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History of the "Three Beams" Conference, the Birth of the Information Age and the Era of Lithography Wars

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The International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication (EIPBN), also known at the "Three Beams" conference, met for the 50th time in 2006. This monograph presents a history of the meeting from its earliest days as a small gathering of electron-beam welding enthusiasts to the present-day international conference on beam technology and nanofabrication. The remarkable first decade or so of the meeting is of particular historical interest. It was during these years that researchers developed new ways of using directed beams of energy to pattern microscopic structures and began applying these new tools to the fabrication of electronic circuits. This technology led directly to the large-scale integration of digital circuits which underpins today's era of information. These early successes also ignited a titanic struggle for supremacy among competing "next generation lithographies," one of which popular wisdom assumed would inherit the mantle of optical lithography in the manufacturing of integrated circuits. This paper reviews the key technical breakthroughs presented at the meeting during this early period and their impact on the world today. The paper also provides detailed tables and references to all fifty EIPBN meetings and proceeding volumes.

I. INTRODUCTION

The International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication, or EIPBN, met for the 50th time in 2006. The explosive growth in the art and science of controlling beams, which is the original *raison d'être* of the conference, lies at the heart of the information revolution which has brought us digital computers, the internet and all the scientific and industrial breakthroughs enabled by them. The mastery of focusing and controlling beams of energy to generate arbitrary patterns was the key breakthrough that allowed the transfer of increasingly gargantuan amounts of information into the digital circuits which we enjoy today.

While what we know today as the EIPBN has served well over these five decades as the premier forum for the communication of progress in the field, the first decade or so witnessed the development of a series of particularly remarkable achievements which set the stage for much of the work that followed and ignited the "lithography wars"—a titanic struggle for supremacy among a dozen or so competing lithographic technologies, the winner which was assumed would inherit the mantle of optical lithography in the manufacturing of integrated circuits. Rather than trying to sum up the entire half-century of the conference and these developments to date, I will focus this monograph primarily on the achievements of the first decade or so, from 1959 to approximately 1972. The interested reader is pointed to the recent, but brief overview of the EIPBN meeting by Smith and Pease [1]. Section II of this paper presents the history of the meeting and proceedings. Section III summarizes the key technical breakthroughs of the early years and discusses their impact on the world today.

II. HISTORY OF THE MEETING AND PROCEEDINGS

There is inevitably some confusion when we refer to the "50th meeting" rather than the "50th anniversary." The reason for this oddity is that the EIBPN, as we know it today, is the fusion of two earlier meetings which ran more or less parallel in the early years. The count of all the previous meetings is now fifty, even though the first meeting took place in 1959, which would make 2006 actually the 48th anniversary of the first meeting.

The conference's origin dates back to March 20, 1959 in Boston, Massachusetts, and a very different conference name, the "Symposium on Electron Beam Melting" which hosted only 16 papers. It was the brainchild of James S. Hetherington of the Alloyd Research Corp. of Watertown, Massachusetts, which has long since gone out of business. Alloyd sponsored the first seven meetings and published the proceedings. The first six "Alloyd" meetings were held in Boston. Since that time they have been held in many locations in the United States and occasionally in Canada. Table 1 lists the number, track, dates, locations, chairs, symposium names, and sponsors for all fifty meetings (1959-2006). Table 1 is broken into Table 1A for the years when the alternating and competing meetings were held (1959-1982) and Table 1B for the merged years (1983-2006). Please refer to Table 1C for abbreviations of the dozen or so names used by the meeting and proceedings over the years and Table 1D for

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abbreviations of the sponsors. The seven Alloyd-sponsored meetings are called the "Alloyd track" in the table. The IEEE and ECS tracks refer to the two competing branches of the meeting in the early years which will be detailed later.

Flipping through the 1959 proceedings reveals that the papers are exclusively about using electron beams for materials processing, such as e-beam melting, cutting and welding of materials, and so forth. This was certainly a hot topic in those days. By the 1960 meeting, however, we can discern the first hints of a revolution that would lead to many profound changes in the meeting and the world at large. I will say more about these developments in Section III. Table 2 presents detailed citations to all fifty volumes of the proceedings (1959-2006), including the conference number, year, proceedings name, editor(s), number of papers and pages, journal issue, publisher, copyright, and LOCN, ISSN and/or ISBN numbers. Table 2 has also been broken into Table 2A for the alternating years (1959-1982) and Table 2B for the merged years (1983-2006). Please refer to Table 2C for abbreviations of the proceedings publishers. The proceedings listed in Table 2 are referred to in the references as *Proceedings* **P1-P50**.

In 1960 the meeting name changed to the "Symposium on Electron Beam Processes" and featured a new chairman, Mr. Robert Bakish of the Alloyd Corp. (see Fig. 1). Bob Bakish turned out to be a man of tremendous vision, energy and generous spirit who organized and ran the meeting in the early years when the field was rapidly growing. While James Hetherington may have been the father of the meeting, Bob Bakish should rightly be called the "Godfather of the Three Beams." Bob Bakish ran the meeting from 1960-1962 and then started a very successful competing meeting which he ran from 1964-1982. For the first few years of the meeting Bob served as an employee of the Alloyd Corp. Later he left and started his own company, the Bakish Materials Corp. of Englewood, NJ.

The 1959-1965 meetings continued to be sponsored by the Alloyd Corp. The explosive growth in the field had swelled the number of attendees from what could not have been more than a few dozen in 1959 to over 350 by 1961, leading Bakish to complain that any more growth would be difficult to manage [2]. By the mid-1960s the tremendous growth, and perhaps a divergence of interests with its founding sponsor, led to a search for alterative sponsorship. Over the 1965-1966 meetings Alloyd was phased out and a new sponsor was adopted, the Electron Devices Society of the IEEE, which continues to this day. In Table 1 the "Alloyd" meetings after 1965 are referred to as the "IEEE track," although it is really the same series of meetings. Starting in 1969, the American Vacuum Society (AVS) began to co-sponsor the meeting, out of which eventually grew several very important developments. I believe the association of these eminent societies with the meeting was a key factor in its continued success.

Figure 1. Robert Bakish (courtesy R. Bakish).

In 1964, the exploding growth and interest in the field led Bob Bakish to start a second meeting of similar name but with different sponsors: the Electrothermics and Metallurgy Division of the Electrochemical Society (ECS), and the Metallurgical Society of the American Institute of Mining Engineers (AIME). The AIME dropped its co-sponsorship after the 1966 conference leaving the ECS as sole sponsor. This meeting occurred every other year and continued until the merger in 1983 (more about this later). In Table 1 this meeting is referred to as the "ECS track." After some fits and starts the proceedings came to be published regularly by the ECS. Sponsorship of a meeting of electron beam researchers by the Electrochemical Society may sound a bit strange. I'm not sure of the origin of this relationship, but it may have something to do with the fact that in the early days of integrated circuits etching was typically performed by wet chemical processes.

Bakish's first and second "ECS beams meeting" went head-to-head with the "IEEE beams meeting" in 1964 and 1966. Apparently, the toll of raiding of each other's attendees promoted a truce, and at the 1967 IEEE beams meeting in Berkeley, California,

Bob Bakish, Tom Everhardt and Fabian Pease met and agreed to alternate the meetings, i.e., no more rival meetings in the same year [3]. This gentlemen's agreement continued until the meeting's merger in 1983.

The IEEE meeting's name continued to morph to reflect the growth of the field. In 1965 it became the "Electron and Laser Beam Symposium" and in 1967 the "Symposium on Electron, Ion, and Laser Beam Technology," marking the first time that all three beams were acknowledged. In 1975 "Laser" was changed to "Photon" marking the emergence of x-ray lithography, and in 1995 "Nanofabrication" was added to the end to acknowledge the emergence of a number of new non-beam patterning techniques, such as nanoimprint lithography.

