# Chapter 24
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# The only way is up, 1994-1996

Still trembling on its feet from the previous turbulence, ASM was lifted up by a reviving market. At the start of 1994, the company hardly managed to realize the conditions for its subsistence. Just before it would perform below par, however, the newest pending products dragged the equipment manufacturer out of its mess.

### ***Industrial context: A most welcome revival***

After the tough early 1990s, the market and economic circumstances improved for ASM (figure 59 in Chapter 23). From 1993 to 1996, the global semiconductor market grew by 60 percent to nearly 137 billion dollars. In its wake, demand for semiconductor equipment increased by 77 percent, from 6.87 billion dollars in 1993 to 19.05 billion dollars in 1996. The healthy prospects of the electronics industry at large raised the confidence of investors, in the Netherlands as well as abroad. Moreover, the semiconductor industry established collaborative efforts for the development of a new wafer size, which indicated the trust of the chip manufacturers in their equipment suppliers and the future.

The market for personal computers propelled the recovery of the chip industry. By 1995, approximately 59.7 million personal computers were shipped worldwide, an increase of more than about 20 percent over 1994.[89] New software like Microsoft Windows 95, introduced in August 1995, made personal computing more accessible for consumers. To run the software, new memory chips with more capacity were needed. As such, the introduction and success of Windows 95 stimulated demand for the latest 8 and 16 Megabit DRAM chips.[90] Furthermore, mobile telephony opened new markets for wireless computer chips. In 1993 about 18.7 million cellular phones were produced, which increased to 108.9 million in 1997, and was expected to grow to 240 million units by 2000.[91]

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89 Dataquest, Jim Handy, 'The 1995-1996 DRAM Fab Outlook – Can PCs Absorb That Much DRAM Capacity?', *Dataquest Memories Worldwide: Telebriefing Summary* (19-6-1995), p. 6; 'Dataquest, 'Worldwide PC Market Grew 24 Percent in 1995', *tech-insider.org* (29-1-1996).

90 Dataquest, Jim Handy, 'How Windows 95 Will Impact Today's Dram Shortage', *Dataquest Memories Worldwide Focus Analysis* (14-8-1995).

91 Dataquest, Bruce Bonner and Dale Ford, 'Flash Talks in Digital Cellular Phones', *Dataquest Communications Semiconductors and Applications Worldwide: Technology Analysis* (9-3-1998).

Since a single personal computer contained numerous memory chips and merely a few microprocessors, the memory segment of the semiconductor industry experienced most growth. The combined market for DRAM, SRAM, and flash memory peaked in 1995 at 55.3 billion dollars in 1995, or 36.5 percent of all semiconductor sales in that year.[92] In an effort to meet demand, memory chip manufacturers heavily invested in new equipment during this boom. A shortage in the latest memory chip had been caused due to deferment of investments by Japanese chip manufacturers during the Japanese crisis of the early 1990s.[93] The new investments in production lines caused a peak in demand for semiconductor equipment.

The boom in semiconductor equipment had positive effects on related stocks. Investors in semiconductor companies – both chip and equipment manufacturers – were eager to join the bonanza. During this period, in the Netherlands, ASM Lithography and BESI (formerly known as ASM Fico) conducted an initial public offering on both the Nasdaq and the Amsterdam Stock Exchange. Anxiety about the viability and prospects of the chip industry seemed to vanish in thin air.

*Another new wafer size*

Confidence in the future was further illustrated in the preparations for a new wafer size. From 1995 onward, industry-wide, the semiconductor industry discussed, negotiated, and defined the introduction of 300-millimeter – or 12-inch – wafers. Just like the 200-millimeter wafer size, such a transition constituted a clear opportunity for equipment vendors. For this new wafer size, all equipment had to be re-evaluated. Suppliers of 200-millimeter equipment were not certain of supplying 300-millimeter wafer tools.

For the first time in the history of the semiconductor industry, the introduction of the new wafer size was prepared by industrial consortia. Earlier, single companies had driven the transition, like Intel with 150-millmeter wafers in 1980, and IBM with 200-millimeter wafers in 1990. The development cost for 300-millimeter equipment was too high to be carried by a single company. Moreover, due to the 1980s' rivalry between the United States, Japan, and Europe, a matured and comprehensive infrastructure existed for industrial collaboration in each of these regions. The global industry association for equipment and materials, SEMI, coordinated standardization efforts. This involved the definition of standards for equipment interfaces, cleanroom facilities, ergonomics, safety, and cost.

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92 Dataquest, Market Statistics: *Worldwide Memory market Share, 1993-1995* (22-5-1996).

93 Dataquest, 'Will the Memory Market Ever Recover?' *Dataquest Memories Worldwide Market Analysis* (30-11-1998) pp. 11 and 12.

The new wafer size carried along new logistic challenges. A full transfer box, containing twenty-five 300-millimeter wafers was almost impossible to carry, nor was it desirable. A 200-millimeter wafer weighed approximately 53 grams, while a 300-millimeter wafer weighed between 128 grams and up to as much as 750 grams, depending on the specifications. Imagine the loss of value when dropping a box full of 300-millimeter wafers! Thus, the new wafer size commanded advanced automation of wafer handling in the factory. Standard Mechanical Interface (SMIF) boxes were replaced for Front-Opening Unified Pod (FOUP) boxes to transfer wafers from one production step to the next. Moreover, these FOUPs were transported by overhead conveyors attached to the ceiling of the cleanroom.

The first semiconductor equipment and material segment to be confronted with the new wafer size involved the producers of silicon crystal shafts and the wafer fabricators. The relative thickness of 300-millimeter wafers increased from 725 micron to 775 micron, while the area increased from 314 to 707 square centimeters.[94] This was an increase of 225 percent. The quality of the silicon wafer had to be the same as that of the previous generation.

Traditionally, silicon epitaxy had been a way to overcome minor deficiencies in silicon wafer quality during the production of chips containing CMOS transistors (cf. introduction of Innovation II). By growing an epitaxial film, electrical properties of the substrate could be controlled, while continuing the crystalline structure of a wafer. To offer the best quality of silicon wafers, most wafer manufacturers offered their wafers with an epitaxial film on top of it. This meant that apart from the wafer fabricators, also the suppliers of epitaxy equipment had to be ready for the new wafer size at an early stage. This was relevant in particular for ASM and Applied Materials. Only after new 300-millimeter silicon wafers – with an epitaxial film – became available, the other 300-millimeter production technologies could be evaluated. Thus, epitaxy led the equipment industry in the transition towards 300-millimeter wafers.

The new wafer size bore consequences for all semiconductor equipment. One example involved the equipment that sequentially or linearly scanned the wafer surface, such as lithography and metrology equipment. The movements involved had to cover a larger surface in the same amount of time, or otherwise the throughput would decrease and the cost of ownership would deteriorate. For plasma CVD, the increase in wafer size affected the coverage of the plasma field and new gas flow patterns. Another concern pertained to the implications for vertical furnaces, the tool type expected to be significantly impacted by the

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[94] On the International 300-millimeter Initiative, see Randal K Goodall, 'The Impact of the 300 mm Scale-Up on IC Fab Process, Metrology, and Automation Equipment', *Silicon Materials Science and Technology: Proceedings of the Eight International Symposium on Silicon Materials Science and Technology* (1998) pp. 1302-1324.

new wafer size.[95] Matters that had to be considered for these machines were the ramp rates, wafer spacing, quartz ware, gas flow, and gravitational effects. While the surface of the wafer almost doubled, this could not be allowed for the footprint of the machines themselves. Within SEMI and in conjunction with the chip manufacturers it was decided that the size of the machines had to remain the same. After all, every square centimeter of a cleanroom was extremely expensive. Furthermore, SEMI restricted price increases to a maximum of 30 percent to control the cost of future chips factories and to make the new wafer size economically more attractive.

From 1996 onward, the evaluation of new 300-millimeter equipment occurred within an American-European research consortium and a Japanese one, in conjunction with preparations for forthcoming 250 and 180 nanometer technology nodes. In the West, a consortium was established called International 300-millimeter Initiative, or I300i, which eventually merged with Sematech, the American research consortium for semiconductor manufacturing technology.[96] In Japan, the new wafer size was prepared by Japan300 (J300) and Semiconductor Leading Edge Technologies (Selete).[97] SEMI organized some harmonization among Selete, I300i, and J300.

After all production steps of a chip factory had been evaluated by the consortia, chip manufacturers had to decide for themselves when to build their first fab for 300-millimeter wafers, which was expected to be around late 1998 to 2000. The commitment of the whole chip industry to the new wafer size strengthened confidence in future investments in semiconductor equipment. Until the first tools got sold, however, equipment manufacturers had to carry the full weight of the development cost and thus the financial risk. If, in other words, the opportunity was beautiful, the burden was rather unilateral initially.

### *Corporate course: Regained confidence and aligning forces*

From 1994 onward, ASM regained its footing. The deliberations about the company's future in either back-end or front-end had gotten beyond a point of closure. The divestments of ASM Pacific Technology stock and the whole of ASM Fico had been necessary to remove the anxiety of the bankers. But this resolution had come at a cost. All the remaining operations – ASM Europe, ASM

95 Ibid.

96 Chip manufacturers Intel, Motorola, Lucent, Texas Instruments, IBM, AMD, Siemens, SGS-Thomson, Philips, Samsung, Hyundai, LG, and TSMC got access to the results of wafer evaluations.

