz microscopy).*

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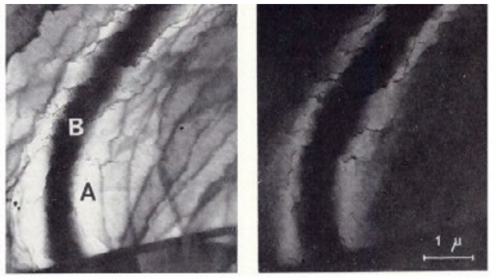

Fig 2: *Left. Anomalous absorption effects at a (111) bend contour in a copper crystal at room temperature. Right. The same area as at left, observed at 400 °C. Images taken at an accelerating voltage of 100 kV. In A the electron beam avoids the atoms and is well transmitted, whereas in position B the electron wave is subject to heavy inelastic scattering.*

In 1956 the Crystallography Section of the Cavendish Laboratory made the first observations on the motion of dislocations in thin metal specimens with the aid of the instrument in the Electron Microscopy Section of the Cavendish and formulated the theory of contrast formation in crystals (Whelan, 2002). This launched the study of the structure of crystalline material in the transmission electron microscope; hitherto these instruments had been used mostly in biology and medicine.

Giorgio Valle was succeeded in 1954 as director of the Bologna Istituto di Fisica by Professor Giampietro Puppi (Bologna 1917–2006), a high-energy physicist. Puppi gave an enormous impetus to his own field of research but also wished to maintain the EM Centre; initially, he gave special attention to ultramicrotomy for the benefit of biologists and medical doctors. He also decided to launch research in a new area, namely, Solid-State Physics, hitherto non-existent in the Istituto di Fisica. The EM Centre was to work side-by-side with the new solid-state group in the formative phase.

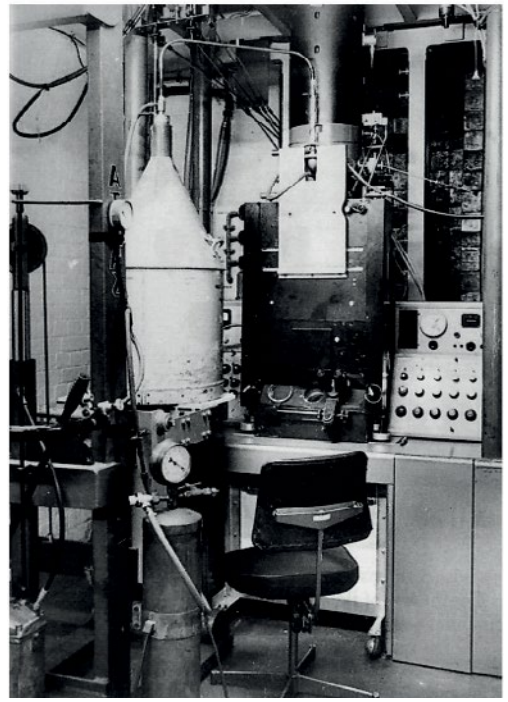

Fig 3: *750 kV HVTEM equipped with a liquid He stage. This set up was used for experiments on superconductors and on the study of the effect of temperature on the preservation of organic specimens under electron irradiation. The liquid helium Dewar was mounted on a trolley and the operator lay stretched on the plane of the console.*

The opening up of this new field of research and the recent awareness of the possibility of seeing the structure of materials with the electron microscope suggested that a new instrument should be acquired and the recently developed methods of electron microscopy adopted. A new electron microscope, a Siemens Elmiskop I, was ordered in 1958 and came into service in 1959. One of us (UV) applied for a NATO study grant for one year, to be spent in the Crystallography Section of the Cavendish Laboratory under the direction of Dr Peter Hirsch (whose 90th birthday was celebrated last year; see Humphreys (2002) for the celebration on the occasion of his retirement in 1992).

The grant application was successful and in November 1960 UV began work in the Cavendish Laboratory on the study of the rearrangement of dislocations in stainless steel during electropolishing. That investigation was important because metallurgists and materials scientists had been accustomed to apply the etch pit and replica methods to the study of bulk metallic specimens, being convinced that thinning was altering the dislocation distribution inside the specimens and hence that no realistic information could be gained on the bulk properties of the material by using thinned foils. (Valdrè & Hirsch, 1963).

In June 1961, an event occurred that made it clear that the technical and scientific areas of competence of the Crystallography Section and the Bologna Electron Microscopy Centre were largely complementary. It was a period of holidays and sabbatical leave; very few people were left in the Group, but Archie Howie, the senior member at that moment, was present (Hirsch and Whelan were in the USA). He mentioned to UV a technical problem awaiting solution for the proper application of the dynamical theory of defect contrast that he and Mike Whelan had developed. The problem consisted in the tilting of specimens within the microscope in any direction through large angles, typically 20 degrees.

UV's first training was as an engineer and, without mentioning what he had in mind to Archie Howie, he started thinking how this problem could be solved. When he returned to Bologna soon after, he discussed the problem with his draftsman and a simple solution was found. Two weeks later, UV returned to the Cavendish with a prototype of a double-tilting cartridge. The Group led by Hirsch,

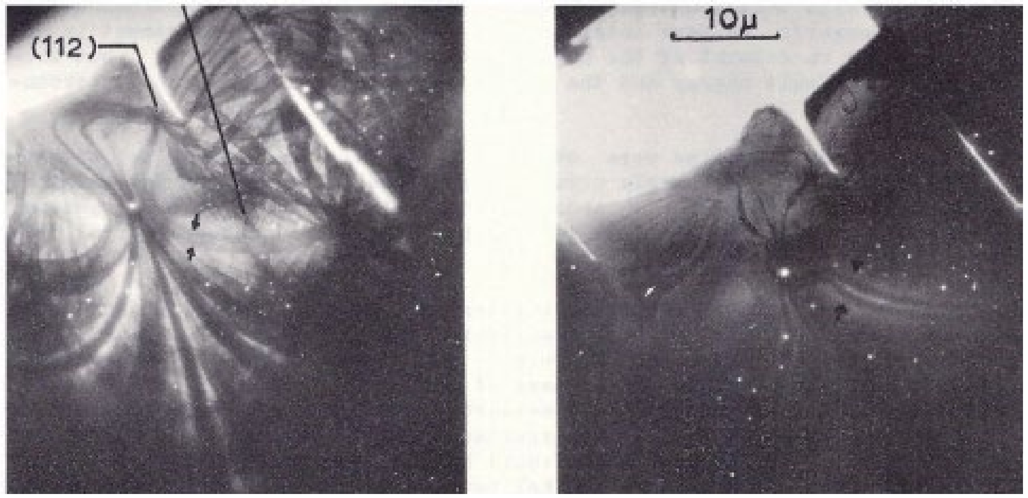

Fig 4: *Left. Image of a lead single crystal taken at liquid helium temperature, below the Debye superconducting transition. Right. The same area observed at room temperature. The decrease in inelastic scattering is evident at low temperature. Accelerating voltage, 500 kV.*