The year 1973 was very important for the IEEE/AVS beams meeting. Before this time the proceedings were not refereed and appear to have been "self published" with a very small circulation. Thanks to the efforts of Prof. C.K. Crawford of MIT, who was Chairman of the New England Chapter of the American Vacuum Society, Dr. Paul Redhead, editor of the Journal of Vacuum Science and Technology (JVST), and Mr. Basil Englis of the American Institute of Physics Publications Office, which published JVST, the proceedings began to be published as the Nov/Dec issue of the journal [4]. This change significantly enhanced the meeting's prestige and boosted circulation from a few hundred to many thousands. The journal's requirement of full anonymous review for all papers improved the quality of the proceedings but required significant effort to build and maintain a database of referees—a never-ending struggle. Also in 1973 the current Steering Committee structure was initiated, with two new members being added and two senior members retired every year. Members serve for five years, including a year's service as Conference or Program Chair, before being put out to pasture on the Advisory Committee.

In 1983, the alternating IEEE and ECS beams meetings agreed to merge into a single annual event, with the proceedings being published by JVST [5]. It was named the "International Symposium on Electron, Ion and Photon Beams" a.k.a. the "Three Beams Symposium." The conference was incorporated Dec. 5, 1985 as a non-profit company in the state of New Jersey named the *International Symposium on Electron, Ion and Photon Beams*, becoming an independent entity with proceedings published by the AVS. In 1991 Optical Society of America co-sponsorship was added and in 1995 the meeting was renamed the "International Conference on Electron, Ion and Photon Technology and Nanofabrication" to more accurately reflect its stand-alone status, since it was no longer a symposium within a larger conference, and to acknowledge the growing importance of nanofabrication.

Today it is a non-profit corporation which is run by a Steering Committee with an Advisory Committee comprising past members of the Steering Committee and representatives from sister conferences in Europe and Japan. By any metric, the meeting continues to be a big success. Abstract submissions are at historic highs (see Fig. 2), with attendance fluctuating between 400 and 550 over the last decade (see Fig. 3). Growth of the size of the program over the years can be seen in Fig. 4, which today comprises some 225 presentations (talks and posters). While the size of the meeting is somewhat larger than Bob Bakish's "manageable limit" of 350 attendees, it is still small and intimate enough so that attendees can see the majority of the presentations of interest.

The modern meeting features three full days of talks and posters kicked off by a plenary session and followed by parallel sessions which are generally limited to two, although increased demand in recent years has necessitated a parallel session of three on the second full day of the meeting. A thriving commercial session has also been in place for at least 25 years. In the early years the conference banquet featured remarks by heavy hitters of the industry, including Gordon Moore and Jack Kilby (see Table 3). The very popular EIPBN Micrograph Contest started by John Randall in 1995 attracted a record 82 entries in 2006.

Proceedings were issued for all fifty years of the meeting. It has been the author's privilege to have access to the entire set of volumes during the preparation of this article, including the early years which are now difficult or impossible to find. This important historical archive comprises some 4,357 articles and 28,484 pages (see Fig. 5)—way too large of body of information for the author even to skim. Want of time has necessitated a focus on the early years of the conference.

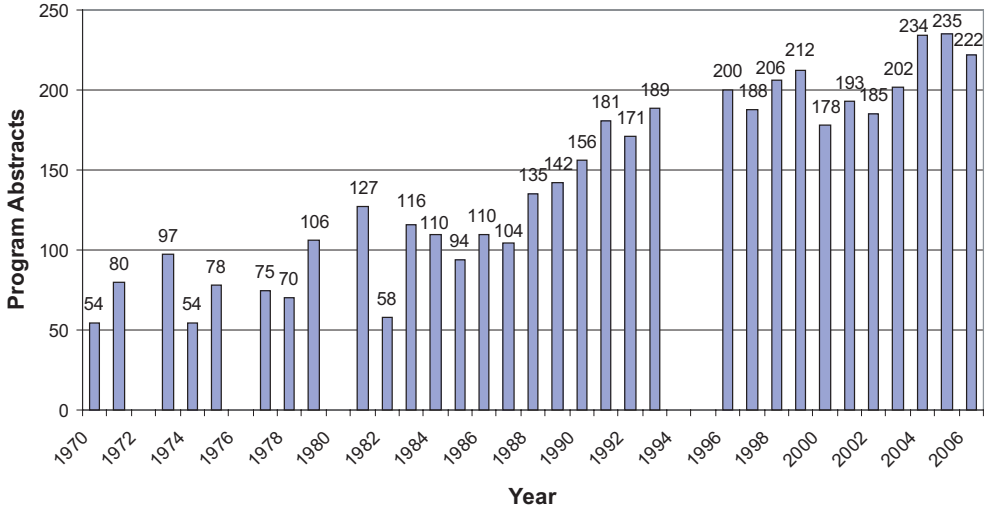

Figure 2. Total EIPBN abstract submissions vs. year (1984-2006).

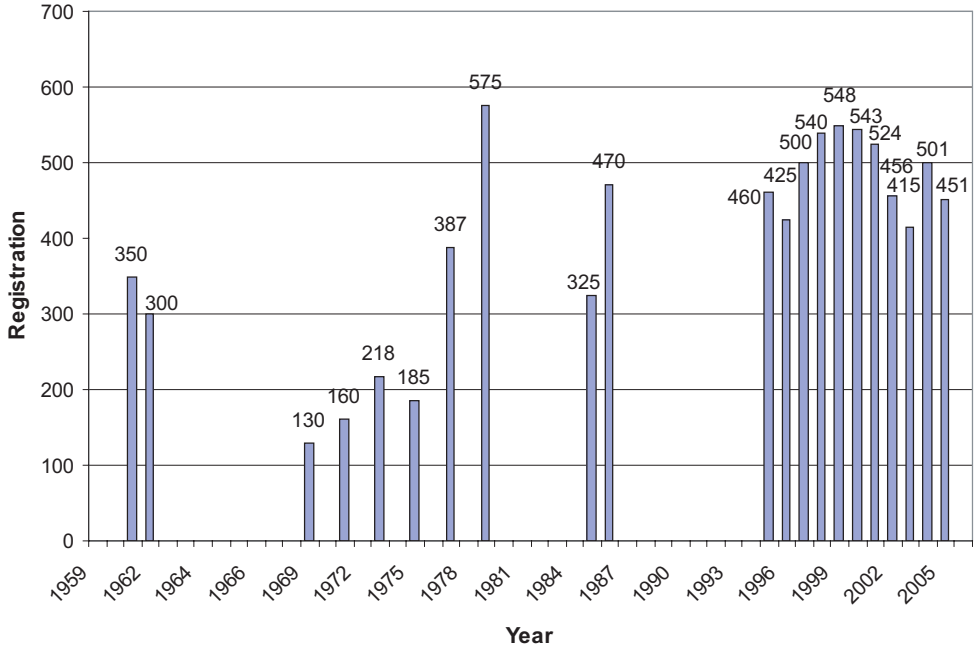

Figure 3. Count of EIPBN attendance vs. year (1959-2006).