97 In it, Fujitsu, Hitachi, Matsushita, Mitsubishi, NEC, Oki, Rohm, Sanyo, Sharp, Sony, and Toshiba evaluated the new equipment. Samsung and Seiko Epson shared in the results as well.

America, and ASM Japan – had to work with a very narrow base (figure 61). These front-end operations relied on the product portfolio of a startup venture, while carrying the organizational burden of a matured firm. The technologies they produced were either phasing out or merely beginning to make inroads into their respective markets. Their products, in other words, could hardly carry the costs of the organization.

*Addressing persistent cash shortages*

Cash remained scarce, which ensured that the pursuit of core competencies remained a pressing concern within front-end.[98] Cash reserves were derived from banks. ASM Pacific Technology's stock secured the bank loans of front-end. Since it was not viable for divestment, the remaining ownership of ASM Pacific Technology was required as leverage to sustain the front-end activities. There seemed to be only one option: slogging on.

In addition to operational costs, there were significant instalments and legal charges that drained the cash flow. In 1994, ASM got entangled in a number of litigations. This involved an accusation by Kulicke & Sofa with regard to the procedures surrounding the divestment of ASM Fico. But there was also a claim by General Signal for compensation for technology used in the A400, which was settled for 1.4 million dollars. Moreover, the litigation against Applied Materials surrounding the Epsilon continued to escalate, swallowing large amounts in legal fees.[99] On top of these exceptional costs, there was the periodical installment of the convertible loan held by investment bankers Grantham, Mayo Van Otterloo & Co. This was too much. The company simply did not have the cash, while turning the installment into stock would give the bankers an undesired hold on the company. Del Prado intervened by providing a personal non-interest bearing loan of 3 million Dutch guilders to ASM, which made it possible to meet the installment.[100]

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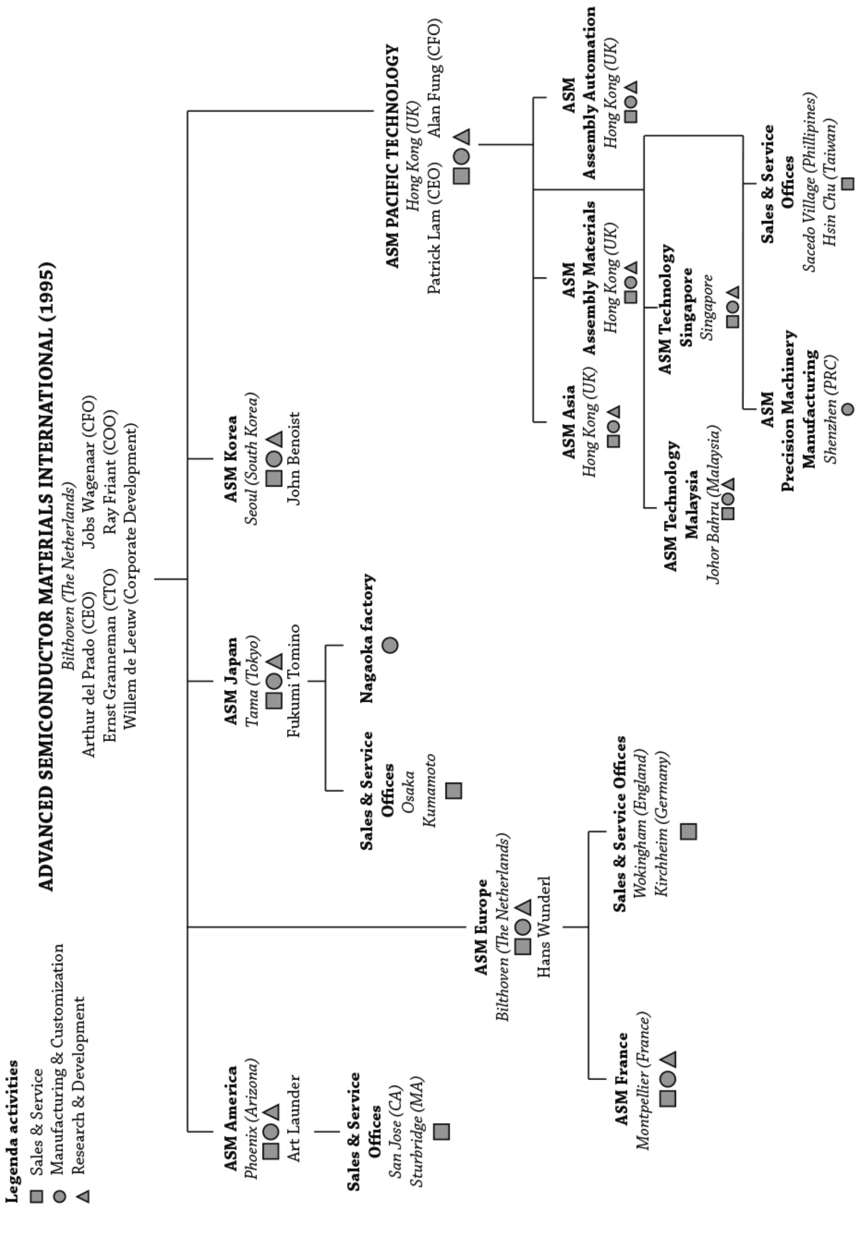
98 ASM International, Willem de Leeuw, 'Position Paper on ASM Front-End Funding' (July 1994) *Archive Arthur del Prado – RvC 1994-1996*.

99 Knobbe, Martens, Olson & Bear, Don Martens, 'Facsimile: ASM America Inc, v. Applied Materials, Inc, ref: ASMEX.023L' (15-2-1994) *Archive Arthur del Prado – RvC 1994-1996*.

100 Earlier installments of 2.8 million Dutch guilders in March 1993 were paid for by 1.3 million shares, 1 million of which were called by ASM International for a value of 1.56 million Dutch guilders in March 1994. The calling of stock prevented further increase of ownership by the investment bankers. – Stibbe Simont Monahan Duhot, Maurits van den Wall Bake, 'Letter to Arthur del Prado, ref: vdWB/ek-91968.B53' (1-2-1994) *Archive Arthur del Prado – RvC 1994-1996;* ASMI, Arthur del Prado, 'GMO Conversion in March, ref: 94.009 AdP/tv' (2-2-1993) *Archive Arthur del Prado – RvC 1994-1996*; Del Prado defended the move as follows: 'A continuation of such dilution will seriously jeopardize our ability to lift our stockprice to the levels whereby equity can be attracted.' Thus he was also interested, of course, in maintaining his personal hold on the company. – ASMI, Arthur del Prado, 'GMO Conversion in March,

**Figure 61**
Organigram of ASM International by 1995




ref: 94.009 AdP/tv' (2-2-1993) *Archive Arthur del Prado – RvC 1994-1996*.

Apart from the financial intervention by Del Prado, the company's financial distress was relieved further by approximately 3.5 million Dutch guilders through the divestment of ASM facilities in Bilthoven. This involved three locations (Rembrandtlaan 4 and 2a and Jan Steenlaan 9), whereas the company headquarters was moved to another location (Jan van Eijcklaan 10). Furthermore, Del Prado, Willem de Leeuw – who in his role as Director of Corporate Development acted as a *de facto* treasury officer – and members of the Supervisory Board re-engaged their financial supporters for new loans. This also involved the Dutch government. ASM's application for a governmentally backed venture capital scheme, called 'industry fund' (*industriefaciliteit*) and involving an amount of 50 million Dutch guilders, was rejected because of ASM's poor solvency status.[101] For another scheme, called Technolease, ASM just missed the boat.[102] Technolease was a 'sale and lease back' construction through which immaterial technological assets – knowledge and intellectual properties – were sold to a bank, the Rabobank, and subsequently rented by the previous owner.[103] This construction provided the seller of the assets with cash to redeem financial distress, while it allowed the bank to decrease taxes on its profits. The scheme was withdrawn, however, before ASM could make use of it.[104]

*Restructuring management*

By the mid-1990s, Friant had managed to cultivate some shared belief in a corporate strategy for ASM's front-end operations. He continued to redefine the flow of information and relations within and among the front-end subsidiaries.

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[101] Del Prado and De Leeuw suggested to pledge the remaining value of ASM Pacific Technology, amounting to 185 million Dutch guilders, as collateral for an 'industry fund' of 50 million Dutch guilders. The scheme was funded by, among others, the National Investment Bank. In preparation of the decision, De Leeuw traveled to all major ASM operations together with representatives from the National Investment Bank. – ASMI, Arthur del Prado, 'Visit to E.Z., The Hague, ref: 94.001 WdL/tv' (14-1-1994) *Archive Arthur del Prado – RvC 1994-1996;* Evert-Jan Velzing, *Innovatiepolitiek: Een reconstructie van het innovatiebeleid van het ministerie van Economische Zaken van 1976 tot en met 2010* (Eburon, Delft, 2013), p. 129.

