Section 57 of the Competition Act (Cap. 50B)

Grounds of Decision issued by the Competition Commission of Singapore

In relation to the notification for decision of the proposed acquisition by ASML Holding N.V. of Hermes Microvision, Inc.

10 August 2016

Case number: CCS 400/005/16

Confidential information in the original version of this Decision has been redacted from the published version on the public register. Redacted confidential information in the text of the published version of the Decision is denoted by [✂].

TABLE OF CONTENTS

I. Introduction 3
II. The Parties 3
III. The Transaction 4
IV. Competition Issues 6
V. Counterfactual 9
VI. Relevant Markets 10
VII. Market Structure 15
VIII. Competition Assessment 22
IX. Efficiencies 29
X. Conclusion 29

I. Introduction

1. On 28 June 2016, a joint notification under section 57 of the Competition Act (Cap. 50B) (the "Act") was made by ASML Holding N.V. ("ASML") and Hermes Microvision, Inc. ("HMI") (collectively "the Parties"), for a decision by the Competition Commission of Singapore ("CCS") as to whether an anticipated acquisition by ASML of 100% of the voting securities of HMI (the "Transaction") will infringe the prohibition under section 54 of the Act.

2. In reviewing the Transaction, CCS has taken into consideration the views and feedback from the Parties' competitors and customers. Responses were received from six [1] competitors and four[2] customers. Substantive feedback was received from three third-parties, and the remaining third-parties indicated that they either had no comments or declined to comment on the notified Transaction.

3. After evaluating the submissions from the Parties, together with the views and feedback from third-parties during the public consultation, CCS concludes that the Transaction will not infringe the prohibition under section 54 of the Act.

II. The Parties

ASML

4. ASML is an entity incorporated in the Netherlands, and is listed on Euronext Amsterdam and NASDAQ. ASML is the ultimate parent company of thirty-seven subsidiaries involved in the development, production, marketing, selling and servicing of advanced high-tech lithography, metrology and software solutions for the semiconductor industry (the "ASML Group"). The ASML Group is organised across three main business lines, namely: (i) deep ultraviolet lithography machines; (ii) extreme ultraviolet ("EUV") lithography machines; and (iii) applications, which includes metrology activities, such as the development and sales of an advanced wafer metrology system (YieldStar), as well as process control applications (software).[3]

5. ASML's registered entities in Singapore include ASML Singapore Pte. Ltd., and Cymer Singapore Pte. Ltd.[4]

6. ASML's activities in Singapore comprise sales of lithography equipment, overlay metrology equipment and process control software. ASML also provides maintenance and customer services in Singapore.[5]

[1] [✂].
[2] [✂].
[3] Paragraph 7.1 of Form M1.
[4] Paragraph 10.1 of Form M1.
[5] Paragraph 10.10 of Form M1.

7. The Singapore turnover of ASML was approximately [✂][6] and the worldwide turnover for ASML was approximately €6.29 billion (approximately S$9.4 billion)[7] in the financial year ended 31 December 2015.

HMI

8. HMI is an entity incorporated in Taiwan and is listed on the Taipei Stock Exchange. HMI is the ultimate parent company of five subsidiaries (the "HMI Group"), and does not belong to a larger corporate group. The HMI Group is engaged in the manufacturing of e-beam inspection tools for chip manufacturers worldwide.[8]

9. HMI does not have any registered entities in Singapore. HMI also has no offices or facilities in Singapore, and does not undertake manufacturing or research and development ("R&D") in Singapore.[9] HMI sells and distributes its e-beam inspection tools directly to customers in Singapore. This is done by HMI's sales team based in Taiwan. [✂].[10]

10. The Singapore turnover of HMI was [✂][11] and the worldwide turnover for HMI was NT$6.65 billion (approximately S$278 million)[12] in the financial year ended 31 December 2015.

III. The Transaction

Nature of the Transaction

11. The Transaction involves the anticipated acquisition by ASML of 100% of the voting securities of HMI in consideration of cash and ASML's voting securities, by way of purchase and exchange of shares under a share swap agreement. The Transaction is conditional upon satisfaction or waiver of certain conditions, including that relevant regulatory approvals, consents or clearances have been given for the completion of the Transaction. Post-Transaction, ASML will own 100% of the voting securities of HMI.[13]

[6] Exchange rate S$/€ used is €1 to S$1.4969. Paragraph 13.3 of Form M1.
[7] Exchange rate S$/€ used is €1 to S$1.4969. Paragraph 13.1 of Form M1.
[8] Paragraph 7.3 of Form M1.
[9] Paragraph 10.11 of Form M1.
[10] Paragraph 1.1 of the Parties' Response dated 13 July 2016 to CCS's Request for Information ("RFI") dated 5 July 2016.
[11] Exchange rate S$/US$ used in Form M1 is US$1 to S$1.3573. Paragraph 13.4 of Form M1.
[12] Exchange rate S$/NT used in Form M1 is NT100 to S$4.1780. Paragraph 13.2 of Form M1.
[13] Paragraphs 11.1 and 11.4 of Form M1.