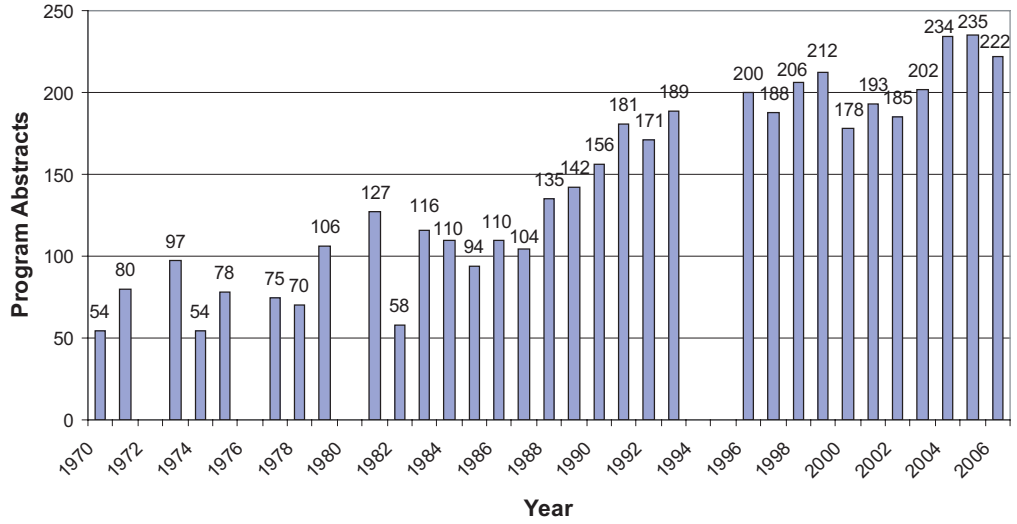

Figure 4. Count of EIPBN program size (talks plus posters) vs. year (1970-2006).

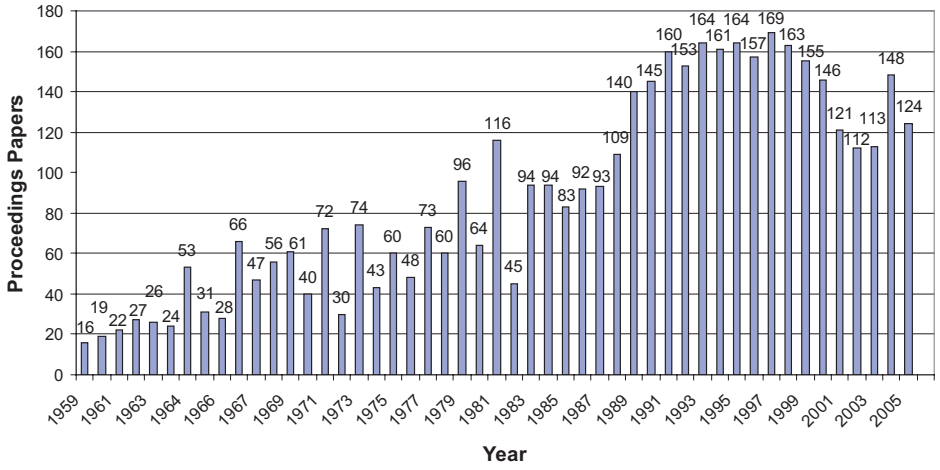

Figure 5. Count of EIPBN papers published in proceedings (1959-2005).

In addition to this archive, the historian should be aware of several other sets of proceedings which cover nearly the same field. In 1975 a European "sister conference" to EIPBN was started which today is called the "International Conference on Micro- and Nano-Engineering," or MNE, the proceedings which are published as an issue of the journal Microelectronic Engineering by Elsevier Press. In 1988 a Japanese sister conference was started called the "International Microprocesses and Nanotechnology Conference," or MNC, the proceedings which are published as a special issue of the Japanese Journal of Applied Physics. Mention should also be made of the SPIE conference proceedings series. The SPIE Microlithography meeting started in 1976 (SPIE Vol. 80). SPIE also hosts the Annual BACUS Symposium on Photomask Technology which began in 1981.

It is remarkable for a small organization to have survived nearly fifty years (although not without some struggles, see [1].) As with the U.S. Constitution, surviving this long requires the ability to change. An all-volunteer organization and rotating Steering Committee structure ensures constant infusions of fresh energy and ideas into the organization. I believe the conference's generous support of students has also been vital to its success. While techniques and applications evolve, there will always be a need for us to squeeze large amounts of

information into the micro and nanosystems that we invent, which is really what the meeting is all about.

III. BIRTH OF THE INFORMATION AGE AND ERA OF THE "LITHOGRAPHY WARS"

Before we proceed it will be necessary to place the 1959 "Symposium on Electron Beam Melting" in historical context. Table 4 summarizes the key technical milestones relevant to the computer industry and beam patterning from 1930-1980. IBM's first large computer based on electromagnetic relays (the Mark 1) was introduced in 1944. Shortly thereafter (in 1947) the transistor was invented. IBM's first large computer based on vacuum tubes (the IBM 701) was introduced in 1952, followed shortly thereafter in 1955 with their first commercial all-solid-state computer (the IBM 608). In 1957, just one decade after the invention of the transistor, IBM announced its intention to completely switch to solid state circuitry.

These developments show that the years leading up to the 1959 symposium meeting were really just the first baby steps of the information age, where computers were built of all-discrete components and used magnetic core memory. The industry in 1959 was "before the Roadmap." Gordon Moore would not pronounce his "law" until 1965, and the first commercial IC, the Intel 4004, was a distant 12 years in the future. Computers at that time were slow, expensive and had miniscule memories. The invention of the integrated circuit 1958 by Kilby and Noyce showed the way to avoid the high cost and low performance of discrete components. However, the means to economically achieve this vision with rapidly increasing levels of integration was not obvious at this point. Against this backdrop the 1959 symposium can be seen as sitting on the cusp of a sea change between discrete and integrated circuits.

What was the electron-beam research community like in those days? The electron microscope had been invented in the early 1930s by Ernst Ruska and Max Knoll of Germany. Progress was slow during the war years so that by the late 1950s scanning e-beam microscopes were still strictly university-built affairs [6]. In the years before 1960 electron microscopy was seen by many as a sleepy backwater research area with limited commercial prospects. Particular mention needs to be made of the group lead by Charles Oatley at Cambridge University in England which between the late 1940s and the early 1960s made a series of important technical advances in scanning electron microscopy [7, 8]. Mention must also be made of the work of James Hillier, who, with a fellow graduate student at the University of Toronto in 1937, built a model electron microscope. Hillier went on to RCA after graduation and was instrumental in their commercialization of the SEM. Among his many inventions, in 1946 he was the first to develop a way to stigmate electron beams [9].

Table 4. Historical Milestones

1931	Invention of the electron microscope by Ernst Ruska and Max Knoll
1944	IBM Mark I introduced, its first large computer based on electromagnetic relays
1947	Invention of the transistor by John Bardeen, Walter Brattain and William Shockley
1947	Invention of holography by Dennis Gabor
1952	IBM 701 introduced, its first large computer based on vacuum tubes
1955	IBM 608 Transistor Calculator introduced, the first commercial all-solid-state computer
1958	Invention of the integrated circuit by Jack Kilby and Robert Noyce
1959	First Symposium on Electron Beam Melting
1959	Richard Feynman gives talk "There's plenty of room at the bottom"
1960	Invention of the laser by T.H. Maiman
1960	Invention of the Everhardt-Thornley electron detector
1964	IBM 360 computer introduced
1965	Gordon Moore pronounces his "law"
1971	Intel launches 4004 integrated circuit
1971	Hewlett-Packard introduces heterodyne laser interferometer
1978	First lithography stepper introduced by GCA Corp.