[102] In a first assessment, ASM listed the investments in its European R&D portfolio since 1982. This amounted to 146 million Dutch guilders. – ASMI, Erik Kamerbeek, 'Memorandum: Background Re Technolease, ref: m-A/940801/EK/if' (11-8-1994) *Archive Arthur del Prado – RvC 1994-1996*; ASMI, Arthur del Prado, 'Progress report august' (July 1994) *Archive Arthur del Prado – RvC 1994-1996*; ASMI, Willem de Leeuw, 'Facsimile message: Letter to W.A. Vermeend, Ministerie van Financiën' (28-3-1995) *Archive Arthur del Prado – Willem de Leeuw*; ASMI, Arthur del Prado, 'Progress report august' (July 1994) *Archive Arthur del Prado – RvC 1994-1996*.

[103] Velzing, *Innovatiepolitiek*, p. 135.

[104] Both Philips and Dutch aircraft builder Fokker used the Technolease construction in, respectively, 1992 and 1994, despite disputes about its legality among officials of the Ministry of Economic Affairs, the Ministry of Finance, and the European Commission.

He established adequate management directives with regard to cash flow, forecasts, and product management. The chief operating officer (COO) stipulated what he expected from the full front-end board – consisting of Del Prado, the chief financial officer (CFO), the chief technology officer (CTO), the general managers, and the product managers – in terms of reporting, availability, and meetings.[105] Having grown organically, rapidly, and in a diversified manner, ASM had always lacked such a coherent structure.

New general managers were appointed, replacing company veterans, filling in interim positions, and revitalizing the operations with their energetic and fresh views on the matters at hand. The five years of crisis had taken its toll on the older executives, most of whom got promoted to a non-executive position within the firm or their subsidiary. At ASM Europe, the bold Hans Wunderl filled in the vacancy of general manager. At ASM Japan, the inquisitive Fukumi Tomino replaced Yo Miyazaki, and at ASM America, Art Launder took over the helm from John Krickl. Ernst Granneman grew in his role of CTO, while Jobs Wagenaar succeeded Hans Peter Hukshoorn as CFO. The new executives offered Friant the chance to renew company procedures, disrupt entrenched habits, and reconcile strategies and interests with each other anew.[106]

*New core products*

ASM's recovery was stimulated by a sudden surge in demand for semiconductor equipment in 1994 and 1995. Four of the company's newest products succeeded in joining the heave. Through the concerted efforts of Friant and Granneman, more certainty emerged about the viability of the various products. The base and methodology for forecasts was harmonized, tested, and adjusted. The improved flows of information boosted performance and prospects. Technological development, after all, had to be market-driven, while commitment of customers was indispensable.[107] Equipment that merely served local demands was de-prioritized. Products only could be continued on a cash-neutral base, and across the subsidiaries so-called 'make-or-buy' analyses were performed to distinguish activities that might be divested or outsourced.

Gradually, a sense of ASM's core competencies for the future emerged. The production of four technologies was sustained, which were innovated and sold

105 ASMI, Ray Friant, 'Memo: Front-End Management Structures' (6-8-1994) *Archive Arthur del Prado – RvC 1994-1996*.

106 Ray Friant, 'Memo: Front-End Organization and Staffing' (20-4-1994) *Archive Arthur del Prado – Ray Friant files.*

107 ASMI, Willem de Leeuw, 'Facsimile message: Front-end management structure, ref: 94.0042 WdL/tv' (23-8-1994) *Archive Arthur del Prado – Willem de Leeuw files.*

by the three geographical operations.[108] ASM America, through its subsidiary ASM Epitaxy, concentrated on the Epsilon single wafer epitaxial reactor. ASM Japan focused on the single wafer plasma enhanced CVD reactor Eagle-10. ASM Europe took care of the A400 vertical reactor. And a new version of the A600 for ultra-high vacuum processes, the A600-UHV, was developed by all front-end operations. It was also clear that the glory days of the horizontal furnaces were over. Most of the intellectual property was sold and products were discontinued. The other vertical furnaces – ASM Japan's VMP and VDF, plus ASM America's A300/EVTR – were de-prioritized.[109] The success of the four products – the Epsilon, Eagle-10, A400 and A600-UHV – helped to restore confidence in the viability of the company.

Each of the front-end subsidiaries, except ASM Epitaxy/America whose Epsilon continued to sell well, had to redefine its core competencies. This directly pertained to the selection of products and also production. Moreover, operating in the advanced, volatile, and complex chip industry called for a long-term strategy. This involved preparing for the forthcoming new 300-millimeter wafer size, but also new applications and processes. Such technological milestones offered unique opportunities to strengthen the focus on organizational and technological competencies and improve the company's cash flow for the future. Economies of scale could be achieved through standardization and harmonization of the 300-millimeter wafer-handling technology across the operations. At the previous conversion to 200-millimeter wafers, ASM had almost entirely missed the boat, and Granneman was determined to prevent this from happening again. However, centralization and harmonization of integral technological components of each of the products seemed impossible. Once again, the competitive strategies of the operations did not align with the corporate strategy of ASM International.

As results improved over 1995, the window of opportunity for further operational alignment and restructuring declined. The original strategic intent of making front-end sellable was no longer relevant. Without this sword of Damocles hanging over their heads, and boosted by the recent success of several products, the decentral realities and stubbornness that had aggravated ASM International's crisis since the late 1980s surfaced once again. Elaborating on

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108 In the 1993 Annual Report, published in April 1994, the new organization was announced. At the time of writing the annual report, the Paragon was still part of ASM America's product portfolio. However, a few months later, this product was mothballed. – ASM International, '1993 Annual Report' (26-4-1994).

109 A few tools were still sold in 1994. This involved some VMP furnaces for LCD production to Korean customers, and a few A300 furnaces for IBM Burlington and Sindelfingen. – ASM International, Arthur del Prado, 'August Progress Report' (July 1994) *Archive Arthur del Prado – RvC 1994-1996 files.*

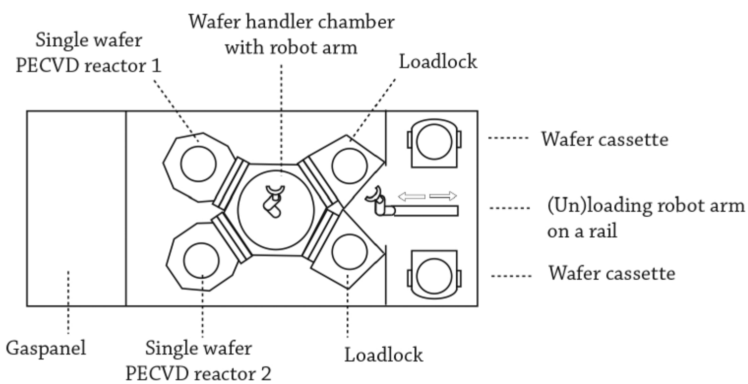
the newly established core competencies, the subsidiaries seemed more eager to pursue the imminent opportunities on their own distinct terms.

## Elaboration of affairs

### *Selecting four core competencies*

At the same time, though, some of the hopeful developments identified the year before by Friant, Del Prado, and Granneman slowly began to materialize.[110] ASM's brightest star continued to be the Epsilon reactor. In 1993, under the guidance of its original and long-time product manager, Armand Ferro, sales went up to 39 million dollars (in a global market of 83 million dollars). Moreover, a newly appointed general manager by the name of Art Launder expected sales to grow to 73 million dollars by 1997.[111] ASM America was market leader. Every year, the applicability of the reactor got extended to new materials and fabrication processes, such as silicon germanium and power chips. Even, America's biggest chip manufacturers chose the reactor to grow selective epitaxial films, and pushed their wafer suppliers to follow their example. Moreover, industry magazine *Semiconductor International* celebrated the Epsilon with its '1994 Editor's Choice Product of the Year Award'.[112]

**Figure 62**
Schematic view-from-above of the Eagle-10 single wafer PECVD reactor, developed, manufactured and sold by ASM Japan from the early-1990s onwards.



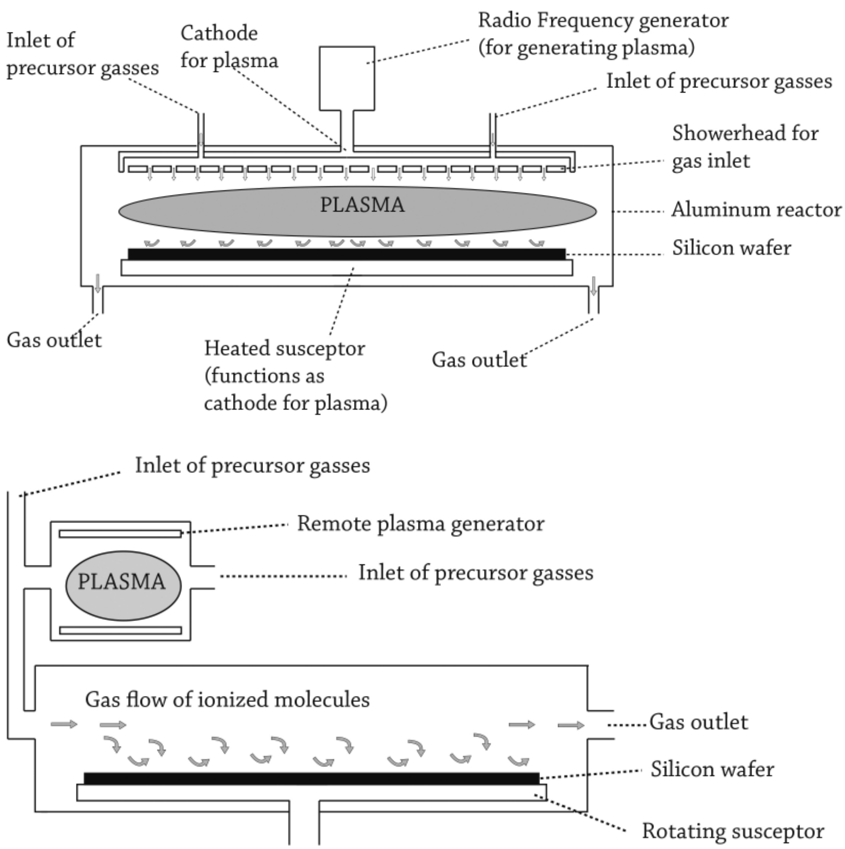

[110] ASMI, Hans Peter Hukshoorn, 'Financieringsplan ASM Front-End' (12-1-1994) *Archive Arthur del Prado – RvC 1994-1996 files*.