then called the Metal Physics Group (part of the Crystallography Section) had two Siemens Elmiskop I instruments; the newer one, identical with the Bologna microscope, was heavily used but the double-tilting cartridge and stage drive could not be directly mounted in the other Elmiskop, an older model. Archie sent letters to the USA and after a period of waiting for the answer took the decision to modify the old Elmiskop in order to install the new stage, more elegant and far less cumbersome than the stage being constructed at the National Physical Laboratory in Teddington. This was risky because it involved the drilling of an 11 mm hole in the objective lens casing near the polepieces, which could have adversely affected its performance. The

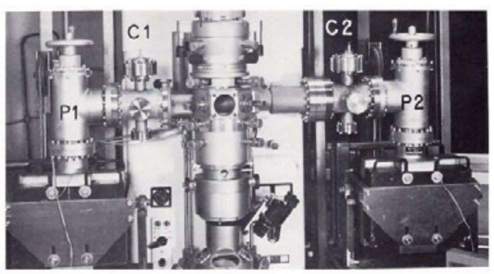

Fig 5: *Elmiskop I equipped with a special specimen chamber for experiments in ultra high vacuum (10^{-8} Torr). The system comprises three differential pumping steps: ion pumps P1 and P2 in addition to the standard pumping system of the microscope. An evaporation source is placed in the intermediate chamber to allow deposition experiments and the study of crystal growth. C1 and C2 are used mainly for pressure measurements.*

installation was a success, thanks to the skill of the technician Freddy Marks.

On his return from sabbatical leave in the USA, Peter Hirsch appreciated the work done and asked UV to design several other types of specimen cartridges: double-tilting and heating (used by several members such as G.R. Booker, P.C.J. Gallagher; L.M. Brown and G.R. Woolhouse and of course Archie Howie and UV) (Figs 1 and 2, Howie & Valdrè, 1964, 1967; Cundy et al., 1969), double-tilting for Lorentz microscopy (J. Jakubovics), double-tilting and cooling down to helium temperatures (Goringe & Valdrè, 1965; 1966; Steeds & Valdrè, 1968; Pozzi & Valdrè, 1971; Capiluppi et al., 1972; Figs 3 and 4). In a collaboration of the Metal Physics Group (K.J. Routledge, R. Vincent, A. Goulden, D. Cherns) and UV with D.W. Pashley and others at the Tube Investment Research Laboratories at Hinxton Hall, Saffron Walden, a special specimen section for studies in ultra-high vacuum was built (Valdrè et al., 1966, 1970; Pashley et al., 1968; Fig. 5). Patent applications were made and obtained by UV in Germany, UK, USA, Japan and Italy. This was possible because he was not a permanent member of the University of Bologna at that time; he was then a "professore incaricato esterno", a sort of freelance with teaching duty defined year by year. Several firms

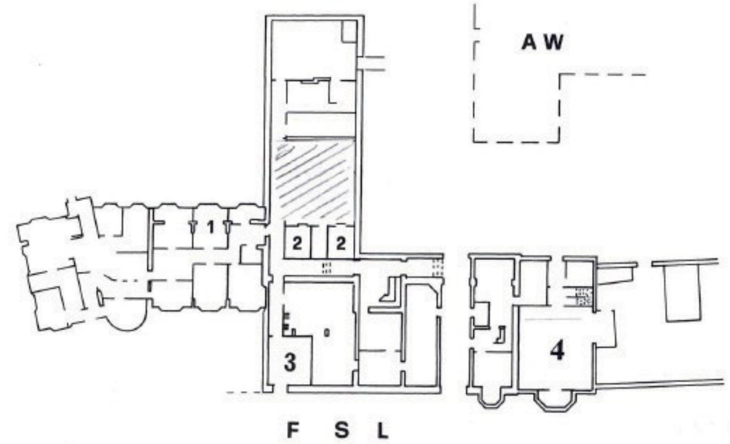

Fig 6: *The Maxwell building at the Old Cavendish Laboratory in Free School Lane (adapted from Nature, 1874, X, 158). 1. Site where the Elmiskop I of the Electron Microscopy Group was installed and where the first observation of the movement of dislocations took place in 1956. 2. Location of the two Elmiskop I microscopes used by the Metal Physics Group. 3. Polishing room. 4. The site where the 750 kV Transmission Electron Microscope (HVTEM) was installed, later equipped with facilities for Scanning Transmission Microscopy (STEM) up to 500 kV, STEBIC, and for Electron Energy Loss Spectrometry (EELS). The whole machine occupied the height of three floors, from the cellar up to the first floor. The hatched area shows approximately the area where the High Resolution 600 kV Electron Microscope (HREM) was installed. AW = Austin Wing building. FSL = Free School Lane with the entrance to the Maxwell building.*

(AEON Labs, Siemens, AEI) obtained permission to fabricate devices covered by the patents.

These collaborative efforts were facilitated from the outset by the fact that both laboratories possessed Siemens instruments; the research funds were provided by P.B. Hirsch until he moved to Oxford University in 1965 to take up the Isaac Wolfson chair of Metallurgy. The Crystallography Section divided: two of the older members (Dr A. Howie and Dr L.M. Brown) remained in Cambridge with some of the other members of the group and formed the new Metal Physics Group UV remained in Cambridge and continued to collaborate with both the new Metal Physics Group (which later changed its name in Microstructural Physics) and the Electron Microscopy Section of Dr Cosslett.