While some important work in the field was certainly being performed elsewhere, the Oatley group was perhaps the most successful at training and inspiring brilliant young engineers who went on to successful careers in electron beam research, many finding their way to jobs in the United States. "Oatley's boys" are well represented among the early proceedings and leadership of the symposium, some of whom contributed over five decades. Students and colleagues in this group include: H. Ahmed, A.N. Broers, T.H.P. Chang, T.E. Everhart, C.W.B. Grigson, D. McMullan, W.C. Nixon, R.F.W. Pease, K.C.A. Smith, P.J. Spreadbury, A.D.G. Stewart and O.C. Wells. Oatley's group was also instrumental in the commercial spin-out of the SEM to the Cambridge Instruments Company (later Lieca Microsystems) which remains a leading manufacturer of e-beam lithography systems to this day.

As mentioned earlier, the 1959 proceedings are exclusively about electron beam processing of materials. Several remarkable papers appear in the 1960 Proceedings which are well worth reading. The first is "Thermoplastic image formation [10]" by W.E. Glenn of GE Research, where he used an e-beam to write five-micron features for analog video recording which he proposed to read out optically. Another interesting paper is "Electron beam machining laboratory developments [11]" by W. Opitz of Carl Zeiss, where he reported cutting 50

micron holes using an electron beam, with holes as small as five microns reportedly possible. These are among the earliest beam patterning papers which were followed by a flood of others on similar topics in subsequent years.

The 1960 paper by Selvin and MacDonald of Sylvania Electronics Systems, "The future of electron beam techniques in microelectronic circuitry [12]," is particularly interesting from a historical perspective. In this paper they propose fabricating entire circuits on substrates by e-beam processes in one vacuum cycle, eliminating "… vacuum evaporation masks, or pattern etching by chemical or electrochemical techniques." Significantly, they do not mention the word "resist." Selvin and MacDonald do not reference the widely cited 1958 Buck and Shoulders article [13] which articulated a very similar vision. This vision of all-e-beam processing was significantly extended and amplified by O. Wells in the 1961 proceedings [14] and in subsequent work by many others over the next few years. In my view these notions demonstrate that the beams community at this time harbored many naïve notions and was clueless as to how large-scale integration of circuits might be practically carried out.

At the 1961 meeting several more interesting papers are interspersed with the e-beam welding contributions. The previously-mentioned paper by O. Wells of Westinghouse Research (one of Oatley's boys), "Electron beams in micro-electronics [14]," is a thorough review of available techniques including evaporation through stencil masks, e-beam machining and chemically assisted e-beam machining. Masked e-beam flood-etching of materials, which he calls "molecular beam etching," appears to be a precursor to plasma etching or reactive-ion beam etching. In the paper he also suggests exposing resists using electron beams but shows no results.

In a truly remarkable paper that year, Möllenstedt and Speidel of the University of Tübingen presented "Newer developments in microminiaturization [15]," where they reported patterning 14 nm-wide lines by e-beam lithography on carbon-coated collodion films, some of the work dating back to 1960 [16]. Fig. 6 here is a reproduction of Fig. 8 in their paper, showing arbitrary patterns with line widths well below 100 nm. They also developed an innovative electroplate-and-peel technique for transferring patterns into fine metal stencils. These pioneering nanofabrication results were achieved over forty years before the word "nanotechnology" came into common use, and only a year after Richard Feynman's famous talk, "There's plenty of room at the bottom."

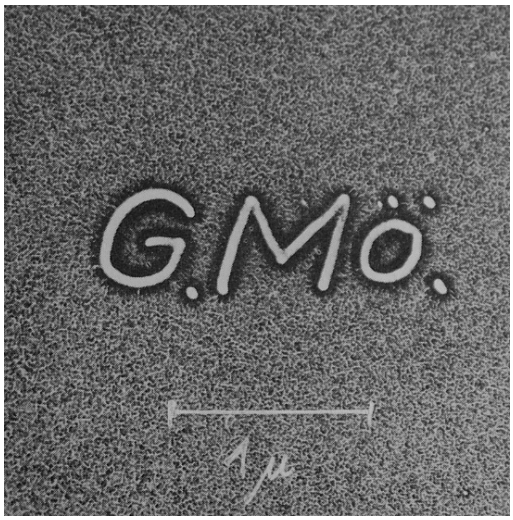

Figure 6. Electron micrograph of sub-100 nm lines written by e-beam lithography on collodion foil with the "electron microprobe recorder," presented at the 1961 meeting by Möllenstedt and Speidel [15]. This was presented only a little more than a year after Richard Feynman's Dec. 31, 1959 talk "There's plenty of room at the bottom."

At the 1962 meeting another very interesting paper appears. S.P. Newberry of GE Labs presented a paper on "Problems in microspace information storage [17]" where he proposed using electron and laser beams for direct read/write information storage, apparently partly based on earlier ideas of R.K. Jurgen [18]. He also points out the advantages of ion over electron beams for lithography and imaging—a topic of much subsequent research and discussion. Newberry discusses the urgent need to shrink the size of memory bits and the limiting relationship between memory density and access time. His discussion of the statistics of electron beams with regard to information storage in small places is remarkable. Fig. 7 here reproduces Fig. 1 of Newberry's paper, showing the amusing lengths to which the memory problem needed to be driven home in those days. This work appears to have spawned a great deal of research on e-beam-addressed memory in subsequent years, which of course has gone nowhere. I would argue, however, that the DVD is a direct descendent of Newberry's ideas, with perhaps a nod towards the previously mentioned work of Glenn.

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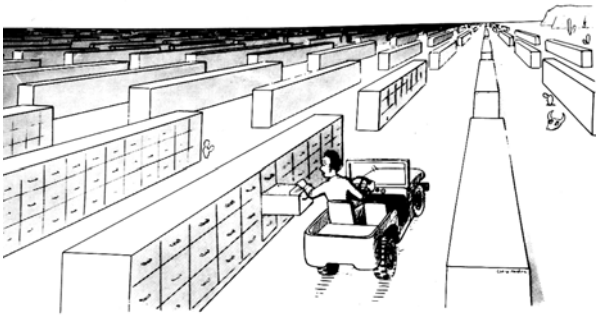

Figure 7. Cartoon from S.P. Newberry's 1962 paper [17] demonstrating the limiting relationship between memory density and access time. The original caption reads: "More filling space does not solve the data storage problem even with all the space in the desert and a jeep for data pickup, access is too slow to search a large memory randomly."

Other "beams" start to be mentioned very early on. In 1961 papers on ion beams appear and in 1964 we see papers on using lasers for cutting and thermionic emission. At the 1965 meeting, K. Kanaya, *et al.* from the Electrotechnical Laboratory and Japan Electron Optics Laboratory presented "Micro color recording, etching and machining by means of high voltage ion beam [19]" where they reported cutting 10 micron holes in silver. This remarkable paper was among the earliest work on focused ion beams.

Lasers hit the 1966 IEEE meeting in a big way. Almost 50% of talks involved lasers! The meeting's kickoff talk by Dennis Gabor on "Wavefront reconstruction or 'holography' [20]" must have been electrifying (he won the Nobel Prize only five years later).

The 1967 IEEE symposium was a turning point in the field and witnessed the public disclosure of some of most important results in all five decades of the meeting, certainly from a historical if not from a technical perspective. To help set the stage for this watershed event, consider that over twenty years after the invention of the SEM and almost the decade since the invention of the integrated circuit, no reliable resist process for electron-beam lithography had yet been developed. Moore's "law" was already common parlance in 1967 and by 1972 line widths were expected to drop below 10 microns. To many prescient observers the "one micron barrier" loomed as crisis of serious proportions due to the well-known limitations of optical lithography.