[111] ASM Epitaxy, 'ASM Epitaxy, Inc: $35,000,000 equity investment. Executive Summary' (April 1993) *Archive Arthur del Prado – ASM Epitaxy files*.

[112] ASM America, Ken Davidson, 'ASM Epitaxy Receives Semiconductor International's 1994 Editor's Choice Best Product Award', *ASM News* (February/March 1995). Archive author.

In Japan, the engineers and sales officers succeeded in carving out some market share for its single wafer plasma deposition tool, the Eagle-10, which had been developed since 1989 (figure 62). The tool clustered two single wafer plasma deposition reactors with a shower-head gas inlet (figure 63). The machine was not a trail-blazer in its business segment, as it followed basic outlines set by single wafer plasma CVD reactors of Applied Materials and Novellus.[113]

**Figure 63**
A simplified side-view of a single wafer plasma enhanced CVD reactor chamber with direct plasma (upper) and remote plasma (lower).
ASM Japan's Eagle-10 used the direct plasma variation. Innovation IV discusses an Epsilon silicon nitride reactor equipped with a remote plasma source, which resembled the remote plasma variation depicted here. For 'plasma enhanced ALD' the same variations are possible as well (cf. Business V). In case of plasma ALD, ASM Japan and ASM Genitech developed a direct plasma variation.




[113] Kano, 'Interview with author'.

But the Eagle-10 proved to be a robust design, and, accompanied by ASM Japan's impeccable reputation for servicing its Japanese customers, it succeeded in attracting the attention of Japan's prominent chip manufacturers. Toyota had qualified a first machine, while it and the likes of NEC, Hitachi, Oki, and Mitsubishi considered the procurement of more.[114] For the 1994 book year about twenty tools were expected to be sold.[115] The Eagle-10 saved ASM's future in plasma deposition technology right when its horizontal furnaces became obsolete.

By 1994, the CVTR/A400 finally gained some traction in the market under the new general manager of ASM Europe, Hans Wunderl. The machine seemed to offer the best of both worlds. Its cluster configuration offered high throughput and its modularity of design allowed for better maintenance and thus cost of ownership (figure 57 in Chapter 22). Moreover, it was capable of growing the full range of probable low pressure CVD, oxidation and diffusion processes.[116] In the spring of 1994, as Tempress filed for bankruptcy, ASM became full owner of the CVTR technology by acquiring the shares of Tempress and NOM in the CVTR joint-venture. Ten key engineers of Tempress were employed by ASM Europe – even though temporarily they stayed on in Hoogeveen. ASM Europe sold the A400 to a small research institute named Fraunhofer Gesellschaft in Itzehoe, Germany. Some tools were sold to European chip manufacturers SGS Thomson Micro-electronics (STM) and Philips. Also, the American chip manufacturer Motorola contemplated procurement.

But the real breakthrough came in June 1994. Micron, practically the only remaining memory manufacturer in the United States, completed an extensive evaluation of vertical furnaces for its forthcoming product lines, the A400 emerging as the system of choice.[117] Micron considered the purchase of approximately 100 systems. Before committing to such a huge order, the memory manufacturer, located in Boise, Idaho, wanted to get several guarantees from ASM Europe. As was reported:

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114 ASMI, Rray Friant, 'Memo: ASM Front-End status' (20-3-1993) *Archive Arthur del Prado – RvC 1992-1993;* ASM International, Ray Friant, 'Memo: Front-End Status' (20-4-1994) *Archive Arthur del Prado Archive – Ray Friant file*.

115 ASMI, Arthur del Prado, 'Progress report august' (July 1994) *Archive Arthur del Prado – RvC 1994-1996;* Fukumi Tomino mentioned an installed base of 1 machine in 1992, 3 in 1993, 14 in 1994, and 32 in 1995. – Fukumi Tomino, 'Correspondence with author'.

116 Even more, all the processes developed for the A600 had been transferred to the A400. As such, it was more advanced than ASM Japan's VMP and VDF vertical furnaces, but not as complex as the A600 – ASM Europe, Boudewijn Sluijk, 'Memorandum: Update Status Marketing Advance 400 CVTR' (3-2-1994) *Archive Arthur del Prado – RvC 1994-1996*.

117 Among the whole range of competitors, ASM had offered the A600-2 but also the A400. – ASM Europe, Boudewijn Sluijk, 'Memorandum: Update Advance 400 marketing status' (17-6-1994) *Archive Arthur del Prado – RvC 1994-1996*.

> 'Steve Appleton, Micron's 33-year-old President, took us to lunch, which I believe was a positive sign of things to come if we perform. He compared ASM America/ASM Europe to ASM Lithography five years ago when they needed help. Steve indicated Micron was prepared to do the same for us, because his people believe in the A400 and we are demonstrating a proactive attitude.'[118]

In the year's remaining months, ASM and Micron negotiated technology, conditions of delivery, and purchase orders.[119] The order proved to amount to nearly 50 systems, containing almost a hundred tubes, in 1995, and about 30 systems, holding 60 tubes, in 1996. From one day to the next, this order turned ASM Europe from a faltering company into an overburdened one.

To fulfill this order, ASM Europe had to outsource production of generic modules. Originally, ASM, Tempress, the Ministry of Economic Affairs, and the NOM – a public investment company in support of employment in the northern Dutch provinces – decided that Tempress would take care of manufacturing. However, its bankruptcy had annulled this arrangement. Since preservation of jobs in the country's northern part had been a prerequisite for the NOM's financial support, ASM contracted Philips Machinefabrieken. This engineering subsidiary of Philips, located in Almelo in the North-East of the Netherlands, had experience with servicing the semiconductor equipment industry. A major part of ASM Lithography's hardware was built by the subcontractor as well. From 1995 onward, Philips Machinefabrieken manufactured the various A400 modules, which were assembled, customized, and tested by ASM Europe in Bilthoven.

The outsource strategy fitted in the company's ambition to focus on its core competences. ASM Europe's competitiveness did not depend on constructing basic modules of metal, painting sheets, and electrical wiring. Such tasks could be done more effectively elsewhere. The Bilthoven operation added value to its product through its ability to facilitate delicate chemical processes with ingenious gas supply systems, control software, and process management. Moreover, the outsourcing scheme offered this operation more flexibility and control of its expenses.

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118 ASM America, Art Launder, 'Facsimile Transmission: Micron Visit – August 8, 1994' (9-8-1994) *Archive Arthur del Prado – RvC 1994-1996*.

119 Micron was in particular wary of knowledge transfers to ASM Japan – and subsequently to Japanese memory manufacturers. The American memory manufacturer was practically the sole survivor of the American-Japanese rivalry of the 1980s, which resulted in Japanese dominance in this segment. Additionally, Micron wanted ASM Europe not to rely solely on Philips Machinefabrieken. ASML collaborated with Philips Machinefabrieken as well, and this implied that Micron would be exposed too much to a supplier with whom it had no direct relations. ASM America, Art Launder, 'Facsimile Transmission: Micron Visit – August 8, 1994' (9-8-1994) *Archive Arthur del Prado – RvC 1994-1996*.

The breakthrough of the A400 almost pulled the curtains for the A600. This complex machine, which had consumed tremendous investments in research & development since the late 1980s, was saved from mothballing by NEC. This chip manufacturer – the world's largest – identified a particular application for which it could use the A600's remarkable capabilities in vacuum processes. NEC wanted to use a modified version of the A600 for the growth selective 'hemispherical grained silicon' (HSG) for its forthcoming 256 Megabit and 1 Gigabit memory chips. HSG required an ultra-high vacuum. In close cooperation between ASM Japan, ASM Europe, ASM America and NEC, a new variation of the A600 was developed: the A600-UHV. For ASM Japan, the collaboration with NEC was highly prestigious, involving state-of-the-art technology for memory manufacturing. For the A600, it was the final effort to prove its commercial viability, after the failure of the A600 plasma, aluminum, and LPCVD variations.