Commercial rationale of the Transaction

12. The Parties submitted that they are active in the development and manufacturing of equipment and software used by the semiconductor industry for the production of integrated circuits [14] ("ICs"), but their products intervene at different stages in the development and production process. The Parties further submitted that the Transaction will allow the Parties to increase the speed of innovation of e-beam technology and to establish an e-beam based inspection technology for use in IC manufacturing.[15]

13. Specifically, CCS understands from ASML's press release in relation to the Transaction that:[16]

> "*Our over-arching goal is to serve our customers even better and offer them the tools they need to achieve higher yields at the most advanced nodes. This acquisition is intended to make a strong product offering even stronger. […] HMI e-beam metrology will deliver accurate patterning information, which ASML can use to optimize its powerful design and process models, a cornerstone of ASML's successful computational lithography business. In return those models can be used to guide the optical and e-beam metrology in a cost-effective manner to characterize the most relevant features on the chip device. Ultimately, this information combined with ASML modeling will provide the ability to adjust ASML's scanners settings for optimal operation in the customers' factories. Therefore, the transaction fits very well within ASML's holistic lithography strategy. Furthermore, HMI has pioneered e-beam inspection systems that are specially designed for mask manufacturers to identify pattern defects in Extreme Ultraviolet (EUV) resulting from the mask. This will support the ramp of ASML's EUV platform, set to be used for volume production of semiconductors starting in 2018.*"

Merger under section 54 of the Act

14. The Parties submitted that the Transaction falls within section 54(2)(b) of the Act.[17]

15. Paragraph 3.6 of the *CCS Guidelines on the Substantive Assessment of Mergers* provides that a merger under section 54(2)(b) of the Act occurs in the case of an acquisition of control. Control may be acquired over an undertaking when the acquiring party becomes the holder of the rights, contracts or other means that entitle the holder to exercise decisive influence over the activities of that undertaking. CCS considers that decisive influence is generally deemed to exist if there is ownership of more than 50% of the

[14] ICs are complex semiconductor devices that combine a large number of transistors and connectivity material arranged in specific patterns to perform complex processing or storage functions. These semiconductor devices contain transistor arrays build on pieces (round slices) of silicon, also known as wafers. Explanation provided at paragraph 18.4 of Form M1.
[15] Paragraph 12.1 of Form M1.
[16] ASML Press Release "ASML to Acquire HMI to Enhance Holistic Lithography Product Portfolio", 16 June 2016. Source: https://www.asml.com/press/press-releases/asml-to-acquire-hmi-to-enhance-holistic-lithography-product-portfolio/en/s5869?rid=53782.
[17] Paragraph 11.2 of Form M1.

voting rights attributable to the share capital of an undertaking which are exercisable at a general meeting.[18]

16. Based on the Parties' submission that the Transaction involves the acquisition by ASML of 100% of the voting securities of HMI and sole control of all the business of HMI, CCS is of the view that the Transaction constitutes a merger pursuant to section 54(2)(b) of the Act.

IV. Competition Issues

17. According to the Parties, their business activities are fully non-overlapping and there are no overlapping goods or services sold by the Parties globally (including in Singapore).[19] Neither of the Parties sells the other's products. HMI's products are not offered as part of any packages offered by ASML.[20] The Parties also submitted that their supporting services, e.g. maintenance and customer services are also fully non-overlapping.[21]

Manufacturing process of ICs

18. The Parties submitted that the manufacturing process of ICs is divided into two phases: (i) front-end processes; and (i) back-end processes.

19. The actual production of ICs takes place during the front-end processes.[22] This production process takes place at highly complex manufacturing facilities where the required circuitry is imprinted on the wafer ("wafer fabs" or simply "fabs"). The equipment necessary for the front-end production process can be sub-divided into two vertically-related levels:

    (a) processing equipment, which are used for the actual production of ICs; and

    (b) process control equipment and software, which control, verify and tune the processing equipment or the wafer produced.[23]

20. Further information on processing equipment and process control equipment and software required for front-end processes is set out in Annex A.

21. During the back-end processes, the wafers are diced (i.e., cut into individual pieces corresponding to the imprinted semiconductor devices), wiring is added and the individual dices are packaged.[24] The back-end process takes place at locations which are

[18] Paragraph 3.10 of the *CCS Guidelines on the Substantive Assessment of Mergers*.
[19] Paragraph 15.1 of Form M1.
[20] Paragraph 5.4 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[21] Paragraph 15.1 of Form M1; and paragraph 7.1 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[22] Paragraph 18.6.1 of Form M1.
[23] Paragraphs 18.8.1 to 18.8.2 of Form M1.
[24] Paragraph 18.6.2 of Form M1.

different from that for the front-end process and involves other types of equipment.[25]

22. The Parties submitted that neither ASML nor HMI provides products or services used by customers in the back-end manufacturing process and neither of their equipment is suitable to be used in the back-end manufacturing process.[26] Therefore, there is no actual or potential horizontal overlap or vertical relationship between ASML and HMI for any back-end manufacturing processes, and the back-end process is not relevant for the Transaction.[27]

Products of the Parties

23. The Parties have submitted that their products intervene at different stages in the development and production process of ICs, i.e., the front-end process.[28] ASML's activities are mainly focused in the lithography cluster of the IC manufacturing process. ASML produces lithography processing equipment, an overlay metrology system and associated process control software, and other process control software.[29] HMI is active in a separate stage in the production chain of ICs. Specifically, HMI is involved in the development and supply of inspection tools and deviation classification software.[30]

24. Set out below are the products related to ICs supplied by the Parties:

(a) With regard to lithography equipment: –

(i) ASML sells the following lithography equipment in Singapore: TWINSCAN NXT, TWINSCAN XT, PAS 5000 (various subtypes).[31] ASML manufactures all types of lithography machines ranging from low-end layer to high-end[32] performance and technology;[33] and

(ii) HMI does not supply any type of lithography equipment.[34]

(b) With regard to overlay metrology equipment: –

(i) ASML sells its overlay metrology equipment under the product name

[25] Paragraph 18.7 of Form M1.
[26] Paragraph 8.1 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[27] Paragraph 18.7 of Form M1; and paragraph 8.1 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[28] Paragraph 12.1 of Form M1.
[29] Paragraph 18.2 of Form M1.
[30] Paragraph 18.3 of Form M1.
[31] Paragraph 14.1.1 of Form M1.
[32] A fab usually has multiple lithography machines of varying levels of precision. Simple chips, i.e., single-feature chips such as heat or light sensors, are produced with low-end equipment. Advanced chips, for instance main processors to be used in smartphones, require high-end and very precise production equipment. However, a high-end chip will also be built up with some low-end layers and mid-end layers, using low-end equipment and mid-end equipment, respectively. (Explanation provided at paragraph 18.11 of Form M1.)
[33] Paragraph 10.5 of Form M1.
[34] Paragraph 19.14 of Form M1.