Still, some progress in the field had been made. By the 1967 meeting talks on the thermal effects of electron beams had shrunk to less than 20% of the papers, showing that the transition of the community away from materials processing towards lithographic applications of beams was nearly complete. However, the naïve notion of manufacturing ICs by resistless all-electron-beam-processing in a single vacuum cycle, as first articulated in 1960, had yet to be seriously countered.

With these historical facts in mind one wonders how the audience at the 1967 meeting received the paper by Thornley and Hatzakis of IBM, titled "Electron-optical fabrication of solid state devices [21]." (Thornley, another one of Oakley's boys, was the co-inventor of the celebrated Everhardt-Thornley secondary-electron detector.) In this paper, 1.0 micron-wide "metal structures" (presumably aluminum) patterned by e-beam lithography have been registered to previously patterned metal structures over oxide steps with an overlay precision of 0.2 microns. Fig. 8 here reproduces Fig. 7 of their manuscript. In many ways this is a most unsatisfying paper, being short and almost completely devoid of technical details. It is only later, through an IBM Technical Disclosure [22] and an IBM Journal of Research and Development paper submitted only two weeks after the 1967 meeting [23], that we learn of the breakthrough discoveries of the first practical e-beam lithography resist, poly-methyl methacrylate or PMMA, and a new pattern transfer process called "liftoff." Most likely IBM attorneys had a hand in truncating the 1967 proceedings manuscript. In any case, the community was already aware of extensive IBM study of applying resists from optical lithography to electron beams, which yielded unsatisfactory results [24].

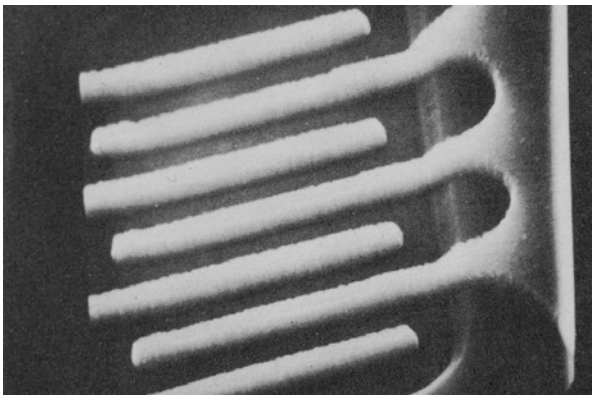

Figure 8. Electron micrograph of 1.0 micron-wide inter-digitated aluminum lines over oxide patterned by electron-beam lithography, from the 1967 Thornley and Hatzakis paper [21]. This was the first public disclosure of results obtained with PMMA resist.

In my view, the 1967 Thornley-Hatzakis paper was a signal event of the information age and the opening salvo of the lithography wars which would rage through the pages of the proceedings for the next four decades, absorbing the careers of a large number of researchers and consuming billions of dollars of R&D funds. There are four mains points to this argument. First, the discovery of the first practical e-beam lithography resist was a huge breakthrough in its own right, especially in light of the backwards direct-write notions prevalent at the time. Second, in a community dominated by wet-etch pattern-transfer mentality with its concomitant undercut and line width control problems, the liftoff process showed a way to achieve high-fidelity deep-submicron pattern transfer. Recall that this was years before plasma etching came to the fore. Third, they demonstrated a process for achieving high precision overlay of multiple e-beam lithography exposures into resist. Lastly, and I would argue, most importantly, the paper signaled the *de facto* official policy of IBM that the well known resolution limits of optical lithography due to the diffraction of light created a barrier to manufacturing smaller devices that needed to be overcome. Quoting from the paper, the "… 'light barrier' is usually considered to limit device dimensions to greater than 1 to 3 microns, … Beyond this barrier, electron optics offer the only known approach to the fabrication of microstructures." To many in the community, the *prima facie* obviousness of these statements combined with the formidable technical resources and essentially unlimited financial might of Big Blue essentially made truth from this fiction. Within a few years, almost every semiconductor manufacturer in the world (with the notable exception of Intel) had bought into this notion and launched large e-beam lithography research programs, notwithstanding the fact that by the last quarter of the 19th century optical microscopy had demonstrated resolution well below 1 μm, approaching 100 nm.

The story of the ensuing struggle for development of what came to be known as the "next generation lithography" would fill a book and is well beyond the scope of this paper. The end to this story is still unknown today, with optical lithography still battling its current main contender, extreme ultraviolet lithography. I would say that, historically speaking, the prognosis for EUVL is not good, considering that the ringside of the battle is littered with the remains of dozens of previous contenders.

The pace of progress in the beams community after 1967 increased rapidly. At the 1969 meeting the IBM group reports improved results and disclosed many more details of their process [25]. Also in 1969 Chang and Stewart (both Oatley boys) of the Cambridge Scientific Instrument Company report results from the first commercial electron-beam lithography system [26]. The 1971 meeting featured the first session on "Fabrication Technology," a topic that would be familiar to an attendee today and demonstrating the rapid maturation of the field. A very important paper appears in the 1971 proceedings by Chang and Wallman, titled "A computer-controlled electron-beam machine for micro-circuit fabrication [27]." Starting in the 1969 proceedings, "computer controlled" electron beam lithography systems began to appear. The original IBM and Cambridge Instruments e-beam lithography systems simply replicated existing optical masks using a kind of pantograph. The 1971 Chang and Wallman paper was the first that I could find that demonstrated direct computer-controlled e-beam patterning of chrome-on-glass photomasks, which came to be an important commercial berth for e-beam lithography and the key technology underpinning the manufacturing of ultra-large scale integrated circuits today.

In concluding the historical review of the meeting's first decade, the very important opening challenges of two of the main contenders of the lithography wars should be mentioned. At the 1971 meeting, Livesay and Fritz of Radiant Energy Systems, Inc. presented a paper titled "Electron image projection systems for microcircuit lithography [28]." This appears to be the first reference to what became known as electron projection lithography which promised to overcome the severe throughput limitations of e-beam lithography. At the 1972 ECS beams meeting Spears, Smith and Stearn presented "X-ray replication of scanning electron microscope generated patterns [29]," which although it had already been disclosed [30], became the opening salvo of the very hotly fought x-ray lithography war. Both these contenders, sadly, became badly mauled by optical projection lithography and ended up in the dustbin of history, but that is a story for another day.

ACKNOWLEDGEMENTS

I am particularly grateful to Mr. Robert Bakish who patiently endured countless phone calls and email messages, until eventually he got fed up and shipped me his entire archive of conference proceedings. His generous donation of this invaluable historical resource to the EIPBN will eventually be placed in a permanent archive. I thank Fabian Pease, Hank Smith and Tom Everhardt for checking facts and providing valuable information which helped solve several mysteries. Additional thanks to Hank Smith for critically reviewing the manuscript. Any remaining errors are mine alone. Thanks also to

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Table 1A. EIPBN meeting: Alloyd, IEEE and ECS tracks, 1959-1982