Among these various hopeful signs, one of the prospective developments failed to live up to its promises: the Paragon, the Epsilon based polysilicon reactor.[120] Batch furnaces – like ASM's A400, for instance – proved to be capable of addressing customers' needs for higher uniformities better. Stand-alone single wafer machines like the Paragon could not compete against the high throughput – and thus low cost of ownership – of the batch furnaces. Moreover, in the few niche applications left, it had to compete with established suppliers of single wafer polysilicon reactors, like American AG Associates and Applied Materials.[121] The seven projected Paragon systems for 1994, as well as sixteen machines for 1995, proved elusive, resulting in an annulment of approximate 12 million dollars in revenues.[122] The Paragon was mothballed in the summer of 1994.[123]

By the first half of 1994, ASM had limited its front-end operations to four products, after the gradual abandonment of all others. The company's geographical subsidiaries now functioned as product groups, bearing responsibility for the global success of their respective products. No longer would there be geographical localization of products, as happened in the early 1980s. In reality, however, this global outreach was not yet feasible. The Eagle-10 was sold solely in Japan, the

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120 ASM America, Art Launder, 'Facsimile Transmission: Paragon Red Flag' (26-8-1994) *Archive Arthur del Prado – Ray Friant file*.

121 Applied Materials and AG Associates offered single wafer polysilicon cluster tools respectively named Precision 5000 and Integra. Through clustering multiple single wafer tools, cost-of-ownership decreased, while superior control and quality of ultra-thin layer stacks was achieved. – Ibid.

122 ASM America, Steve Reiutz, 'Paragon Business Plan' (3-2-1994) *Archive Arthur del Prado – RvC 1994-1996*.

123 The technology was transferred to the governmentally supported IVPS project (cf. Chapter 22 and Chapter 26).

Epsilon primarily in the United States and modestly in Europe and Japan, and the A400 largely in Europe and the United States.

The four products on which front-end activities relied – Epsilon & ASM America, Eagle-10 & ASM Japan, A400 & ASM Europe, and the A600-UHV – compartmentalized technological development. The new organization ensured that each of the subsidiaries focused on the technology in which it excelled. This also provided focus to technological development within the overall company and reduced the chance of easy excuses from subsidiaries, to dodge responsibility, and of overlap in development efforts – problems that plagued the company in the years around 1990.

*A rising sun in the East*

Throughout 1994 and into 1995, the Asian market for semiconductor technologies contributed significantly to ASM's recovery. The Japanese market finally recuperated, carrying not only ASM Japan along with it, but also ASM Pacific Technology, which elaborated on its operational foundations in Shenzhen, Hong Kong, and Singapore and sustained its profitability every consecutive year. Moreover, the Korean market rapidly developed into a factor of significance for wafer processing equipment. During the mid-1990s, the Asian ASM companies repositioned themselves to benefit from the hopeful developments in the East, driving ASM's recovery.

The Japanese operation had suffered from the country's economic stagnation and an obsolete product portfolio. Having experienced incredible heights, depressing lows, and witnessing the bewildering series of restructurings at the headquarters, the company's general manager Yo Miyazaki had trouble adjusting to the new course set out by Friant and Del Prado. Old sores and frustrations hindered his ability to focus on the present needs. If he wanted the leadership to take the particular circumstances of the Japanese market into account, this was out of the question due to the perilous financial situation of ASM and the globalizing market. After Friant and Miyazaki clashed, Del Prado sought to mitigate the conflict between his old-time Japanese companion and the interests of the overall company.[124] Yet the failure of ASM Japan to have a cash neutral balance over 1992, 1993, and 1994 gave Friant sufficient ammunition to force the Japanese subsidiary into compliance.[125]

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124 Friant, 'Interview with author'; ASM Japan, Yo Miyazaki, 'Letter to Arthur el Prado, ref: KK-92.0093' (7-2-1992) *Archive Arthur del Prado – ASM Japan 90's files*; ASM International, Ray Friant, 'Memo: ASMJ Situation' (4-11-1993) *Archive Arthur del Prado – Ray Friant file*.

125 ASMI, Ray Friant, 'Memo: ASM Japan Restructuring' (26-1-1994) *Archive Arthur del Prado – RvC 1994-1996*.

In the spring of 1994, ASM Japan was restructured, involving lay-offs of almost a hundred employees that had been pending for some time already. The manufacturing of some components was moved temporarily to ASM America to utilize currency advantages, and a small facility in Kumamoto was closed. More importantly, the management changed. Miyazaki got a new role, removing him from the daily management. The 45-year-old Fukumi Tomino – together with Del Prado, Miyazaki, and controller Hitoshi Miura one of the co-founders of ASM Japan – was appointed general manager. Tomino's long tenure in various positions and his younger age (compared to his 58-year-old predecessor) made him perfectly suited to work on the commercialization of the Eagle-10.[126] Although the transfer of power from Miyazaki to Tomino was rather painful for the staff members, it set the Japanese subsidiary on course for recovery.[127] The joining of the Eagle-10 with a recuperating Japanese semiconductor market did the rest.

ASM Pacific Technology continued to grow steadily. Sales increased from 62.8 million dollars in 1989 (and a profit of 11.8 million) to 133.3 million in 1993 (and a profit 19.9 million).[128] As such, the market capitalization of the assembly and packaging equipment manufacturer and its constant dividends constituted a lifeline for parent company ASM International.

ASM Pacific Technology was distinctly a Chinese company. Management was hierarchical, economical, and strongly embedded in the South-East Asian region. Its products were manufactured and sold in high volumes with a low variety among the systems. Typically, dozens of wire- or die-bonders were installed at a customer, with fairly minor differences in specifications. This was in contrast to the front-end deposition systems, which were ordered in much lower volumes and had to deposit a wide range of different chemical processes, implying low volumes and high variety. This characterization of ASM Pacific Technology's products helped the Asian firm to compete on a price-performance ratio. Pivotal was its Shenzhen facility which enabled an integrated production strategy: all parts were made internally, from screws to more complex components. Tapping into the vast

126 Ray Friant, 'Interview with author'; ASM International, Ray Friant, 'Memo: Front-End Organization and Staffing' (20-4-1994) *Archive Arthur del Prado – Ray Friant file*.

127 Fukumi Tomino, 'Interview with author'; Hitoshi Miura, 'Interview with author'; and Ray Friant, 'Interview with author'.

128 Or, as it was noted originally, in Hong Kong dollars: 1989 sales of 490 million HKD, 1989 profits of 92 million HKD, 1993 sales of 1.03 billion HKD and 1993 profits of 146 million HKD. Exchange rate on December 31, 1989, was 7.809 HKD to 1 USD, and 7.7265 HKD to 1 USD on December 31, 1993. Exchange rate derived from www. Poundsterlinglive.com (viewed: 12-9-2018). Sales ASM Pacific Technology derived from ASM Pacific Technology annual reports.

market for cheap labor in mainland China, the Hong Kong operation was able to control the cost of its equipment, even up to its components.

In contrast to ASM front-end, research and development centered around technology, not products. R&D groups targeted specific technological competencies – like vision & pattern recognition, motion control, etc. – and served the various product groups, such as gold wire bonders, aluminum wire bonders, die bonders, etc. This new structure helped to overcome structural deficiencies that hampered its parent company, ASM International, such as double work in development, the dichotomy between competitive strategies and corporate interests, and a tenacious manifestation of a 'not-invented-here' attitude among product groups.

Outperforming its competitors in pricing, ASM Pacific Technology served numerous smaller semiconductor assembly & packaging companies. This applied in particular to those active in light emitting diodes (LED), which required relative small volumes: about thirty machines per customer. Being a latecomer to the market and having lucrative exposure to numerous small-scale LED assembly firms in the South-East Asian region, this strategy enabled the ASM operation to familiarize and control the complex wire bonding technique.

By the mid-1990s, ASM Pacific Technology had made inroads with a new product, which symbolized its newly established confidence.[129] It was a wire bonder, named AB309, which was meant to bond golden wires between a CMOS die and its package. Bonding wires between die and package of LED involved just two aluminum wires, whereas equipment applicable for CMOS chips needed tens of delicate golden wires. As such it required much more control of speed and motion. Critical technology comprised a pattern recognition system, a stepper driven assembly table, a flexible indexer, and loop control. Competitors like Kulicke & Soffa, and Shinkawa had much more experience in this area. But through the AB309, of which about 1100 were shipped by 1995, ASM Pacific Technology set itself on course to become a major player in the market for semiconductor assembly equipment.

With regard to its position within the wider ASM family, the Chinese saying 'the mountains are high, and the emperor is far away' seemed fitting. ASM Pacific Technology's location, its focus on niche semiconductor segments, and its stable profits did not warrant too much involvement or actions from the ASM International Supervisory Board. Patrick Lam merely involved Del Prado, being the firm's president, in his business decisions. The autonomy of ASM Pacific Technology even increased after the divesture of ASM Fico. Only one subsidiary in semiconductor assembly and packaging remained, negating the need for

[129] Y.M. Wong, 'Interview with author'; W.K. Lee, 'Interview with author'; Patrick Lam, 'Interview with author'; and Peter Lo, 'Interview with author'.

formulating corporate strategy and respective competitive strategies for this market. As long as Lam's output continued to be profitable, quarterly presentation to the ASM Supervisory Board sufficed. Lam in fact never took the trouble of traveling to Bilthoven. Instead, during a tour with Del Prado in February 1995, the Supervisory Board visited all the Asian facilities of ASM Pacific Technology and ASM Japan. It was the first of its kind. Since the mountain did not come to Mohammed, Mohammed had to go to the mountain.