"YieldStar" in Singapore.[35] ASML's overlay metrology tool is used as part of the lithography process to ensure that the next structural level on the wafer is applied spatially correct in relation to the previous ones;[36] and

(ii) HMI is not active on this market as it does not supply overlay metrology equipment.

(c) With regard to process control software: –

(i) ASML is focused on process control software specifically for the lithography cluster of a wafer fab.[37] ASML, through its wholly-owned subsidiary Brion Technologies, Inc. ("Brion"), is active in the area of wafer design software, which is a type of software that helps to design the lay-out of ICs being manufactured and is therefore used in the development phase and not during the actual manufacturing process;[38] and

(ii) HMI has only developed classification software associated with its e-beam inspection tool, and ASML does not sell software that can be used as a substitute to HMI's software. Other than that, HMI does not offer any software to customers.[39]

(d) With regard to wafer inspection equipment: –

(i) ASML is not involved in the development and supply of inspection tools;[40] and

(ii) HMI sells the following e-beam wafer inspection tools in Singapore: eScan Series (for voltage contrast inspection of three dimensional IC-structures), and eP Series (for hotspot and physical defect inspection).[41] HMI has also developed e-beam equipment especially designed for EUV mask (or 'reticle') inspection (eXplore Series) and has sold a few tools, but the Parties submitted that this product is not expected to take off before the commercialisation of EUV lithography machines.[42]

25. In relation to supporting services, e.g. maintenance and customer services, the Parties submitted that these are also fully non-overlapping. ASML's maintenance and customer services are focused on ASML equipment and the process around it in the wafer fab.

[35] Paragraph 14.1.2 of Form M1.
[36] Paragraph 12.8 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[37] Paragraph 12.16 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[38] Paragraph 12.17 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[39] Paragraph 19.15 of Form M1; and paragraph 12.13 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[40] Paragraph 19.16 of Form M1.
[41] Paragraph 14.2.1 of Form M1.
[42] Paragraph 10.9 of Form M1.

HMI is doing the same with respect to HMI's e-beam inspection tools.[43]

26. CCS has assessed the Parties' submissions and also verified whether there are any other overlapping businesses between the Parties. CCS notes that there are no overlapping goods or services sold by the Parties globally, including in Singapore. In this respect, CCS has assessed whether the Transaction is likely to give rise to any substantial lessening of competition ("SLC") concerns, in particular conglomerate effects, in any market in Singapore.

V. Counterfactual

27. As stated in paragraph 4.6 of the *CCS Guidelines on Substantive Assessment of Mergers*, CCS will, in assessing mergers and applying the SLC test, evaluate the prospects for competition in the future with and without the merger. The competitive situation without the merger is referred to as the "counterfactual". The SLC test will be applied prospectively, that is, future competition will be assessed with and without the merger.

28. The *CCS Guidelines on Substantive Assessment of Mergers* also states that in most cases, the best guide to the appropriate counterfactual will be prevailing conditions of competition, as this may provide a reliable indicator of future competition without the merger. However, CCS may need to take into account likely and imminent changes in the structure of competition in order to reflect as accurately as possible the nature of rivalry without the merger.[44]

Parties' submissions

29. The Parties submitted that, in the absence of the Transaction, they will continue to operate separately and independently. However, there will be a loss in opportunity for the Parties to rationalise and achieve the efficiencies as described in Section IX below.[45] The Parties also submitted that competitors are likely to continue to compete for customers with, or without, the Transaction.[46]

CCS's assessment

30. CCS is of the view that the prevailing conditions of competition would be the likely scenario without the Transaction and this would accordingly be the counterfactual to which the SLC test is applied.

[43] Paragraph 7.1 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[44] Paragraph 4.7 of the *CCS Guidelines* on *Substantive Assessment of Mergers.*
[45] Paragraph 23.1 of Form M1.
[46] Paragraph 23.2 of Form M1.

VI. Relevant Markets

(a) Product Markets

Parties' submissions

31. The Parties submitted that the relevant product markets are:

    (a) lithography equipment;
    (b) overlay metrology equipment;
    (c) process control software; and
    (d) wafer inspection equipment.[47]

32. The Parties further submitted that it is not necessary to conclude on the exact delineation of any sub-segments within each of these broader product markets.[48]

Lithography equipment

33. The Parties submitted that front-end processing equipment comprises sophisticated types of equipment, each of which covers a specific stage in the manufacture of semiconductors.[49] Lithography equipment, which is supplied by ASML but not HMI, is one of the main types of front-end processing equipment, and it is used to imprint a specific pattern on the wafer (i.e., it is used to actually manufacture the ICs).[50]

34. The Parties submitted that lithography equipment constitutes a separate relevant product market, as other types of processing equipment cannot perform the same functions as lithography machines.[51] According to the Parties, from a supply-side perspective, it is not possible to easily switch production lines from producing other types of processing equipment to the production of lithography machines.[52]

35. According to the Parties, manufacturers of lithography equipment exert competitive pressure on each other, even though there may be a difference between the various types of lithography machines (i.e., high-end, mid-end and low-end lithography machines). The Parties submitted that, there is ample room for substitution from a supply-side perspective, and customers play a particularly important role with respect to the focus areas of lithography equipment manufacturers. Lithography machines which are used to imprint low-end, mid-end and high-end layers are all part of the same relevant product market and used in the same manufacturing process.[53] The Parties submitted that high-