The first official collaboration between the EM Group of Bologna and the Cavendish Laboratory took place in 1968 thanks to a completely unrelated event. In that year the UK again applied for entry into the EEC (European Economic Community) but General de Gaulle, then President of the French Republic, vetoed it. The Italian Government was on the other hand strongly in favour of the entry and, in order to sweeten British bitterness, decided to set up bilateral scientific collaborations with the UK. Two committees were appointed, one by the SERC for Britain and one by the CNR (National Research Council) for Italy. One member of the CNR Committee was Prof. Puppi, the Director of the Istituto di Fisica of the University of Bologna (UV's Director). Puppi was well acquainted with the close contacts UV had established with the Cavendish Laboratory and asked UV if he had a proposal to put forward.

The proposal made by UV, in accordance with his colleagues of the Cavendish, was to investigate the use of the Aharonov–Bohm paradox to improve the contrast and even the resolution in the images obtained from a crystalline material observed in an electron microscope through the optimization of the phase shift in the interference between direct and diffracted beams. The phase shift was to be obtained in a controlled manner by the use of an energized mini-coil placed, in the simplest case, between the direct and one diffracted beam. The three-year research proposal was approved by the two sides and Dr Vernon Ellis Cosslett (1908–

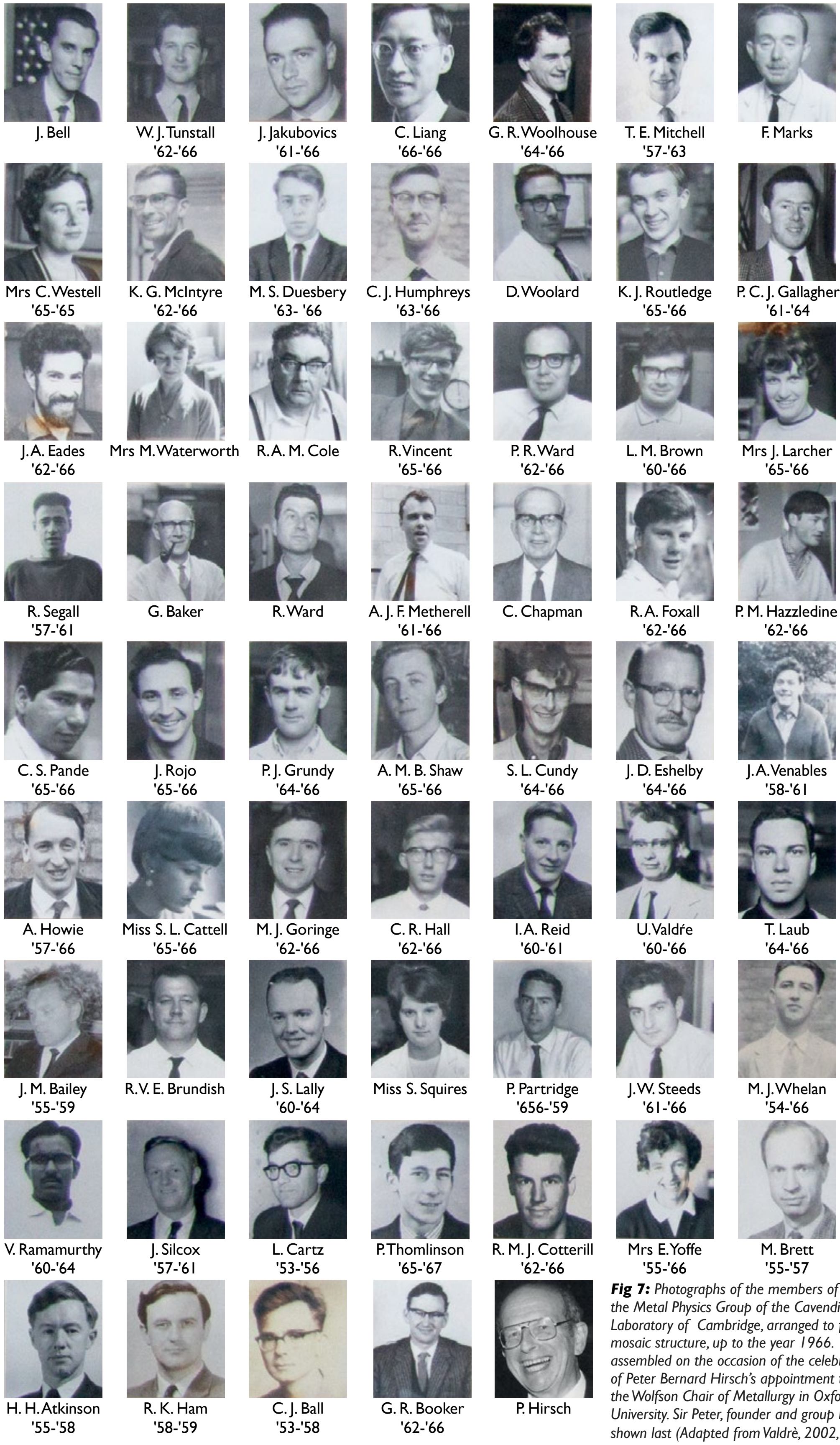

Fig 7: *Photographs of the members of the Metal Physics Group of the Cavendish Laboratory of Cambridge, arranged to form a mosaic structure, up to the year 1966. This was assembled on the occasion of the celebration of Peter Bernard Hirsch's appointment to the Wolfson Chair of Metallurgy in Oxford University. Sir Peter, founder and group leader is shown last (Adapted from Valdrè, 2002, p.13).*

1990), head of the Electron Microscopy Section in the Cavendish Laboratory, was responsible at the British end and UV for the Italian side. The British Group consisted of Drs Peter Chapman and Ed Boyes and Mr Geoff Jones with the occasional help of other technical assistants. The Italian Group comprised research students and three technical assistants whose task was to produce mini-coils and a system of two holes carried by semicircular discs sliding in a controlled manner side by side in the diffraction plane in order to change the distance between the holes until it matched the distance between two diffraction spots. The mini-coil was to be inserted in the space between the holes in the two semicircular discs.

The British Group received the requested funds at the beginning of the collaboration in one lump sum while the Italian Group received only one third of the agreed sum; the second instalment would be given provided a report of activity was submitted at the end of the first year of research. This condition was respected by UV, only to discover that it took one full year to get the second instalment. The same thing happened at the end of the second year. The result was that the British side ended the investigations in three years without achieving the target and the Italian side continued alone, without the support of the instrumentation acquired by the British side, until the fifth year with the achievement of partial results (Valdrè, 1975, 1979). This experience underlines the damage that can be caused by bureaucracy and by short-sighted politicians! Interest in using the Aharonov-Bohm effect for phase contrast has been revived by the work of Chris Edgcombe and others using rings of magnetic material rather than coils.