Meanwhile, in order to join the rapid growth of the Korean market – led by Samsung – Del Prado contemplated the establishment of a Korean operation. The characteristics of the Korean market resembled those of Japan in the early 1980s. The involvement of a local party and a clear commitment to localize production were central to obtain a footing in this promising market. Earlier, ASM had served Korean chip manufacturers via ASM Asia – a business unit of ASM Pacific Technology – and later via a local distributor called Won Ik.[130] This resulted in a few sales, such as two A300's, one Plasma III furnace, and an Epsilon One to Samsung, and a VMP-100 to Hyundai.[131] However, by 1995, Samsung indicated that ASM had to consider another way of serving the Korean market.[132]

From June 1995, John Benoist and Jaap Beijersbergen worked to prepare the joint-venture. Benoist had been president of Tempress until this firm's bankruptcy a year earlier, and being experienced and undaunted, he was entrusted by Del Prado with this responsibility.[133] The Dutchman oversaw negotiations with probable partners for a joint-venture and with governmental agencies.[134] In

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130 This firm engaged in three activities: distribution, quartz manufacturing, and LED. It had 190 employees, and totaled 53 million dollars in sales for 1992. – ASM Wafer Process Equipment Limited, Steve Reiutz 'Fax to Friant, Krickl, Del Prado, Miyazaki, Mogi: ASM Organization in Korea' (18-1-1993).

131 ASM International, Arthur del Prado, 'Memo to Art Launder: Won Ik' (17-11-1994) ) *Archive Arthur del Prado – ASM Korea/ASM Genitech, J.V. Korea*; Won Ik Corporation, 'Presentation of Sales Meeting: For ASM International meeting Mar. 10-11 in Holland' (10-5-1994) ) *Archive Arthur del Prado – ASM Korea/ASM Genitech, J.V. Korea*.

132 ASM Wafer Process Equipment Limited, Steve Reiutz 'Fax to Friant, Krickl, Del Prado, Miyazaki, Mogi: ASM Organization in Korea' (18-1-1993).

133 ASM International, John Benoist, 'Fax to Arthur del Prado: Samsung' (21-3-1995) *Archive Arthur del Prado – ASM Korea/ASM Genitech, ASM Korea 1993-1995*.

134 Candidates for the joint-venture were Won-Ik, Hyundai, Dong Bu, and Oyang Scientific Inc – ASM International, Arthur del Prado, 'Memo to Ivo Raaijmakers: Dong Bu' (13-1-1997) *Archive Arthur del Prado – ASM Korea/ASM Genitech, J.V. Korea*; ASM International, Arthur del Prado, 'Fax to Y.H. Lee, Won Ik Corporation' (30-10-1995) *Archive Arthur del Prado – ASM Korea/ASM Genitech, ASM Korea 1993-1995*; Won Ik Korea, B.H. Ahn, 'Fax to John Benoist' (27-10-1995) *Archive Arthur del Prado – ASM Korea/ASM Genitech, ASM Korea 1993-1995*; Oyang, Scientific Incorporated, John Benoist, 'Fax to Arthur del Prado: J-V + Agency Agreement' (24-10-1995) *Archive Arthur del Prado – ASM Korea/ASM Genitech, ASM*

March 1996, ASM Korea was established as a joint-venture between ASM International and a local agency called Oyang Scientific, Inc.[135] Benoist remained general manager of the new South-Korean subsidiary, receiving support from Beijersbergen.[136] They focused on getting the A400, the A600, and the Epsilon One sold to Samsung, LG, and Hyundai.

*Centripetal versus centrifugal forces*

Although Friant succeeded in stimulating communication among the operations, the business units' pursuit of their own interests and opportunities still bore centrifugal effects. ASM remained a diversified company with epitaxy, vertical furnaces, and plasma CVD as its core competencies. The business units continued to be responsible for the development and execution of the various competitive strategies. Consistently, there was strive about whether particular elements could be fully deployed as competitive strategies or had to be subjected to the corporate strategy.

Throughout 1995 and 1996, this dichotomy manifested itself most clearly in a scheme involving central coordination for manufacturing and technological development. Since the early 1990s, management at ASM International in Bilthoven had been aware of the ineffectiveness of maintaining multiple manufacturing locations. As Del Prado stated years earlier:

> 'Manufacturing of the same products at more than one place at ASM had led to disastrous effects, because R&D and engineering have been allowed to diverge in all directions. Needless to say that economies of scale also played a factor.'[137]

However, the equity crisis that numbed the company, together with the implosion of ASM Europe and the AMTC, prevented a resolute solution of this issue (cf. Innovation III). In the meantime, Friant struggled to control the cost

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*Korea 1993-1995*. The establishment received input from various governmental agencies, including the Ministry of Science and Technology, and the national Science and Technology Policy Institute (STEPI). – Royal Netherlands Embassy, W.L. Bronkhorst, 'Fax from Chargé d'Affaires W.L. Bronkhorst to Arthur del Prado: Your visit to Seoul' (27-2-1995) ) *Archive Arthur del Prado – ASM Korea/ASM Genitech, J.V. Korea*.

135 Oyang, the predecessor of OSI, represented ASM and ASML in 1984-1985. Tokyo Electron became supplier as well, and requested the termination of the ASM agency. In 1995, Oyang reorganized and became OSI. It had 7 employees. – ASM International and Oyang Scientific Inc, 'Sales Agency Agreement' (20-3-1996) *Archive Arthur del Prado – ASM Korea/ASM Genitech, ASM Korea '96-'02*.

136 Jaap Beijersbergen, 'Interview with author'.

137 ASM International, Arthur del Prado, 'Memorandum to Ray Friant: ref:92.070 AdP/tv' (26-8-1992) *Archive Arthur del Prado – Ray Friant file*.

of manufacturing in Nagaoka, Phoenix, and Bilthoven. Moreover, in the spring of 1996, Art Launder resigned as general manager of ASM America, after being a mere year in office. While Friant intervened as interim-manager in addition to his job of COO, the lack of a dedicated general manager allowed further deterioration of manufacturing efficiency.

In 1996, Del Prado distinguished an opportunity to address the matter. He wanted to elaborate on the template used for the production and engineering of the A400. During the rapid ramp-up of production of A400s to meet the Micron order, both ASM Europe and Philips Machinefabrieken collaborated to their mutual satisfaction. Del Prado was eager to elaborate on this successful manufacturing strategy. As he communicated to Friant:

> 'Considering what they [Philips Machinefabrieken] did for ASM-E in the A400 arena and what they did for ASM-L in the stepper field, throwing in all their technology resources, we can only win.' [138]

The entrepreneur had concocted a scheme that would kill two birds with one stone. He wanted to deploy the engineering skills of Philips Machinefabrieken for the design and manufacturing of a standard wafer handling platform. Such a platform could be used for the new 300-millimeter versions of the Epsilon and the Eagle-10 single wafer reactors, or for the A600 and A400 vertical batch systems. It was an ingenious way of centralizing some part of manufacturing, in this case at Philips Machinefabrieken. Moreover, ever since the late 1980s, the ASM executive board had been trying to create a common platform for all the various products and processes (see Innovation III). While competitors like Applied Materials succeeded, ASM seemed to be incapable of overcoming the divergent interests of the various products groups.

The forthcoming introduction of 300-millimeter wafers constituted another opportunity to establish an ASM-wide wafer handling platform, and achieve much desired economies of scale.[139] To facilitate the new wafer size, all wafer handling technology of the ASM products had to be redesigned. This formed a clear window of opportunity to harmonize and standardize the wafer handling platforms. As Del Prado explained to Friant, who remained wary of rushing into over-ambitious endeavors again:

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138 ASM International, Arthur del Prado, 'Memo: Agenda Front-end Board' (5-9-1996) *Archive Arthur del Prado – Ray Friant file*.

139 ASM International, Ray Friant, 'Minutes of the Front-End Board Meeting Phoenix, September 9 and 10, 1996' (18-2-1996) *Archive Arthur del Prado – ASMI Management 90's; Management Meetings '89-'04.*

> 'I am still convinced our basic platform approach is excellent but it is a difficult one to manage. ... Besides all the human, political and strategic aspects of the above, we have to enable ourselves to manufacture cost effectively and with a time to market momentum to capture the windows of opportunity the market offers us. Along this line it has been proven how valuable the cooperation and exploitation of an integrated supplier of parts, modules, subassemblies and almost finished systems can be. (A400/PMF/Micron)'[140]

At the head office, Del Prado's assessment was shared by CTO Ernst Granneman, Strategic Marketing Director Chris Werkhoven, and a new scientific executive named Sieb Radelaar.[141] Each of these technologists propagated the design of a common platform that would even 'surpass a "me too" update of today's technology.' [142]

At the subsidiaries, however, this viewpoint was not automatically shared. Both at ASM America and at ASM Japan, the product groups knew exactly how they wanted to compete. After all, they were responsible for the competitive strategy of their product. Complying with the headquarters' ambitions would distract attention from their own game plans, while also diverting scarce resources.

Most striking was the discussion surrounding the redesign of the standalone single wafer Epsilon reactor into a cluster system. By 1995, Epsilon lost ground to Applied Materials' clustered single wafer epitaxial reactor, the Centura.[143] The competition with Applied not only intensified in court surrounding mutual infringements of intellectual property but also in productivity, costs, and service of the machine.