[47] Paragraph 20.1 of Form M1.
[48] Paragraphs 19.21, 20.2 and 20.3 of Form M1; and paragraph 14.2 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[49] Paragraph 18.9 of Form M1.
[50] Paragraph 18.9.1 of Form M1; and paragraph 12.3 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[51] Paragraph 12.4 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[52] Paragraph 12.4 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[53] Paragraph 14.1 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.

end equipment can technically be used to imprint low-end and/or mid-end layers, although this would be highly inefficient. The Parties added that it is technically not possible to use low-end or mid-end equipment to imprint high-end layers, as the resolution of such equipment is not high enough.[54]

36. The Parties also submitted that lithography equipment is not a type of metrology and inspection ("M&I") equipment (see paragraph 37 below for more details on M&I equipment).[55]

Overlay metrology equipment

37. The Parties submitted that M&I equipment, together with process control software, support processing equipment as part of the manufacturing process in a fab. M&I equipment is used to detect deviations, defects and other irregularities that may harm the functioning of the IC.[56] Each type of M&I equipment services a separate step in the production process (see paragraph 8 in Annex A for details) and the techniques applied may vary depending on the subject of inspection and the required detail.[57] All of the types of M&I equipment are required by every semiconductor manufacturer for the process of IC production.[58]

38. Overlay metrology equipment, which is supplied by ASML but not HMI, is a type of M&I equipment used to study patterned wafers during IC manufacturing.[59]

39. According to the Parties, overlay metrology equipment constitutes a separate relevant product market, as other types of process control equipment cannot perform the same functions as overlay metrology equipment.[60] From a supply-side perspective, it is not possible to easily switch production lines from producing other types of process control equipment to the production of overlay metrology equipment.

Process control software

40. The Parties submitted that there are, broadly, two types of process control software: (i) software used to operate the processing equipment; and (ii) software that uses the output of M&I equipment and provides feedback to optimise the settings of the processing equipment.[61] In respect of the latter, the process control software may also use statistical data to optimise the settings of the processing equipment. For instance, virtual metrology is used to predict wafer properties based on statistical methods without performing the

[54] Paragraphs 1.1 and 1.2 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.
[55] Paragraph 19.12 of Form M1.
[56] Paragraph 18.12 of Form M1.
[57] Paragraph 19.13 of Form M1; and paragraph 12.12 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[58] Paragraph 4.2 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.
[59] Paragraph 18.16.1 of Form M1; and paragraph 12.8 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[60] Paragraph 12.9 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[61] Paragraph 19.5 of Form M1.

physical measurement itself.[62]

41. The Parties further submitted that every step of the production process for ICs requires specific process control software, and various types of process control software cannot be used to perform the same function. It is also not possible to make a very clear-cut distinction between the various types of process control software, in particular, if such software is not directly associated with a particular type of equipment.[63]

42. ASML develops and supplies software for many applications in the semiconductor industry, including software that is not directly associated with a specific type of equipment.[64] However, ASML does not sell software that competes with HMI's software.[65]

43. HMI's activities with regard to software are limited as HMI has only developed classification software associated with its e-beam inspection tool. HMI's software is not a standalone product that is sold separate from HMI's e-beam tool. In this regard, HMI is not a specialised software developer that develops software for many different applications.[66]

Wafer inspection equipment

44. The Parties submitted that wafer inspection tools, which are supplied by HMI but not ASML, are used to check the IC structures for critical deviations and other irregularities.[67] Wafer inspection takes place after the lithography process, after etching, after the deposition process and after the chemical-mechanical planarization ("CMP") process, with each inspection step requiring a specific type of measurement and tools.[68]

45. According to the Parties, there are two types of wafer inspection equipment:

    (a) **Optical inspection equipment**. This type of equipment is less sensitive (or precise) than e-beam technology inspection equipment), although the inspection speed is much faster and the cost is lower; and

    (b) **E-beam inspection equipment**. The sensitivity of this type of equipment is better than optical inspection equipment, but the inspection speed is much slower and the cost is higher.[69]

46. The Parties submitted that, optical inspection technology is currently the mainstream technology for wafer inspection. With the adoption of new semiconductor materials, new

[62] Paragraph 18.14 of Form M1.
[63] Paragraph 19.15 of Form M1.
[64] Paragraph 19.15 of Form M1.
[65] Paragraph 19.7 of Form M1.
[66] Paragraphs 19.15, 20.3 and 21.2 of Form M1.
[67] Paragraph 19.8 of Form M1.
[68] Paragraph 18.16.3 of Form M1.
[69] Paragraphs 19.16.1 and 19.16.2 of Form M1.

processing technologies and the continuing shrinking of semiconductors, there is a growing demand for very high resolution in the manufacturing process of very high-end semiconductors.[70] This leads to the development of alternative technologies that allow for high resolution. E-beam technology is an alternative technology for inspection of these smaller structures.[71]

47. The Parties expect optical inspection technology to remain as the mainstream technology for wafer inspection, at least in the short to mid-term (five to 10 years). The Parties added that optical inspection tools are able to inspect IC structures down to 14 nanometre ("nm"), and possibly lower. ASML expects that IC features below 14 nm will enter into commercial production during the year 2017.[72] The Parties noted that e-beam inspection tools are only expected to gain a larger market penetration as the customers (i.e., chip manufacturers) transition to the next technology stages ("nodes") in which the IC structures are becoming increasingly smaller. However, according to the Parties, even in respect of such smaller IC structures, it is expected that it is still feasible to use optical inspection equipment for the large dimension patterns or non-critical layers of a wafer. In addition, optical inspection equipment manufacturers continue to develop advanced optical technology to improve the sensitivity of the equipment.[73]