In late 1972 and early 1973, the Cavendish Laboratory moved from the old site in Free School Lane (Fig. 6) in the centre of Cambridge to the new building on Madingley Road (now J.J. Thomson Avenue).

The next formal collaboration between CNR and SERC started in 1976 and ended in 1980; the British group was led by Dr L.M. Brown assisted by the research students D. Fathy and D.M. Dlamini. The target was the study and the characterization of semiconductor materials and devices by means of a new method, called STEBIC (Scanning Transmission Electron Beam Induced Current), which combined diffraction contrast, induced electrical conductivity and electron energy loss microanalysis (Fig. 8). One of the results was a measurement of the displacement energy of atoms of semiconductor elements and of the damage produced in p-n junction under irradiation by fast electrons (Fathy et al., 1980a, b; Brown et al., 1980; Dlamini et al., 1983).

A third three-year collaboration was initiated in the mid 1980's under the responsibility of Dr A. Howie with the assistance of research students F.J. Rocca and M.N. Mohd Muhid. It was concerned with the subject already tackled in 1970 with Dr R.M. Glaeser of the University of California at Berkeley (Glaeser

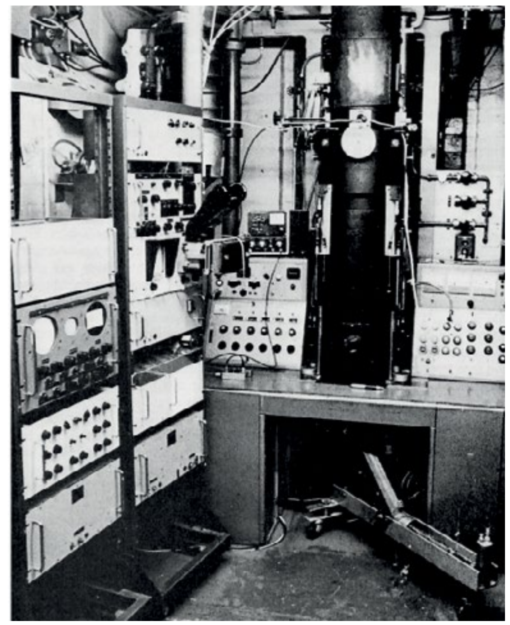

Fig 8: *The Cambridge 750 kV High Voltage Transmission Electron Microscope (HVTEM) equipped with accessories for scanning transmission electron microscopy (HVSTEM) at a maximum voltage of 500 kV, Electron Beam Induced Current (EBIC) performed by the racks on the left side and an Electron Energy Loss Spectrometer placed under the console.*

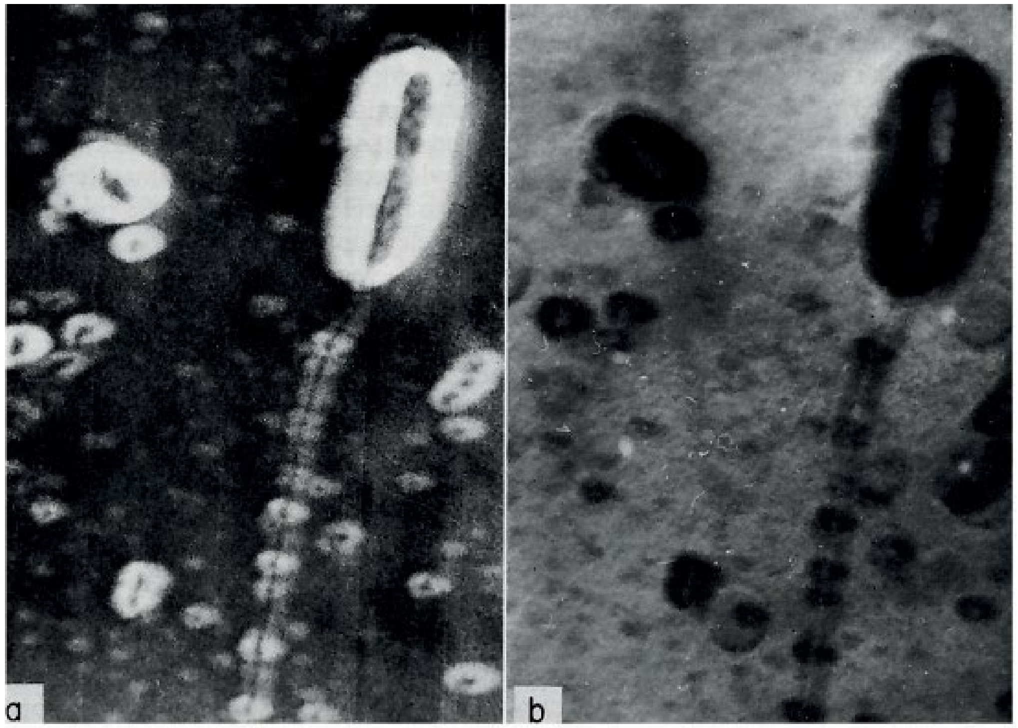

***Fig 9:** Comparison between two images of the same region of a thinned Si device, both taken at 500 kV, showing precipitates. (a), STEBIC image; (b), TEM image.*

et al., 1971), namely, the damage produced by the electron beam on organic and biological crystalline materials (Howie et al., 1985; 1987; 1988; 1990).

A fourth collaboration began in 1990 and was mainly supported by the European Community with the participation of researchers from Italy, the UK, France and Spain under the British responsibility of A. Howie and subsequently of Dr Andrew Bleloch. The aim of the project was the production and characterization of nanotips for use in scanning transmission electron microscopes (STEMs) and in atomic force microscopes (AFMs) (James et al., 1995; Edgcombe & Valdrè 2002). Chris Edgcombe continues to work on field emitters today.

The importance of human interactions is worth emphasising. Many members of the Metal Physics Group visited Bologna: A. Howie, L.M. Brown, M.J. Whelan, J.W. Steeds, D. McMullan, A. Winter, C.J. Humphreys, S. Pennycook, Ann Dray, T.T. Tang, H. Hashimoto, L.P.G. Jones, P. Everatt, … and several members and research students from Bologna visited Cambridge: P.G. Merli, V. Bortolani, A. Valdrè, G. Valdrè, P. Zucchetti, G. Angella, B. Fraboni, R. Berti,

These collaborations continued for 42 years, up to 2002 when UV and several of his English colleagues retired.