To compete with Applied Materials' cluster reactor Centura, Werkhoven tried to amass support for the development of a clustered epitaxy system in Phoenix. Combining multiple Epsilon reactors decreased cost-of-ownership and improved ASM's competitiveness. The rather expensive wafer handling and cleanroom interface modules could be amortized over multiple instead of a single reactor

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140 ASM International, Arthur del Prado, 'Memo to Ray Friant' (June 1996) *Archive Arthur del Prado – Ray Friant file*.

141 ASM International, Ray Friant, 'Minutes of the Front-End Board Meeting Phoenix, September 9 and 10, 1996' (18-2-1996) *Archive Arthur del Prado – ASMI Management 90's; Management Meetings '89-'04*.

142 ASM International, Arthur del Prado, 'Memo: Agenda Front-end Board' (5-9-1996) *Archive Arthur del Prado – Ray Friant file*.

143 ASM America, Art Launder, 'Facsimile Transmission: Epsilon Red Flag' (26-8-1994) *Archive Arthur del Prado – Ray Friant file*.

chamber. Through a joint-development program with Siemens Semiconductors, a single wafer handler platform – dubbed A800 – was already integrated with various Epsilon process modules (see Chapter 26). This first wafer handling platform had been designed and manufactured by Philips Machinefabrieken, and was envisaged to be a stepping stone for ASM International's ambition in platform consolidation.

At ASM America a strong product group was in charge. It consisted of Armand Ferro as dedicated product manager, John Krickl in the varying roles of interim general manager and senior sales manager, Gloria Zemla as controller, and a number of engineers including Bob Haro and Richard Crabb. Most of them had been involved with the machine since the 1980s (cf. Innovation II). Their familiarity with the machine's properties and capabilities enabled a deliberate exploration of opportunities. Earlier attempts to diversify the Epsilon to other applications, such as the polysilicon Paragon reactor, proved futile. Furthermore, the success of the Epsilon product group had been critical in the survival of ASM front-end in the early 1990s. They had won their spurs. They stuck to their game plan of innovating and commercializing standalone single wafer epitaxial equipment.

Moreover, with regard to the forthcoming 300-millimeter standard, the product group had already made substantial progress. Manufacturers of epitaxy equipment led the industry – together with silicon wafer manufacturers – in preparations for the new 300-millimeter wafer standard. In this context, ASM America already secured commitment of major wafer manufacturers Komatsu, Wacker, Monsanto, and chip manufacturer Motorola for the 300-millimeter Epsilon in the spring of 1995.[144] Furthermore, ASM Europe and German wafer manufacturer Wacker, with support from the European Community, started a research project with the acronym LASSIE, meaning Large Area Substrate Silicon Epitaxy.[145] The customer participation in the Advisory Council and LASSIE endorsed the course of ASM America's development externally – in competition with Applied Materials – but also internally, vis-à-vis ASM's head office.

The attempt to centralize manufacturing and harmonize technological development got bogged down in the fall of 1996. By that time, Friant was ready

[144] Representatives of these customers took part in an Advisory Council, which functioned as a soundboard for the Epsilon engineers. – Armand Ferro, 'Interview with author'; ASM International, 'Progress Report June 1995' (June 1995) *Archive Arthur del Prado – RvC 1994-1996 file*.

[145] LASSIE was part of the fourth European Framework Program (ESPRIT) of the European Commission; ASM International, 'Large-Area Substrate Silicon Epitaxy (LASSIE). Proposal for the ESPRIT 4th Framework Programme for the Development of a 300 mm Wafer Epitaxy System' (6-6-1995) *Archive Arthur del Prado – RvC 1994-1996 file*.

to retire as COO. Having originally been appointed as interim-COO, his tenure was extended several times as he was in the middle of steering ASM away from the abyss. In the fall of 1996, his successor was ready to replace him.[146] This was Daniel Queyssac, an Americanized French industry veteran who had worked for Italo-French chip manufacturer SGS-Thomson and American equipment manufacturer Novellus.

A worldwide management meeting was the last one presided by Ray Friant. In 1996, from 19 to 22 November, the full front-end board convened in Phoenix. The event constituted Friant's last opportunity to reach agreement and establish common goals. To this end, he organized a team-building day, involving rafting, horseback riding, and a number of games. Tactically Friant had created groups of teams of managers who in his view should know each other better. Even Del Prado participated, while Friant's successor Queyssac – and a few other new staff members – attended as well. Never before had such a day been organized at ASM.

Despite the joyous activities and their contributions to the team spirit, individual differences in corporate and competitive strategies persisted. Although Queyssac followed in the footsteps of Friant, forcing his point of view and management control onto the front-end organizations, the strong-willed and headstrong engineers and managers of the various subsidiaries went their own way.

CTO Ernst Granneman met with this same attitude in the fall of 1996, when he scheduled a 'technology council meeting' on this topic. During these gatherings, R&D managers and engineers met to discuss technological topics and create an atmosphere of mutual understanding. To stimulate peer-to-peer appreciation and creativity among the engineers, Granneman awarded a bottle of scotch whisky to the engineer with the most innovative and creative propositions.[147] The meetings helped to map and amass support for various roadmaps in the company. For this particular meeting, he had put the issue of a 300-millimeter wafer handler on the agenda, and invited the engineers to discuss probable specifications (figure 64). Granneman explained that the new 300-millimeter manufacturing systems formed a unique opportunity to prune the proliferation of common technology across the subsidiaries. The provisional A800 and the Epsilon standalone tools constituted a good example, but he also referred to the Japanese Eagle-10 plasma CVD reactor:

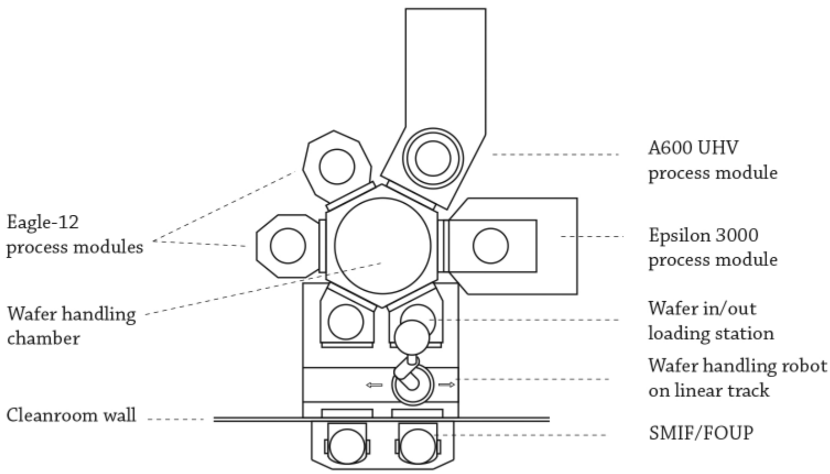
> 'Although, the epi module can be used on a 300mm cluster system, such a system is not scheduled yet. ... The future 300m PECVD modules

[146] In 1993, Queyssac had already been identified as successor for Friant by Del Prado and Friant. – ASMI, Rray Friant, 'Memo: ASM Front-End status' (20-3-1993) *Archive Arthur del Prado – RvC 1992-1993*.

[147] Ernst Granneman, 'Interview with author'.

> will be connected to a 300mm cluster platform. ... As the objectives to develop only one platform to be used for Eagle 10 as well as for Epsilon, it is necessary to design a platform which also accommodates the Epsilon specs.'[148]

**Figure 64**
Schematic view from above of a potential central wafer handler serving reactor chambers of ASM's subsidiaries
This configuration was proposed by Chief Technology Officer Ernst Granneman during a Technology Council Meeting in the fall of 1996. For the new wafer size – 300 millimeters – a standardized wafer handler might be able to serve all the various reactor types within ASM International, such as ASM Japan's Eagle-12, ASM Japan/Europe's A600-UHV, and ASM America's Epsilon 3000. Such a general-purpose wafer handler might offer economies of scale across the company. Yet the viability of this proposal for several of the applications was not accepted by engineers of the various subsidiaries.




However, during the meeting, the engineers emphasized the differences. The Eagle PECVD single wafer tool required its own platform, as did the Epsilon. This meant that a wafer handler platform could not be defined, which in its turn meant that Del Prado could not proceed with his scheme to further centralize manufacturing at Philips Machinefabrieken. The status quo persevered.

*Birth of a visionary*

The increased confidence was not limited to the subsidiaries; it also concerned Del Prado. Since the late 1980s, the entrepreneur had been consistently blamed for the company's inherent weaknesses. The bankers, his Supervisory Board,

[148] ASM International, Ernst Granneman, 'Fax: Announcement Technology Council Meeting #18: ASM 300mm wafer handling/cluster platforms and related corporate technology' (10-12-1996) *Archive Arthur del Prado – ASMI Management '90s – Technology Council Meeting.*

managers, employees – all heaped criticism on his inability to address failing organizational processes within and among the subsidiaries. Ten years after his celebratory acclamation, the 1983 Dutch Director of the Year seemed to be knocked off his pedestal.

His position of dominant shareholder (he still retained about 35 percent of ASM stock), his achievements in building the company, and his rampant perseverance prevented that the founder got sidelined. Nevertheless, facing the shutdown of his company and also through Ray Friant's personal energetic and imposing personality, Del Prado had conceded major responsibilities. By relying on Friant to take care of the operational management, Del Prado's role within the firm changed. He remained chief executive officer, and fully engaged with his firm. But, now, he could focus more on areas in which he excelled, such as scavenging for new opportunities and charming prospective investors, management candidates, or equipment manufacturers. In other words, he could work on developing ASM's future course, while not being distracted by the daily management affairs.