CCS's assessment of the relevant product markets

48. CCS has considered the Parties' submissions. Third-party feedback received by CCS corroborates the Parties' submissions that lithography equipment, overlay metrology equipment, process control software and wafer inspection equipment constitute distinct product markets.[74]

49. In light of third-party feedback and the Parties' submissions which indicate that different types of lithography equipment and different types of wafer inspection tools have different applications,[75] CCS has also considered the possibility of narrower product market definitions for lithography equipment (i.e., high-end, mid-end and low-end lithography equipment) and wafer inspection equipment (i.e., optical inspection equipment and e-beam inspection equipment). However, as there are no overlapping goods or services sold by the Parties globally, including in Singapore, CCS is of the view that it is not necessary to conclude on precise product market definitions in this case. CCS further notes that, regardless of whether narrower market definitions are adopted for lithography equipment and/or wafer inspection equipment product markets, CCS's conclusion following its assessment (as set out below) would be the same.

[70] Paragraph 19.17 of Form M1.
[71] Paragraph 19.18 of Form M1.
[72] Paragraph 9.1 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.
[73] Paragraph 19.20 of Form M1.
[74] Responses from [✂].
[75] Response from [✂]; and paragraph 18.19 of Form M1.

(b) Geographic Markets

Parties' submissions

50. The Parties submitted that the geographic market for the relevant product markets set out in paragraph 31 above are worldwide in scope, as suppliers and customers of processing equipment, process control equipment and process control software operate, supply and source their products and services around the world and consequently have branches worldwide.[76]

CCS's assessment of the relevant geographic markets

51. CCS understands that the supply of the Parties' products may not be constrained by the location of the suppliers' business operations. For lithography equipment, CCS notes feedback from [✂][77] that customers source their supply of such equipment worldwide. CCS further understands from [✂][78] that its customers source [✂] directly from its offices around the world, and it similarly makes all its equipment available for sale in Singapore. CCS also notes the Parties' submissions that HMI sells and distributes its e-beam inspection tools directly to customers in Singapore, through its sales team based in Taiwan.

(c) Conclusion on Relevant Markets

52. In view of the Parties' submissions and feedback from third-parties, CCS is of the view that the relevant markets for the competition assessment of the Transaction are:

(a) the worldwide supply of lithography equipment to Singapore;
(b) the worldwide supply of overlay metrology equipment to Singapore;
(c) the worldwide supply of process control software to Singapore; and
(d) the worldwide supply of wafer inspection equipment to Singapore,

(collectively, the "Relevant Markets").

[76] Paragraph 20.4 of Form M1.
[77] Response from [✂].
[78] Response from [✂].

VII. Market Structure

(a) Market shares and market concentration

Parties' submissions

Market shares by value (worldwide and Singapore)

53. **Lithography, overlay metrology and wafer inspection equipment.** The Parties submitted that the estimated worldwide market shares by value for lithography, overlay metrology and wafer inspection equipment markets are as follows:

Company	Revenue in 2015 (S$ million)[79]	Market Share 2015 (%)	Market Share 2014 (%)	Market Share 2013 (%)
Product: Lithography equipment (worldwide)[80]				
ASML	[✂]	[80-90]	[80-90]	[80-90]
Nikon Corporation ("Nikon")	[✂]	[10-20]	[10-20]	[10-20]
Canon, Inc ("Canon")	[✂]	[0-10]	[0-10]	[0-10]
Total	[✂]	**100**		
Product: Lithography equipment (Singapore)[81]				
ASML	NA	[90-100]	[90-100]	[90-100]
Nikon	NA	[0-10]	[0-10]	[0-10]
Canon	NA	[0-10]	[0-10]	[0-10]
Total	NA	**100**		
Product: Overlay metrology equipment (worldwide)[82]				
KLA-Tencor Corporation ("KLA-Tencor")	[✂]	[50-60]	[50-60]	[50-60]
ASML	[✂]	[30-40]	[30-40]	[30-40]
Total	[✂]	**100**		
Product: Overlay metrology equipment (Singapore)[83]				
KLA-Tencor	NA	[90-100]	[90-100]	[90-100]
ASML	NA	[0-10]	[0-10]	[0-10]
Total	**NA**	**100**		

[79] Exchange rate S$/€ used is €1 to S$1.4969.
[80] Paragraph 21.1 of Form M1.
[81] Paragraph 5.2 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.
[82] Based on footnote 10 of Form M1, the worldwide market share figures for overlay metrology equipment are based on market intelligence by ASML.
[83] Paragraph 5.3 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.

Company	Revenue in 2015 (S$ million)[84]	Market Share 2015 (%)	Market Share 2014 (%)	Market Share 2013 (%)
Product: Wafer inspection equipment (worldwide)[85]				
KLA-Tencor	[✂]	[70-80]	[70-80]	[70-80]
Applied Materials, Inc. ("AMAT")	[✂]	[0-10]	[0-10]	[0-10]
Hitachi, Ltd ("Hitachi")	[✂]	[0-10]	[0-10]	[0-10]
HMI	[✂]	[0-10]	[0-10]	[0-10]
Other	[✂]	[0-10]	[0-10]	[0-10]
Total	[✂]	**100**		
Product: Wafer inspection equipment (Singapore)[86]				
HMI	NA	[0-10]	[0-10]	[0-10]
Total	**NA**	**NA**		

***Table 1**: Revenue and Market Shares by Product Markets*[87]

54. **Process control software.** The Parties submitted that they do not have the worldwide and Singapore market size and market share estimates for process control software, as there are no published industry statistics or known reliable third-party sources for this.[88] Moreover, process control software revenue cannot be simply attributed to a certain region, because software is oftentimes not site-specific and not operated on-site. For instance, [✂].[89]

55. The Parties added that software associated with specific equipment forms an integrated product with the equipment concerned. Such software is also mostly developed by the equipment maker, which implies that companies' positions mirror their position on the equipment markets.[90] The Parties submitted that [✂]% of ASML's customers purchase its lithography and overlay metrology equipment without the associated ASML process control software required to ensure proper functioning equipment.