By pure coincidence the arrival of UV in Cambridge coincided with the beginning of the project to build a high voltage electron microscope, the maximum accelerating voltage of which would be 750 kV. Cambridge was the first university in the United Kingdom to be equipped with a high-voltage transmission electron microscope and was the first laboratory anywhere to produce scanning transmission images at high voltage (500 kV). See Cosslett (1968a, b, 1981), Darlington (1974) and Strojnik & Sparrow (1977). The background to this venture is described by P.B. Hirsch: "Following the results obtained in Japan on 350 kV machines, and reports of progress on the Toulouse 1.5 MeV

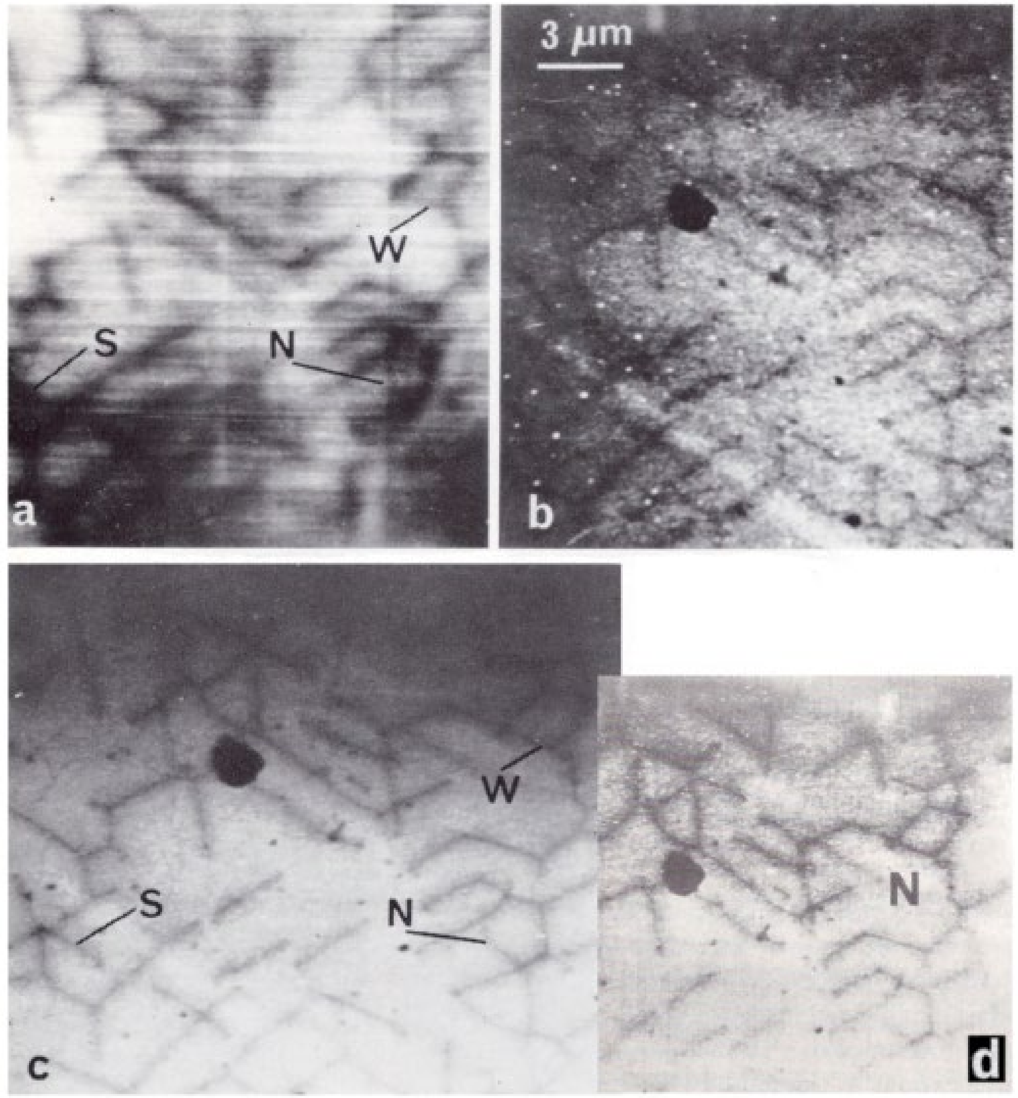

***Fig 10:** Images of a dislocation network taken sequentially from the same region of a thinned Si Avalanche Photo Detector in the same microscope, in order to correlate dislocations visible by diffraction contrast and induced electrical conductivity. (a), STEBIC image, 200 kV; (b), STEM image, 200 kV; (c), STEM image, 500 kV; (d), TEM image, 200 kV. N = No contrast; W = Weak contrast; S = Strong contrast. The magnification bar in Fig. 10a is 3 μm.*

microscope, a Committee was set up at the end of 1959 by the NPL [National Physical Laboratory] 'to consider the purposes that could be served by a high voltage electron microscope, and whether the use of a high voltage metallurgical microscope would be the best means of serving these purposes'. …The Committee reported finally in May 1961… Two projects were proposed, one a 600 kV instrument to be built at the Cavendish (by Drs Cosslett and K.C.A. Smith), the other a joint NPL–AEI 1 MeV microscope with maximum resolution. Only the first of these projects succeeded in obtaining financial support, namely £60,000, from the Paul Instrument Fund of the Royal Society. The operating voltage of the Cavendish instrument was raised to 750 kV and the instrument became fully operational in 1966 [only six years after Dupouy had presented the first images obtained with the Toulouse high-