#	Track	Year	Dates	Location	Conference Chair(s)	Program Chair(s)	Symposium Name	Sponsors
1	Alloyd	1959	March 20	Boston, MA	James S. Hetherington	James S. Hetherington	First SEBM	Alloyd Res.
2	Alloyd	1960	March 24-25	Boston, MA	Robert A. Bakish	Robert A. Bakish	Second SEBP	Alloyd Corp.
3	Alloyd	1961	March 23-24	Boston, MA	Robert A. Bakish	Robert A. Bakish	Third SEBP	Alloyd Elec.
4	Alloyd	1962	March 29-30	Boston, MA	Robert A. Bakish	Robert A. Bakish	Fourth SEBT	Alloyd Elec.
5	Alloyd	1963	March 28-29	Boston, MA	John R. Morley	John R. Morley	Fifth Annual MEBS	Alloyd Elec.
6	Alloyd	1964	April 27-28	Boston, MA	John R. Morley	John R. Morley	Sixth Annual MEBS	Alloyd Gen.
7	ECS	1964	May 3-7	Toronto, Canada	Robert A. Bakish	Robert A. Bakish	First ICEIBST	ECS/EMD, AIME/MS
8	Alloyd	1965	Mar 31-April 2	University Park, PA	Auguste B. El-Kareh	Auguste B. El-Kareh	ELBS	Alloyd Gen., PSU
9	IEEE	1966	April 6-8	Ann Arbor, MI	Joseph E. Rowe, Auguste B. El-Kareh	George I. Haddad	Eighth Annual ELBS	IEEE/GED/GPMP, UM
10	ECS	1966	April 17-20	New York, NY	Robert A. Bakish	Robert A. Bakish	2nd ICEIBST	ECS/EMD, AIME/MS
11	IEEE	1967	May 9-11	Berkeley, CA	Charles Susskind	R. Fabian W. Pease	IEEE 9th Annual SEILBT	IEEE/GED, UCB, ONR, ARO
12	ECS	1968	May 6-9	Boston, MA	Robert A. Bakish	Robert A. Bakish	3rd ICEIBST	ECS/EMD
13	IEEE	1969	May 21-23	Gaithersburg, MD	Louis L. Marton	Louis L. Marton	10th SEILBT	IEEE/GED, AVS, UMd, NBS, NSF, ONR
14	ECS	1970	May 10-15	Los Angeles, CA	Robert A. Bakish	Robert A. Bakish	4th ICEIBST	ECS/EMD
15	IEEE	1971	May 12-14	Boulder, CO	Frank S. Barnes	Richard F.M. Thornley	11th SEILBT	IEEE/GED, AVS, UCol, NSF
16	ECS	1972	May 7-12	Houston, TX	Robert A. Bakish	Robert A. Bakish	5th ICEIBST	ECS/EMD
17	IEEE	1973	May 21-23	Cambridge, MA	Alec N. Broers	Edward D. Wolf	12th SEILBT	AVS, IEEE/GED, ARO, NSF, MIT
18	ECS	1974	May 12-17	San Francisco, CA	Robert A. Bakish	Robert A. Bakish	6th ICEIBST	ECS/EEMD
19	IEEE	1975	May 21-23	Colorado Spr., CO	George R. Brewer	R. Fabian W. Pease	13th SEIPBT	AVS, IEEE/GED, NSF
20	ECS	1976	May 4-7	Washington, DC	Robert A. Bakish	Robert A. Bakish	7th ICEIBST	ECS/EEMD
21	IEEE	1977	May 25-27	Palo Alto, CA	Thomas E. Everhart	Gilbert L. Varnell	14th SEIPBT	AVS, IEEE/EDS
22	ECS	1978	May 22-26	Seattle, WA	Robert A. Bakish	Robert A. Bakish	8th ICEIBST	ECS/EEMD
23	IEEE	1979	May 29-June 1	Boston, MA	Henry I. Smith	T.H. Philip Chang	15th SEIPBT	AVS, IEEE/EDS
24	ECS	1980	May 12-16	St. Louis, MO	Robert A. Bakish	Robert A. Bakish	9th ICEIBST	ECS/EEMD
25	IEEE	1981	May 26-29	Dallas, TX	Gilbert L. Varnell	Don R. Harriott, John H. Bruning	16th SEIPBT	AVS, IEEE/EDS
26	ECS	1982	May 10-14	Montreal, Canada	Robert A. Bakish	Robert A. Bakish	10th ICEIBST	ECS/EDIHTMD

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Table 1B. EIPBN meeting merged, 1983-2006

#	Track	Year	Dates	Location	Conference Chair	Program Chair	Symposium Name	Sponsors
27	Merged	1983	May 31-June 3	Los Angeles, CA	Robert L. Seliger	Mike Hatzakis	1983 ISEIPB	AVS, IEEE/EDS, ECS
28	Merged	1984	May 29-June 1	Tarrytown, NY	Michael Hatzakis	John Kelly	1984 ISEIPB	AVS, IEEE/EDS, ECS
29	Merged	1985	May 28-31	Portland, OR	Lynwood W. Swanson	John H. Bruning	29th ISEIPB	AVS, IEEE/EDS, ECS
30	Merged	1986	May 27-30	Boston, MA	Nicholas P. Economou	Andrew R. Neureuther	30th ISEIPB	AVS, IEEE/EDS
31	Merged	1987	May 26-29	Woodland Hills, CA	John L. Bartelt	Richard E. Howard	31st ISEIPB	AVS, IEEE/EDS
32	Merged	1988	May 31-June 3	Ft. Lauderdale, FL	Hans C. Pfeiffer	Evelyn L. Hu	32nd ISEIPB	AVS, IEEE/EDS
33	Merged	1989	May 30-June 2	Monterey, CA	Jerome C. Wiesner	Alan D. Wilson	33rd ISEIPB	AVS, IEEE/EDS
34	Merged	1990	May 29-June 1	San Antonio, TX	Noel MacDonald	Jon Orloff	34th ISEIPB	AVS, IEEE/EDS
35	Merged	1991	May 28-31	Seattle, WA	Daniel J. Ehrlich	Jane M. Shaw	35th ISEIPB	AVS, IEEE/EDS, OSA
36	Merged	1992	May 26-29	Orlando, FL	Larry F. Thomson	Randall L. Kubena	36th ISEIPB	AVS, IEEE/EDS, OSA
37	Merged	1993	June 1-4	San Diego, CA	Fritz Hohn	Franco Cerrina	37th ISEIPB	AVS, IEEE/EDS, OSA
38	Merged	1994	May 31-June 3	New Orleans, LA	Harold Craighead	Ilesanmi Adesida	38th ISEIPB	AVS, IEEE/EDS, OSA
39	Merged	1995	May 30-June 2	Scottsdale, AZ	John N. Randall	Dieter P. Kern	39th ICEIPBTN	AVS, IEEE/EDS, OSA
40	Merged	1996	May 28-31	Atlanta, GA	Donald M. Tennant	Stella W. Pang	40th ICEIPBTN	AVS, IEEE/EDS, OSA
41	Merged	1997	May 27-30	Dana Point, CA	Anthony Novembre	Geraint Owen	41st ICEIPBTN	AVS, IEEE/EDS, OSA
42	Merged	1998	May 26-29	Chicago, IL	Alfred Wagner	Christie R.K. Marrian	42nd ICEIPBTN	AVS, IEEE/EDS, OSA
43	Merged	1999	June 1-4	Marco Island, FL	Mark Gesley	John C. Wolfe	43rd ICEIPBTN	AVS, IEEE/EDS, OSA
44	Merged	2000	May 30-June 2	Rancho Mirage, CA	Lloyd R. Harriott	John Melngailis	44th ICEIPBTN	AVS, IEEE/EDS, OSA
45	Merged	2001	May 29-June 1	Washington, DC	Douglas J. Resnick	Mark McCord	45th ICEIPBTN	AVS, IEEE/EDS, OSA
46	Merged	2002	May 28-31	Anaheim, CA	Raman G. Viswanathan	Roderick R. Kunz	46th ICEIPBTN	AVS, IEEE/EDS, OSA
47	Merged	2003	May 27-30	Tampa, FL	Timothy R. Groves	Mark L. Schattenburg	47th ICEIPBTN	AVS, IEEE/EDS, OSA
48	Merged	2004	June 1-4	San Diego, CA	W. Dan Meisburger	Roxann L. Engelstad	48th ICEIPBTN	AVS, IEEE/EDS, OSA
49	Merged	2005	May 31-June 3	Orlando, FL	Kevin Cummings	Martin Peckerar	49th ICEIPBTN	AVS, IEEE/EDS, OSA
50	Merged	2006	May 30-June 2	Baltimore, MD	Shane R. Palmer	Shalom J. Wind	50th ICEIPBTN	AVS, IEEE/EDS, OSA