[84] Exchange rate S$/€ used is €1 to S$1.4969.
[85] Based on footnote 10 of Form M1, the worldwide market share figures for wafer inspection equipment are based on market intelligence by ASML.
[86] Paragraph 5.5 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.
[87] 2015 market share figures were submitted by the Parties in paragraph 21.1 of Form M1. 2013 to 2014 market share figures were submitted by the Parties in paragraph 13 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[88] Paragraph 21.3 of Form M1; and paragraph 5.4 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.
[89] Paragraph 5.4 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.
[90] Paragraph 13.4 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.

56. The Parties however noted that there are a number of specialised players active on the market segment for the provision of software that is not associated with particular equipment:

(a) In the overall market for process control software, ASML's share is less than [0-10]%;[91]

(b) With respect to the process control software specifically for the lithography cluster of a wafer fab, ASML estimated that KLA-Tencor, Qoniac GmbH and ASML [✂];[92]

(c) With respect to wafer design software, ASML (through its wholly-owned subsidiary Brion) has an estimated market share of approximately [30-40%] in 2015 (and this was approximately [30-40]% in 2013 and [30-40]% in 2014). Mentor Graphics is slightly larger than ASML with an estimated market share in the range of [40-50]%, while Synopsys has an estimated market share in the range of [10-20]%.[93]

Market shares by volume (worldwide and Singapore)

57. The Parties submitted that they do not have information on the worldwide total market size by volume or market share estimates by volume, for lithography equipment, overlay metrology equipment and wafer inspection equipment.[94]

58. With regard to lithography equipment sales, the Parties submitted that [✂].[95]

59. The Parties submitted that they also do not have the Singapore-wide total market size and market share estimates by volume for the relevant product markets, as there are no published industry statistics or known reliable third-party sources for this. The Parties expect the Singapore-wide market share estimates to be in the same range as the worldwide shares.[96]

CCS's assessment of market shares and market concentration

60. CCS has considered the Parties' submissions. CCS further notes from third-party feedback that existing competitors have been active in supplying products to customers in the Relevant Markets for [✂] years.[97] Third-party feedback also indicates that suppliers of the products in the Relevant Markets compete on various aspects, including [✂].[98]

[91] Paragraph 13.5 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[92] Paragraph 13.5 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[93] Paragraph 13.6 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[94] Paragraph 21.2 of Form M1.
[95] Paragraph 13.1 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[96] Paragraph 22.1 of Form M1.
[97] Responses from [✂].
[98] Responses from [✂].

61. While CCS has considered the possibility of further segmentation of the Relevant Markets, CCS notes that it is not necessary to consider the Parties' market shares and market concentrations under narrower market definitions in this case, given that there are no overlapping goods or services sold by the Parties globally, including in Singapore.

62. CCS further notes that the Transaction will not result in any increment in the Parties' market shares or any change in the level of concentration in each of the Relevant Markets. Notwithstanding this, CCS has assessed whether the Transaction is likely to give rise to any SLC concerns, in particular conglomerate effects, in the Relevant Markets.

(b) Barriers to entry and expansion

63. Paragraph 7.2 of the *CCS Guidelines on the Substantive Assessment of Mergers* states that, generally, entry by new competitors or expansion by existing competitors may be sufficient in likelihood, scope and time to deter or defeat any attempt by the merger parties or their competitors to exploit the reduction in rivalry flowing from the Transaction (whether through coordinated or non-coordinated strategies).[99]

Parties' submissions

64. The Parties submitted that the semiconductor industry is characterised by constant technological change and development. Specifically the Parties expect the wafer inspection segment to grow in the near future. The main competitors in the semiconductor industry are focusing on securing positions and expanding into related areas through innovation and consolidation.[100]

65. Examples of consolidation involving suppliers of semiconductor processing equipment or process control tools include:

(a) Lam Research Corporation's ("Lam's") acquisition of KLA-Tencor for US$10.6 billion (approximately S$14.6 billion) which is expected to be completed by mid-2016;

(b) ASML's acquisition of Cymer, Inc. in 2013; and

(c) Lam's acquisition of Novellus Systems, Inc. in 2011.[101]

66. The Parties further submitted that innovation and consolidation in the market will inevitably lead to increased competition within the semiconductor industry, and especially in the wafer inspection segment.[102]

[99] Paragraph 7.2 of *CCS Guidelines on Substantive Assessment of Mergers.*
[100] Paragraph 18.22 of Form M1.
[101] Paragraphs 18.24.1 to 18.24.3 of Form M1.
[102] Paragraph 18.22 of Form M1.