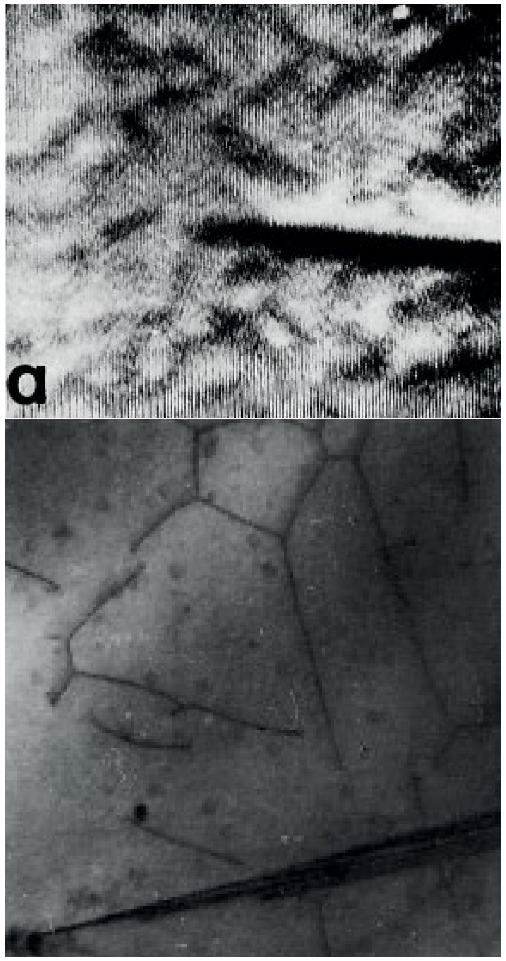

Fig 11: *Images of the same region of a thinned Si device showing dislocations. The crack is used to facilitate identification of the areas. (a), EBIC image obtained in a scanning electron microscope operated at 30 kV.*
(b). 500 kV TEM image. The magnification mark corresponds to 1 μm.

voltage microscope]; the total direct cost was about £100,000. It was inundated at once with users from metallurgical laboratories throughout the country, both industrial and academic; the biggest single user was AERE [Atomic Energy Research Establishment] Harwell". Many personal and human details are to be found in Smith (2013). The possibility of examining thick specimens and studying materials at low temperatures with such an instrument was much appreciated (Fig.3).

On 1 January 1970, UV was appointed Director of the International School of Electron Microscopy, the second of such schools to be held in the Centro di Cultura Scientifica "E. Majorana" in Erice, in Sicily. The first course took place from 4 - 18 April 1970 and was followed by six more courses divided between materials science and the biomedical sciences, terminating in 1989. For reasons of reliability, competence and availability, the basic nucleus of teachers for both series of courses came mainly from the University of Cambridge. One participant in the first course in 1970 was the Israeli Dr Dan Shechtman, who later received the Nobel Prize for Chemistry for the discovery of quasicrystals (2011). All the lectures given at the four courses in the Science of Materials were printed in extended versions and contained useful problems with related solutions. The corresponding books are: *Electron Microscopy in Material Science* (U. Valdrè Ed.), Academic Press, London, 1971 (xxiii+757 pp); *Electron Microscopy in Materials Science* (E. Ruedl and U. Valdrè Eds) vols I-IV, Commission of the European Communities, EUR 5515e, 1975, (xii+1599 pp.); *Surface and Interface Characterization by Electron Optical Methods* (A. Howie and U. Valdrè Eds), Plenum Press, London, 1988 (viii+319 pp.); *Impact of Electron and Scanning Probe Microscopy on Materials Research* (D.G. Rickerby, G. Valdrè and U. Valdrè Eds) NATO Science Series E: Applied Sciences- Vol. 364, Kluwer Academic Publishers, London, 1999 (xxiv+489 pp.).

In 1975, the modes of operation of the high-voltage microscope were extended by the addition of an energy-loss spectrometer (Darlington & Sparrow, 1975) and, in the years 1976–1977, a scanning transmission unit was added, as mentioned earlier, operating at a maximum voltage of 500 kV (Darlington, 1974; Strojnik & Sparrow, 1977; Smith, 2009; Fig. 8). From then on, the instrument was used almost exclusively as a HV-STEM for the study of semiconductor devices by means of the STEM/EBIC technique (Sparrow and Valdrè, 1977; Figs 9, 10, 11), it was effectively run by UV.

As part of the celebrations for the 900th anniversary of the foundation of the Alma Mater Studiorum di Bologna in 1988, the title of Laurea Honoris Causa was conferred on Prof Archibald Howie of Cambridge University for his theoretical and experimental work on electron–specimen interactions in the electron microscope.

Fig 12: *The Archive Centre of Churchill College, Cambridge (Courtesy of the Churchill Archive Director, Mr Allen Packwood).*

Another formal aspect of the relation between the universities of Cambridge and Bologna appeared in 1994, with the creation of a Bologna–Clare Hall Fellowship. Clare Hall is a Cambridge college for graduates only. Each year the University of Bologna proposes a candidate for this Fellowship. UV, who was already an Associate of Clare Hall, was the first Professor from the University of Bologna to be appointed to this Fellowship.

With the retirement of Dr Cosslett in 1975, which coincided with the continuing removal of the Cavendish to new buildings in Madingley Road, part of his group moved to the new premises while Cosslett himself remained in the Old Cavendish to superintend a new project: construction of an atomic resolution electron microscope (Cosslett et al., 1979).

The prohibitively high cost of these microscopes made it unlikely that any Italian Institute, public or private would be able to acquire a high-voltage microscope and UV therefore turned to Professor Carlo Rizzoli, Rector of Bologna University from 1976 to 1985, suggesting that funds should be set aside to enable Italian scientists to have access to the Cambridge instrument. Carlo Rizzoli, a medical doctor and himself a former user of the electron microscope did not hesitate; he summoned his secretary on the spot and instructed him to allocate a suitable sum of money to the University of Cambridge so that Italian microscopists could use the 750 kV TEM. The Italian users were in practice UV himself, his son Giovanni, a couple of Bologna research students and Dr E. Ruedl of the Ispra Centre of the Atomic Community. However most of the work was done in collaboration with members of the Microstructural Physics Group led by Archie Howie and Mick Brown, such as Tim Sparrow, Simon Blythe and Peter Everatt.

In 1993, not long after the death of Cosslett in 1990, the General Board of the University of Cambridge re-attributed the space occupied by the HVEM and the HREM to the Department of Materials Science and Metallurgy and the Department of Social and Political Sciences (Fig. 6). This resulted in the cessation of activity of the 750 kV microscope, which was already dwindling, in 1995 and the dismantlement of everything in the laboratory space around this machine. UV therefore attempted to save as many of the records of this instrument as possible. The Department of Materials Science and Metallurgy, which had already expanded into the adjoining Austin Wing of the (former) Cavendish Laboratory in Free School Lane, decided to conserve part of the Haefely Cockcroft–Walton high-voltage generator; a few stages of the structure had to be removed to make it fit into the entrance hall of the Austin Wing where visitors can now admire it.