Throughout the mid-1990s, Del Prado regained confidence in his capability for recognizing, and appropriating, future opportunities. This was stimulated by the significant growth of the semiconductor equipment industry and four specific events: the balancing of the ion implantation investment of the late 1980s, the initial public offering of ASM Lithography and Berliner Electro Semiconductor Industries (BESI), and the improved quotation of ASM International on the stock exchange. These events proved Del Prado's critics wrong, and established the entrepreneur as visionary.

Initial appreciation of Del Prado's visionary instincts followed from a consideration of the investments in ASM Ion Implant. This operation was divested in 1988 to appease the anxious banks. In the fall of 1994, De Leeuw assessed the return on investments.[149] He calculated that ASM had invested 10.5 million dollars, for which it obtained 15.4 million dollars during the sale, and 5.4 million dollars in subsequent royalties from 1989 to 1993. In other words, ASM's investment of 10.5 million dollars had resulted in a revenue of 20.8 million dollars.

Secondly, ASM Lithography conducted an initial public offering in March 1995 on the Amsterdam Stock Exchange and Nasdaq, floating 12.6 million shares (38.2 percent) for 28.5 Dutch guilders per share.[150] This meant that the company was valued at 940.5 million Dutch guilders. Philips already earned 273.6 million

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149 ASMI, Willem de Leeuw, 'Memo: ASM Ion Implant' (16-8-1994) *Archive Arthur del Prado – RvC 1994-1996*.

150 Including some commissions. ASM Lithography, *1995 Annual Report* (February 7, 1996).

Dutch guilders from this transaction, floating 9.6 million shares.[151] Since ASM International's divestment of the stepper manufacturer in 1988, it had grown from 35 million Dutch guilders in 1988 to 534 million in 1994.[152] This incredible achievement of the ASM Lithography employees negated all preconceived doubts about the viability of a Dutch stepper manufacturer. Moreover, it proved Del Prado's rather rash decision to save the Philips' stepper technology from oblivion to be quite worthwhile.

The third event contributing to Del Prado's renewed confidence was the initial public offering of BESI. In December 1995, the manufacturer of semiconductor packaging equipment sold 9.6 million shares (37.7 percent) for 13 dollars each on the Nasdaq, the Amsterdam Stock Exchange, and the Frankfurt Stock Exchange.[153] This concerned the former ASM Fico activities, totaling 88 million dollars in sales in 1994, but also Meco, a manufacturer of plating equipment, plating chemicals, and lead-frames, which was acquired on May 1, 1995, and totaled 98.5 million dollars in 1994 sales. Fico and Meco had been integrated into BESI for 60 million guilders and 115 million guilders, respectively, and together they now enjoyed a market capitalization of 331 million dollars (or 530 million Dutch guilders). This was a harsh contrast to the low valuations attributed by Del Prado's bankers prior to ASM Fico's divestment. Although the disentanglement of Fico from ASM had contributed to this achievement, the public offering of BESI also proved the viability of Del Prado's entrepreneurship.

And finally, Del Prado's tenure consolidated through the radically improved quotation of ASM International on the stock market (figure 65). Elaborating upon its strong sales of 670 million Dutch guilders in 1995, 'reflecting a 92 percent gain in front-end and a 11 percent improvement in back-end,' ASM's stock improved.[154] Front-end sales increased from 181 million Dutch guilders in 1994 to 342.5 million in 1995 and 361 million in 1996.[155] Over 1995, the company had an average market capitalization of 548.43 million Dutch guilders, a remarkable improvement after its deplorable average valuation of 28.66 million Dutch guilders (!) over 1993.[156]

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151 In successive flotations in 1996 and 1997, it capitalized even more on ASM Lithography's success, diluting its ownership to 23.9 percent.

152 ASM Lithography, *1994 Annual Report* (February 73 1995).

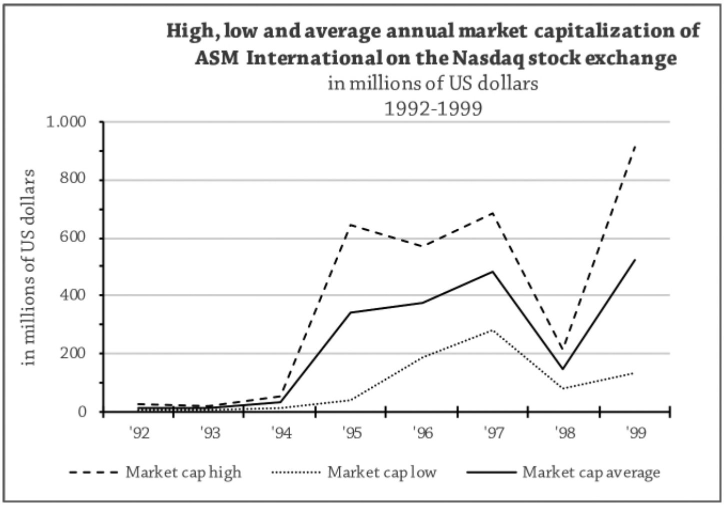
153 After withholding commission, 117.9 million dollars in proceedings went to the company. – Morgan Stanley & Co, *BE Semiconductor Industries Prospectus 9,600,000 common shares* (4-12-1995) *Archive Arthur del Prado – BESI files*; Richard Blickman, 'Interview with author'.

154 ASM International, *1995 Annual Report* (15-3-1996).

155 ASM International, *1998 Annual Report* (26-2-1999).

156 In 1995, ASM had 10,460,581 outstanding shares with an average price of 32,69 dollars per share, valuing the company at 341.96 million dollars. December 31, 1995, 1 dollar traded for 1.6038 Dutch guilders. However, at the peak of the market in the third quarter of 1995, ASM

**Figure 65**
Graph of high, low, and average annual market capitalization on the Nasdaq stock exchange from 1992 to 1999.




This significant improvement of the company's results allowed Del Prado to renew relations with his bankers. This was done by capitalizing on the renewed investor appreciation. In March 1996, ASM pursued a stock split during which shareholders got three shares for every single share, multiplying the number of outstanding shares threefold to about 31 million.[157] The rationale behind this move was to increase the liquidity of stock, which might result in improved stock prices. The success of ASM Lithography and BESI also paved the way for a listing of ASM on the Amsterdam Stock Exchange by December 1996. Being a Dutch company, the exposure to investors in its home country might be beneficial. During the offering, ASM sold 1.5 million common shares, whereas Del Prado and the American investment bankers Grantham, May, Van Otterloo & Co. sold 2.6 million common shares.[158] After the transaction, Del Prado retained 28.2 percent of the company. On the date of listing, ASM's market capitalization amounted

stock was valued 61,25 dollars per share, valuing the company at 640.71 million dollars, or 1.02 billion Dutch guilders. In 1993, stock price averaged between 2.125 to 0.625 dollar per share, and with 10,742,366 shares outstanding, and one dollar worth 1.94 guilders. – ASM International, *1995 Annual Report* (15-3-1996) and ASM International, *1993 Annual Report* (26-4-1996).

157 ASM International, Jobs Wagenaar, 'Memorandum to the Supervisory Board: Splitsing van aandelen' (29-9-1995) *Archive Arthur del Prado – RvC 94-96 file.*

158 Del Prado sold 1.5 M of his 10.803 million shares. Diluting his share from 34.3 to 28.2%. The investment bankers retained 9.9 percent.

to 594.5 million Dutch guilders.[159] The company itself retained about 26 million Dutch guilders in proceeds, which constituted a welcome replenishment to its cash flow.

Surrounding the offering, ASM repaid about 13.8 million of bank loans. More importantly, ASM finally relieved itself from the 25 million Dutch guilders convertible loan held by Grantham, Mayo, Van Otterloo & Co, which had been looming under very unfavorable terms since 1987.[160] Furthermore, ASM International completed a renewal of its bank loans at ABN Amro and the National Investment Bank, which involved an expansion of the credit facilities and deferment of installments. While about 176 million Dutch guilders in gross interest bearing debt remained, these actions decreased the financial pressure from the banks.[161]

The staggering results confirmed Del Prado's assessment about his firms, and increased his grudge toward his banks. After all, they had forced him to divest these lucrative and promising operations. If the crisis years since the mid-1980s caused Del Prado to doubt his entrepreneurial instincts, this was negated by the quotations of ASM Lithography, BESI, and ASM International – even though it is fair to add that the valuation of the first two had been the sole achievement of their engineers and managers. Regardless, the events on the stock exchange re-established his role of visionary, as a man capable of recognizing technological opportunities and enabling innovation beyond the common horizon of investors.

159 ING Barings, Merrill Lynch International, and ABN Amro Rothschild, 'ASM International Offer of 4,100,00 Cmmon Shares' (11-12-1996).

160 ASM International, Arthur del Prado, 'Progress Report January 1996' (February 1996) *Archive Arthur del Prado – RvC 96=98 file*.

161 All of this debt was secured against all available assets, including property, inventory, ASMPT, etc.– ASM International, Jobs Wagenaar, 'Memorandum to Supervisory Board: Funding opportunities' (January 1997) *Archive Arthur del Prado – RvC 96=98 file*.