67. Specific to e-beam technology, the Parties also submitted that HMI is itself a new entrant in the wafer inspection equipment market with its e-beam equipment and other competitors are also becoming active in this particular field (as e-beam is a new technology).[103] HMI entered the wafer inspection equipment market in 2003.[104] AMAT has developed e-beam tools for CD SEM and defect review (with integrated deviation classification software) and is known to be developing a faster tool.[105] KLA-Tencor is also known to be active in this field.[106] It is therefore likely that there will be competing e-beam technology solutions on the market in the near future.[107]

68. HMI noted in its 2015 Annual Report that, based on e-beam inspection tools installed, its estimated market share for overall e-beam inspection tools is about 85%.[108] However, the Parties submitted that although HMI has a high share of e-beam inspection tools this represents only a comparatively small number of machines in absolute sales figures, as e-beam inspection tools is a nascent market segment. Thus, competitors could match HMI's position with a relatively low number of equipment sales and a shorter period of time.[109]

Capital expenditure

69. The Parties submitted that it is difficult to estimate with any precision the total cost of entry into the relevant product markets. Generally, the relevant product markets operate in an innovative market environment and entry into the relevant markets is capital intensive in terms of R&D and production facilities.[110]

70. The Parties also highlighted that, in addition to entirely new entrants, existing players are able to expand into new product segments. There are very large players active in the semiconductor industry for which the required capital or working capital for entry into a new product segment should not constitute significant entry obstacles.[111] By way of example, the Parties submitted that the key costs involved for a supplier to manufacture a type of lithography equipment that it is not normally active in, would vary between a minimum of [✂][112] and [✂][113], depending on the gap in the technical capabilities of the supplier, and how such technical gap would be overcome, for example, through productivity enhancement, or increases in wavelength or numerical aperture. The Parties are, however, not aware of such a situation having occurred previously.[114]

[103] Paragraph 29.1 of Form M1.
[104] Page 5 in Annex 6 of Form M1.
[105] Paragraph 18.23 of Form M1, see also http://www.appliedmaterials.com/company/contact/portfolios.
[106] Paragraph 18.23 of Form M1, see also http://www.kla-tencor.com/Product-Releases/sp-18455.html.
[107] Paragraph 18.23 of Form M1.
[108] Page 86 in Annex 6 of Form M1.
[109] Paragraph 10.2 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[110] Paragraph 26.1 of Form M1.
[111] Paragraph 26.2 of Form M1.
[112] Exchange rate S$/€ used is €1 to S$1.4969.
[113] Exchange rate S$/€ used is €1 to S$1.4969.
[114] Paragraph 2.1 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.

Regulation

71. The Parties submitted that they are unaware of any restrictions on the importation of any semiconductor processing equipment or process control tools in Singapore.[115]

CCS's assessment of barriers to entry and expansion

72. CCS notes feedback from competitors which indicate that entry into each of the Relevant Markets is [✂].[116] For example, a competitor opined [✂].[117] [✂].[118] Similarly, another competitor noted that [✂].[119] CCS also understands that [✂].[120]

73. While high capital investments, specialised expertise and significant lead times for the development of new products are likely to be required to enter into the Relevant Markets, CCS notes third-party feedback that [✂].[121] For example, a competitor noted that [✂].[122] In addition, CCS notes that an entrant to the Relevant Markets need not be physically present in Singapore in order to supply to Singapore, given that lithography equipment, overlay metrology equipment, process control software and wafer inspection equipment can be sourced worldwide.

74. On balance, CCS is of the view that barriers to entry and expansion in the Relevant Markets exist although they are not insurmountable. Significant resources and time would have to be invested by any potential new entrant before they can be considered a significant competitive constraint.

(c) Countervailing buyer power

Parties' submissions

75. The Parties submitted that the demand-side of the Relevant Markets is characterised by large, concentrated sophisticated buyers who have sufficient countervailing bargaining power to negotiate purchases. For example, ASML's customers include large companies such as [✂].[123]

76. The Parties submitted that customers in the semiconductor industry do not organise standard tenders where there is a general outreach to the market in which suppliers can participate and submit an offer on the basis of detailed pre-determined specifications. The procurement procedure in the semiconductor industry is a custom-made and dynamic process between customers and suppliers. Suppliers of equipment are individually

[115] Paragraph 18.21 of Form M1.
[116] Responses from [✂].
[117] Response from [✂].
[118] Response from [✂].
[119] Response from [✂].
[120] Responses from [✂].
[121] Responses from [✂].
[122] Response from [✂].
[123] Paragraph 32.1 and 32.2 of Form M1.

approached by customers and then engaged in multiple rounds of discussions and negotiations for a period of time about the technical specifications of the required equipment, the technology to be used and the production costs, amongst others, and how to best deliver on the specific needs of that customer. This ultimately leads to an offer for the sale of equipment and/or software specifically tailored to the technical and financial requirements of the customer.[124]

77. The Parties added that the fact that customers in the semiconductor industry have sufficient countervailing bargaining power was also confirmed most recently by competition authorities in the market investigation carried out in the context of the Lam and KLA-Tencor merger.[125] The Parties also noted that countervailing buyer power present in this case was akin to CCS Case No. 400/001/14 – Applied Materials, Inc./Tokyo Electron Limited, where CCS found that for the relevant semiconductor manufacturing equipment markets considered in that merger, there is relatively strong countervailing buyer power.[126]

CCS's assessment of countervailing buyer power

78. For lithography equipment, one third-party commented that the decision to purchase such equipment depends on factors such as [✂].[127] For the overlay metrology equipment, process control software and wafer inspection equipment, a competitor commented that customers would have to [✂].[128] Despite this, it is not uncommon for the customers to [✂].[129] Further, CCS notes that the equipment and software needs of some of the Parties' customers are also [✂].[130] Given the above, CCS is of the view that it is generally difficult, though not impossible, for customers to switch suppliers.

79. [✂].[131]

80. Third-party feedback indicates that customers are [✂].[132]

81. On balance, CCS is of the view that there is some degree of countervailing buyer power which would pose a competitive constraint on the merger parties.

[124] Paragraph 3.1 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[125] Paragraph 32.3 of Form M1.
[126] Paragraph 32.4 of Form M1.
[127] Response from [✂].
[128] Response from [✂].
[129] Response from [✂].
[130] Responses from [✂].
[131] Response from [✂].
[132] Responses from [✂].