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Table 1C. Symposium & proceedings legend (in chronological order)

SEBM	Symposium on Electron Beam Melting
SEBP	Symposium on Electron Beam Processes
SEBT	Symposium on Electron Beam Technology
MEBS	Meeting of the Electron Beam Symposium
ICEIBST	International Conference on Electron and Ion Beam Science and Technology
ELBS	Electron and Laser Beam Symposium
SEILBT	Symposium on Electron, Ion, and Laser Beam Technology
EIBST	Electron and Ion Beam Science and Technology
SEIPBT	Symposium on Electron, Ion and Photon Beam Technology
SEIBST	Symposium on Electron and Ion Beam Science and Technology
ISEIPB	International Symposium on Electron, Ion, and Photon Beams
ICEIPBTN	International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication

Table 1D. Symposium sponsor legend

AIME/MS	American Insitute of Mining Engineers, Metallurgical Society
Alloyd Corp.	The Alloyd Corp., Cambridge MA
Alloyd Elec.	Alloyd Electronics Corp., Cambridge MA
Alloyd Gen.	Alloyd General Corp., Medford MA
Alloyd Res.	Alloyd Research Corp., Watertown MA
ARO	Army Research Office
AVS	American Vacuum Society
ECS	Electrochemical Society
ECS/EEMD	Electrochemical Society, Electronics and Electrothermics and Metallurgy Divisions
ECS/EDIHTMD	Electrochemical Society, Electronics, Dielectrics and Insulation, and High Temperature Materials Divisions
ECS/EMD	Electrochemical Society, Electrothermics and Metallurgy Division
IEEE/EDS	Institute of Electrical and Electronics Engineers, Electron Devices Society
IEEE/GED	Institute of Electrical and Electronics Engineers, Group on Electron Devices
IEEE/GPMP	Institute of Electrical and Electronics Engineers, Group on Parts, Materials and Packaging
MIT	Massachusetts Institute of Technology
NBS	National Bureau of Standards
NSF	National Science Foundation
ONR	Office of Naval Research
OSA	Optical Society of America
PSU	Pennsylvania State University
Ucol	University of Colorado
UCB	College of Engineering - U.C. Berkeley
UM	University of Michigan
UMd	University of Maryland

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Table 2A. EIPBN proceedings: Alloyd, IEEE and ECS tracks, 1959-1982

Proc	Year	Proceedings Name	Editor(s)	Papers	Pgs	Journal Issue (or Notes)	Pub.	Copyright	LOCN (ISSN after 1992)	ISBN
P1	1959	Proceedings of First SEBM	James S. Hetherington	16	93		AR	none		
P2	1960	Proceedings of the Second SEBP	Robert A. Bakish	19	149		AC	1960, AC		
P3	1961	Proceedings of the Third SEBP	Robert A. Bakish	22	379		AE	1961, AE		
P4	1962	Proceedings of the Fourth SEBT	Robert A. Bakish	27	530		AE	1962, AE	62-51780	
P5	1963	Proceedings of the Fifth Annual MEBS	John R. Morley	26	394		AE	1963, AE	62-51780	
P6	1964	Proceedings of the Sixth Annual MEBS	John R. Morley	24	387		AG	1964, AE	62-51780	
P7	1964	First ICEIBST	Robert A. Bakish	53	945		Wiley	1965, Wiley	65-14260	
P8	1965	Proceedings of the ELBS	A.B. El-Kareh	31	541		unk	none		
P9	1966	Proceedings of the Eighth Annual ELBS	George I. Haddad	28	520		unk	none		
P10	1966	Electron and Ion Beam Science and Technology, Volume 1 and 2; Proceedings of the Second ICEIBST	Robert A. Bakish	66	1213	Metallurgical Society Conferences, Vol. 51 (in two volumes)	G&B	1969, AIMMPE	67-28243	
P11	1967	Record of the IEEE 9th Annual SEILBT	R.F.W. Pease	47	440	(IEEE Catalog No. F-79)	SFP	1967, IEEE	62-51780	
P12	1968	EIBST, Third International Conference	Robert A. Bakish	56	666		ECS	1968, ECS	65-14260	
P13	1969	Record of the 10th SEILBT	Louis L. Marton	61	544	(IEEE Catalog No. 69 C 22-ED)	SFP	1969, IEEE	62-51780	
P14	1970	EIBST, Fourth International Conference	Robert A. Bakish	40	666		ECS	1970, ECS	71-120300	
P15	1971	Record of the 11th SEILBT	R.F.M. Thornley	72	696	(IEEE Catalog No. 71 C 23-ED)	SFP	1971, IEEE	62-51780	911302-17-X
P16	1972	EIBST, Fifth International Conference	Robert A. Bakish	30	420		ECS	1972, ECS	71-120300	
P17	1973	Proceedings of the 12th SEILBT	Edward D. Wolf	74	267	JVST, Vol. 10(6), Nov/Dec 1973, pp. 909-1132, A1-A32	AIP	1974, AVS	74-76522	0-88318-209-2
P18	1974	EIBST, Sixth International Conference	Robert A. Bakish	43	594		ECS	1974, ECS	71-120300	
P19	1975	Proceedings of the 13th SEIPBT	R.F.W. Pease, John G. Skinner	60	266	JVST, Vol. 12(6), Nov/Dec 1975, pp. 1121-1387	AIP	1975, AVS	75-33519	0-88318-221-1
P20	1976	Proceedings on the SEIBST, Seventh International Conference	Robert A. Bakish	48	617		ECS	1976, ECS	71-120300	
P21	1977	Proceedings of the 14th SEIPBT	Gilbert L. Varnell, John L. Bartelt	73	262	JVST, Vol. 15(3), May/June 1978, pp. 837-1099	AIP	1978, AVS	78-61015	0-88318-242-4
P22	1978	Proceedings on the SEIBST, Eighth International Conference	Robert A. Bakish	60	670	ECS Proceedings Vol. 78-5	ECS	1978, ECS	71-120300	
P23	1979	Proceedings of the 15th SEIPBT	T.H. Philip Chang, Mike Hatzakis	96	426	JVST, Vol. 16(6), Nov/Dec 1979, pp. 1610-2036	AIP	1980, AVS	80-81057	0-88318-264-5
P24	1980	Proceedings on the SEIBST, Ninth International Conference	Robert A. Bakish	64	662	ECS Proceedings Vol. 80-6	ECS	1980, ECS	71-120300	
P25	1981	Proceedings of the 16th SEIPBT	Don R. Harriott, John H. Bruning	116	562	JVST, Vol. 19(4), Nov/Dec 1981, pp. 868-1430	AIP	1982, AVS	81-70678	0-88318-293-9
P26	1982	Proceedings on the SEIBST, Tenth International Conference	Robert A. Bakish	45	474	ECS Proceedings Vol. 83-2	ECS	1980, ECS	71-120300	

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Table 2B. EIPBN proceedings: merged meeting, 1983-2006