Ugo Valdrè found himself entrusted with the task of saving as much as possible of the microscope column and the various accessories and related instruments in the HVEM space (dark room, the specimen preparation equipment, archives etc). It was materially impossible to add any of this to the small collection of historic relics in glass showcases standing along a corridor in the new Cavendish Laboratory. UV then turned to the Whipple

Museum containing objects of interest in the history of science. A single visit to the already overcrowded building showed him that there was little hope there but he did persuade the curator to accept the most important component of any microscope, optical or electron optical: the objective lens. With the help of Anton King, UV transferred this magnetic lens, which weighs around 50 kg, to the Whipple Museum (which fortunately adjoins the Old Cavendish Laboratory). The remaining material was jettisoned, apart from the series of drawings and blueprints of the microscope that UV transported to Bologna together with some of the smaller components. UV hoped that they could be saved from destruction by placing them in some archive.

Twenty years passed without any real opportunity of finding a permanent home for this material.

In January 2015, UV asked his old friend and colleague Peter Hawkes for advice, knowing that he was aware of the problems of preserving material valuable for historians of science. PWH had been a member of the Electron Microscope Section of the Cavendish Laboratory from 1959 to 1975 and lived through the period of intense activity that led to the construction first of the high-voltage instrument and subsequently of the high resolution microscope. PWH, who is a Friend of the Cambridge University Library and a former Fellow of Churchill College, made enquiries concerning the possibility of depositing UV's collection in the University Library or in the University Archives or the Churchill College Archives (Churchill College has a large, modern Archives Centre, which houses the papers of Ellis Cosslett and of Charles Oatley among many others). After some months of negotiation, Mr Allen Packwood, director of the Churchill Archives Centre, agreed to accept the material as a gift free of conditions. These drawings and other papers would thus join the other documents concerning Dr Cosslett's scientific activity (Fig. 12).

There remained the question of the cost of transporting this voluminous material from Bologna to Cambridge, which was considerable. A request for sponsorship was addressed to Sig. Alberto Tinti, Sales Director South Europe of FEI: the reply was rapid and entirely favourable. And now, thanks to the generosity of the FEI Company, these 50-year-old historic documents have found the perfect resting place. All of us who are concerned about the conservation of these documents owe a large debt of gratitude to the FEI company for their willingness to respond to our request for help to save this historic record of a bold and very successful electron-optical project. This instrument enabled microscopists from many countries to pursue their research in unexplored areas.

The title of this paper ends with a question mark. We hope that readers will agree that the answer is in the affirmative.

Acknowledgements. We are grateful to Professor Archie Howie for several constructive comments and suggestions during the preparation of this article.

References.

D. Bocciarelli and G.C. Trabacchi, Il microscopio elettronico dell'Istituto Superiore di Sanità. *Rendiconti dell'Istituto Superiore di Sanità* (Roma), **9** (1946) 762-768

L.M. Brown, G.R. Woolhouse and U. Valdrè. Radiation-induced coherency loss in a Cu-Co alloy, *Phil. Mag*. **17** (1968) 781-789

L.M. Brown, D. Fathy and U. Valdrè, Inhibition of electron beam damage in the depletion layer of p-n junctions in silicon. In *Electron Microscopy and Analysis 79* (T. Mulvey, Ed.) 137–140 (Institute of Physics Conf. Ser. No. 52, London, 1980)

C. Capiluppi, G. Pozzi and U. Valdrè, On the possibility of observing fluxons by transmission electron microscopy. *Phil. Mag*. **26** (1972) 865–883

V.E. Cosslett, High voltage microscopy in England. In *Electron Microscopy 1968*, Proc 4th European Regional Conference on Electron Microscopy, Rome 1968 (Daria Steve Bocciarelli, Ed.) Vol. 1, 19–24 (Tipografia Poliglotta Vaticana, Rome, 1968a).

V.E. Cosslett, The high-voltage electron microscope. *Contemp. Phys*. **9** (1968b) 333–354.

V.E. Cosslett, The development of electron microscopy and related techniques at the Cavendish Laboratory, Cambridge, 1946-79, Part II. *Contemp. Phys*. **22** (1981) 147-182.

V.E. Cosslett, R.A. Camps, W.O. Saxton, David J. Smith, W.C. Nixon, H. Ahmed, C.J.D. Catto, J.R.A. Cleaver, K.C.A. Smith, A.E. Timbs, P.W. Turner and P.M. Ross, Atomic resolution with a 600-kV electron microscope. *Nature* **281** (1979) 49–51.

S.L. Cundy, A. Howie and U. Valdrè, Preservation of electron microscope image contrast after inelastic scattering. *Phil. Mag*. **20** (1969) 147–163

E.H. Darlington, A scanning attachment for the Cavendish HVEM. In *High Voltage Electron Microscopy*, Proceedings of the Third International Conference, Oxford 1973 (P.R. Swann, C.J. Humphreys and M.J. Goringe, Eds) 136–139 (Academic Press, London & New York 1974).

E.H. Darlington and T.G. Sparrow, A magnetic prism spectrometer for a high voltage electron microscope, *J. Phys. E: Sci. Instrum*. **8** (1977) 596–600

E.H. Darlington and U.Valdrè, Imaging of weak Lorentz objects (p-n junctions) by high voltage Fresnel TEM and STEM. *J. Phys. E: Sci. Instrum*. **8** (1975) 321–324

D.M. Dlamini, L.M. Brown and U. Valdrè. EBIC/TEM investigations of defects in bent silicon crystals. In *Electron Microscopy and Analysis 83* (P. Doig, Ed.) 143–146 (Institute of Physics Conf. Ser. No. 68, London, 1983)

C.J. Edgcombe and U. Valdrè. Experimental and computational study of field emission characteristics from amorphous carbon single nanotips grown by carbon contamination. I. Experiments and computation. *Phil. Mag. B*, **82** (2002) 987-1007

D. Fathy, T.G. Sparrow and U. Valdrè, Application of EBIC to displacement energy determination. In *Electron Microscopy and Analysis 79* (T. Mulvey, Ed.) 135–136 (Institute of Physics Conf. Ser. No. 52, London 1980a)

D. Fathy, T.G. Sparrow and U, Valdrè, Observation of dislocations and microplasma sites in semiconductors by direct correlations of STEBIC, STEM and ELS. *J. Microsc. (Oxford)* **118** (1980b) 263–273