Proc	Year	Proceedings Name	Editor(s)	Papers	Pgs	Journal Issue (or Notes)	Pub	Copyright	LOCN (ISSN after 1992)	ISBN
P27	1983	Proceedings of the 1983 ISEIPB	Mike Hatzakis, T.H. Philip Chang	94	411	JVST B, Vol. 1(4), Oct/Dec 1983, pp. 959-1400	AIP	1983, AVS	83-72987	0-88318-431-1
P28	1984	Proceedings of the 1984 ISEIPB	John Kelly	94	421	JVST B, Vol. 3(1), Jan/Feb 1985, pp. 41-463	AIP	1984, AVS	84-73561	0-88318-464-8
P29	1985	Proceedings of the 29th ISEIPB	John H. Bruning	83	378	JVST B, Vol. 4(1), Jan/Feb 1986, pp. 61-438	AIP	1985, AVS	86-70034	0-88318-489-3
P30	1986	Proceedings of the 30th ISEIPB	Andrew R. Neureuther	92	409	JVST B, Vol. 5(1), Jan/Feb 1987, pp. 47-456	AIP	1986, AVS	86-73213	0-88318-517-2
P31	1987	Proceedings of the 31st ISEIPB	Richard E. Howard	93	397	JVST B, Vol. 6(1), Jan/Feb 1988, pp. 107-504	AIP	1988, AVS	87-73570	0-88318-555-5
P32	1988	Proceedings of the 32nd ISEIPB	Evelyn L. Hu	109	505	JVST B, Vol. 6(6), Nov/Dec 1988, pp. 1809-2314	AIP	1988, AVS	88-82669	0-88318-592-X
P33	1989	Proceedings of the 33rd ISEIPB	Alan D. Wilson	140	681	JVST B, Vol. 7(6), Nov/Dec 1989, pp. 1387-2068	AIP	1989, AVS	89-81510	0-88318-672-1
P34	1990	Proceedings of the 34th ISEIPB	Jon Orloff	145	736	JVST B, Vol. 8(6), Nov/Dec 1990, pp. 1323-2059	AIP	1990, AVS	90-85325	0-88318-841-4
P35	1991	Proceedings of the 35th ISEIPB	Jane M. Shaw	160	790	JVST B, Vol. 9(6), Nov/Dec 1991, pp. 2829-3619	AIP	1991, AVS	91-76907	1-56396-012-5
P36	1992	Proceedings of the 36th ISEIPB	Randall L. Kubena	153	751	JVST B, Vol. 10(6), Nov/Dec 1992, pp. 2509-3260	AIP	1992, AVS	92-55004	1-56396-134-2
P37	1993	Papers from the 37th ISEIPB	Franco Cerrina	164	951	JVST B, Vol. 11(6), Nov/Dec 1993, pp. 2155-3016	AIP	1993, AVS	1073-0788	1-56396-275-6
P38	1994	Papers from the 38th ISEIPB	Ilesanmi Adesida	161	822	JVST B, Vol. 12(6), Nov/Dec 1994, pp. 3235-4057	AIP	1994, AVS	1073-0788	1-56396-423-1
P39	1995	Papers from the 39th ICEIPBTN	Dieter P. Kern	164	800	JVST B, Vol. 13(5), Nov/Dec 1995, pp. 2323-3123	AIP	1995, AVS	1073-0788	1-56396-539-9
P40	1996	Papers from the 40th ICEIPBTN	Stella W. Pang	157	760	JVST B, Vol. 14(6), Nov/Dec 1996, pp. 3619-4379	AIP	1996, AVS	1071-1023	1-56396-672-7
P41	1997	Papers from the 41st ICEIPBTN	Geraint Owen	169	861	JVST B, Vol. 15(6), Nov/Dec 1997, pp. 2091-2952	AIP	1997, AVS	1071-1023	1-56396-768-5
P42	1998	Papers from the 42nd ICEIPBTN	Christie R.K. Marrian	163	830	JVST B, Vol. 16(6), Nov/Dec 1998, pp. 3126-3956	AIP	1998, AVS	0734-211X	1-56396-873-8
P43	1999	Papers from the 43rd ICEIPBTN	John C. Wolfe	155	765	JVST B, Vol. 17(6), Nov/Dec 1999, pp. 2690-3455	AIP	1999, AVS	0734-211X	1-56396-909-2
P44	2000	Papers from the 44th ICEIPBTN	John Melngailis	146	738	JVST B, Vol. 18(6), Nov/Dec 2000, pp. 2876-3614	AIP	2000, AVS	0734-211X	1-56396-969-2
P45	2001	Papers from the 45th ICEIPBTN	Mark McCord	121	619	JVST B, Vol. 19(6), Nov/Dec 2001, pp. 2318-2937	AIP	2001, AVS	0734-211X	0-7354-0039-3
P46	2002	Papers from the 46th ICEIPBTN	Roderick R. Kunz	112	559	JVST B, Vol. 20(6), Nov/Dec 2002, pp. 2561-3120	AIP	2002, AVS	0734-211X	0-7354-0104-7
P47	2003	Papers from the 47th ICEIPBTN	Mark L. Schattenburg	113	564	JVST B, Vol. 21(6), Nov/Dec 2003, pp. 2623-3187	AIP	2003, AVS	0734-211X	0-7354-0163-2
P48	2004	Papers from the 48th ICEIPBTN	Roxann L. Engelstad	148	712	JVST B, Vol. 22(6), Nov/Dec 2004, pp. 2876-3587	AIP	2004, AVS	0734-211X	0-7354-0219-1
P49	2005	Papers from the 49th ICEIPBTN	Martin Peckerar	124	641	JVST B, Vol. 23(6), Nov/Dec 2005, pp. 2578-3218	AIP	2005, AVS	0734-211X	0-7354-0299-X
P50	2006	Papers from the 50th ICEIPBTN	Shalom J. Wind	97	474	JVST B, Vol. 24(6), Nov/Dec 2006, pp. 2788-3262	AIP	2006, AVS	0734-211X	

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Table 2C. Publisher legend

AIMMPE	American Institute of Mining, Metallurgical and Petroleum Engineers, NY
AIP	American Institute of Physics, NY (for AVS)
AC	The Alloyd Corp., Cambridge MA
AE	Alloyd Electronics Corp., Cambridge MA
AG	Alloyd General Corp., Medford MA
AR	Alloyd Research Corp., Watertown MA
AVS	American Vacuum Society
ECS	The Electrochemical Society, NY
G&B	Gordon and Breach, NY
IEEE	Institute of Electrical and Electronics Engineers, Inc.
JVST	Journal of Vacuum Science and Technology
SFP	San Franciso Press, Inc., San Franciso, CA
unk	unknown
Wiley	John Wiley and Sons, Inc., NY

Table 3. EIPBN banquet speakers

#	**Track**	**Year**	**Banquet Speaker**
11	IEEE	1967	John H. Bloomer
13	IEEE	1969	Dr. E.R. Piore, VP, IBM Corp.
15	IEEE	1971	Dr. Robert Adler, VP and Dir. of Research, Zenith Corp.
17	IEEE	1973	Dr. Lewis M. Branscomb, VP and Chief Scientist, IBM, former director of NIST
19	IEEE	1975	Dr. James A. Dunne, JPL
21	IEEE	1977	Dr. Gordon Moore, President of Intel Corp.
23	IEEE	1979	Dr. James A. Krumhansl, NSF
25	IEEE	1981	Dr. Jack Kilby, inventor of the integrated circuit
27	Merged	1983	Dr. Donald L. Hammond
28	Merged	1984	Dr. John Armstrong, VP Research, IBM
29	Merged	1985	Dr. Lowell Wood, Lawrence Livermore National Laboratory
30	Merged	1986	Raymond Stata, President, Analog Devices
50	Merged	2006	Felice Frankel, science photographer