R.M. Glaeser, V.E. Cosslett and U. Valdrè, Low temperature electron microscopy: radiation damage in crystalline biological materials, *J. Microscopie* **12** (1971) 133-137

M.J. Goringe and U. Valdrè. Observation of the martensitic transformation in superconducting V_3Si by transmission electron microscopy. *Phys. Rev. Lett.* **14** (1965) 823-4

M.J. Goringe and U. Valdrè. Transmission electron microscopy of vanadium-silicon (V_3Si) at low temperature. *Proc. Roy. Soc.* A **295** (1966) 192-216

A. Howie and U. Valdrè. Temperature dependence of anomalous transmission effects. In *Proc 3rd European Regional Conference on Electron Microscopy*, Prague 1964 (M. Titlbach, Ed.) Vol. A. 377-378 (Czechoslovak Academy of Sciences, Prague 1964)

A. Howie and U. Valdrè, Temperature dependence of the extinction distance in electron diffraction. *Phil. Mag*. **15** (1967) 777–781

A. Howie, F.J. Rocca and U. Valdrè, Electron beam ionization damage processes in p-terphenyl. *Phil. Mag*. B**52** (1985) 751–757

A. Howie, M.N. Mohd Muhid, F.J. Rocca and U. Valdrè, Electron beam damage in organic crystals. In *Electron Microscopy and Analysis 1987* (L.M. Brown Ed.) 155–158 (Institute of Physics, Bristol, 1987)

A. Howie, M.N. Mohd Muhid, F.J. Rocca and U. Valdrè. Electron beam damage in organic materials. In *Proc. IVth Asia-Pacific Conference and Workshop on Electron Microscopy,* Bangkok, 1988 (V. Mangclaviraj, W. Banchorndhevakul and P. Ingkaninun, Eds.) 237-

334 (The Electron Microscopy Society of Thailand, Bangkok)

A. Howie, M.N. Mohd Muhid and U. Valdrè, Investigation of beam energy threshold and atom diffusion effects in ionisation damage of organic molecular crystals. In *Electron Microscopy 1990*, Proc. XII Int. Congress for Electron Microscopy, Seattle, WA, USA, Vol.2 (L.D. Peachey and D.B. Williams Eds) 406–407 (San Francisco Press, San Francisco)

C.J. Humphreys (Ed.) *Understanding Materials. A Festschrift for Sir Peter Hirsch* (Maney, London, for The Institute of Materials, 2002)

E.M. James, A.L. Bleloch, J.J. Rickards and U. Valdrè. In-situ characterization of nanometre-sized field emitters in a scanning transmission electron microscope. Atti XX Congr. di Microscopia Elettronica, Rimini 1995, Suppl. *Microsc. Elettron.* **16**, No. 2 (1995) 203-204

D.W. Pashley, M.J. Stowell, E.A. Robinson, T.J. Law and U. Valdrè. An U.H.V. Specimen Chamber and its Application to the Direct Study of Epitaxial Growth. In *Electron Microscopy*

1968, Proc 4th European Regional Conference on Electron Microscopy, Rome 1968 (Daria Steve Bocciarelli, Ed.) Vol. I, 387–388 (Tipografia Poliglotta Vaticana, Rome, 1968)

G. Pozzi and U. Valdrè, Study of electron shadow patterns of the intermediate state of superconducting lead. *Phil. Mag.* **23** (1971) 745–762

K.C.A. Smith, STEM at Cambridge University: reminiscences and reflections from the 1950s and 1960s. *Adv. Imaging & Electron Phys.* **159** (2009) 387–406

T.G. Sparrow and U. Valdrè, Application of scanning transmission electron microscopy to semiconducting devices. *Phil. Mag.* **36** (1977) 1517–1528

J.W. Steeds and U. Valdrè. Observation of lead at liquid Helium temperatures in a high voltage microscope. In *Electron Microscopy 1968*, Proc 4th European Regional Conference on Electron Microscopy, Rome 1968 (Daria Steve Bocciarelli, Ed.) Vol. I, 43-44 (Tipografia Poliglotta Vaticana, Rome, 1968)

A. Strojnik and T,G, Sparrow, An improved scanning system for a high-voltage electron microscope. *J. Phys. E: Sci. Instrum.* **10** (1977) 502–504

G.C. Trabacchi. Il microscopio elettronico. *Rendiconti dell'Istituto Superiore di Sanità* (Roma), **10** (1947) 1222-1235

U. Valdrè, Recenti sviluppi dell microscopia elettronica a contrasto di fase controllato, su immagini in fuoco. *Atti Convegno Gruppo Strumentazone e Tecniche non Biologiche della Società Italiana di Microscopia Elettronica*, Bologna, LAMEL–CNR, Giugno 1974, 37–56 (Cooperativa Libraria Universitaria, Bologna 1975)

U. Valdrè, Electron microscope stage design and applications. *J. Microsc. (Oxford)* **117** (1979) 55–75

U. Valdrè and P.B. Hirsch. Rearrangement of dislocations in stainless steel during electropolishing, *Phil. Mag.*, **8** (1963) 237-246

U. Valdrè. Understanding Peter: A Recollection of Facts and Anecdotes about Sir P.B. Hirsch. In *Understanding Materials. A Festschrift for Sir Peter Hirsch* (C.J. Humphreys, Ed.) 1-16 (Maney, London, for The Institute of Materials, 2002)

U. Valdrè, D.W. Pashley, E.A. Robinson, M.J. Stowell, K.J. Routledge and R. Vincent. An ultra high vacuum specimen chamber with facilities for growing thin films. In *Electron Microscopy 1966*, Proc. Sixth Internat. Congress for Electron Microscopy, Kyoto 1966, Vol. I (R. Uyeda, Ed.) 155–156

U. Valdrè, A. Robinson, D.W. Pashley, M.J. Stowell and T.J. Law, An ultra-high vacuum electron microscope specimen chamber with facilities for vapour deposition studies. *J. Phys. E: Sci. Instrum.* **3** (1970) 501–506

M.J. Whelan, The early observation of defects in metals by transmission electron microscopy. In *Understanding Materials. A Festschrift for Sir Peter Hirsch* (C.J. Humphreys, Ed.) 17–35 (Maney, London, for the Institute of Materials, 2002)