VIII. Competition Assessment

(a) Non-coordinated effects and conglomerate effects

82. Non-coordinated effects may arise where, as a result of the Transaction, the merged entity finds it profitable to raise prices (or reduce output or quality) because of the loss of competition between the merged entities. Other firms in the market may also find it profitable to raise their prices because the higher prices of the merged entity's product will cause some customers to switch to rival products, thereby increase demand for the rivals' products.[133]

83. In assessing whether a conglomerate merger could have anticompetitive effects, CCS will consider the ability of customers to exercise countervailing power, and in particular the incentives of customers to buy the portfolio from a single supplier. In a situation where customers can and do source the portfolio products from multiple suppliers and are likely to continue to do so post-merger, it is unlikely that the merger would substantially lessen competition.[134]

Parties' submissions

84. The Parties submitted that the Transaction will not give rise to horizontal effects as ASML and HMI produce very different types of equipment and do not have any horizontally overlapping activities.[135] The Parties also submitted that the Transaction will not give rise to any non-horizontal, portfolio or conglomerate effects that substantially lessens competition in the Relevant Markets.[136]

85. **Lithography equipment**. The Parties submitted that post-Transaction, ASML will not have any ability or incentive to foreclose competitors in the lithography equipment market.

86. In this regard, wafers consist of multiple layers imprinted by different lithography machines ranging from low-end to high-end layers and wafers go through multiple rounds of lithography, etching, deposition and CMP. After each step, wafers are inspected for defects. A typical wafer fab's machine park consists of a mix of low-end layer lithography machines (where Canon is the major player), mid-end layer lithography machines (where Nikon and ASML are equally represented) and high-end lithography machines (typically ASML machines). Most wafer fabs have an installed machine park of lithography machines with a remaining lifetime of many years; the typical lifetime of a lithography machine is much more than 20 years.[137]

[133] Paragraph 6.3 of *CCS Guidelines on the Substantive Assessment of Mergers*.
[134] Paragraph 8.16 of *CCS Guidelines on the Substantive Assessment of Mergers*.
[135] Paragraph 33.1 of Form M1.
[136] Paragraph 34.2 of Form M1.
[137] Paragraph 34.6 of Form M1.

87. HMI's e-beam inspection tools are currently only used (when actually used in the production process) for key inspection points on critical layers of a wafer and has no established position on the market. It is only commercially feasible for the merged entity to ensure that post-Transaction, the merged entity's e-beam inspection tools are, and remain compatible with, competing lithography machines and use the best data available regarding (layers imprinted by) those machines, as there is a large installed machine park of non-ASML lithography machines. In view thereof, the Parties submitted that there is no foreclosure risk.[138]

88. Optical inspection is currently the main inspection technology and is expected to remain the main technology in at least the mid-term future. Optical inspection equipment makers also invest in improving the technology further. For this reason, post-Transaction, the merged entity has no ability to foreclose competing lithography equipment, even if it was able to create compatibility issues with respect to competing lithography equipment.[139]

89. In addition, there are a number of players on the market that are known to be investing in developing e-beam technology. In particular, AMAT has developed e-beam tools for CD SEM and defect review (with integrated classification software) and is known to be developing a faster tool. KLA-Tencor is also known to be active in this field. It is therefore likely that there will be competing e-beam technology solutions on the market in the near future.[140]

90. As such, the Parties submitted that post-Transaction, ASML will not have the ability or incentive to foreclose competing lithography equipment.[141]

91. **Overlay metrology equipment**. The Parties submitted that the merged entity will not be able to engage in any anticompetitive tying or bundling of ASML's overlay metrology equipment and HMI's e-beam inspection tools as:

    (a) overlay metrology equipment is a distinct type of M&I equipment from wafer inspection tools, used in a separate step in the overall IC production process; and

    (b) while a customer would be able to use ASML's overlay metrology equipment (i.e., at a different step of the overall IC production process) and HMI's e-beam inspection tool in the same wafer fab, a customer would equally be able to use non-ASML overlay metrology equipment in conjunction with HMI's e-beam inspection tool.[142]

92. The Parties also noted that the other competitive characteristics of the wafer inspection equipment market (discussed below) would similarly apply.[143]

[138] Paragraph 34.6 of Form M1.
[139] Paragraph 34.7 of Form M1.
[140] Paragraph 34.8 of Form M1.
[141] Paragraph 34.4 of Form M1.
[142] Paragraph 12.21 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[143] Paragraph 12.23 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.

93. **Process control software**. The Parties submitted that the merged entity will not be able to engage in any anticompetitive tying or bundling of ASML's process control software with HMI's e-beam inspection tools. Specifically:

(a) ASML does not sell software that can be used as a substitute to HMI's software (which is associated with its e-beam inspection tool);
(b) [✂]; and

(c) [✂].[144]

94. Further, the Parties noted that the process control software market also features large competitors, such as, KLA-Tencor.[145]

95. **Wafer inspection equipment**. The Parties submitted that there is equally no foreclosure risk on the wafer inspection market, as post-Transaction, the merged entity will neither be able nor have any incentive to engage in tying or bundling practices with respect to the e-beam tool to the detriment of customers.[146]

96. The Parties submitted that there are two types of wafer inspection equipment:

(a) **Optical inspection equipment**: this type of equipment is less sensitive (or precise) than e-beam technology inspection equipment), although the inspection speed is much faster and the cost is lower; and

(b) **E-beam inspection equipment**: the sensitivity of this type of equipment is better than optical inspection equipment, but the inspection speed is much slower and the cost is higher.[147]

97. The Parties submitted that e-beam technology is currently essentially used in R&D. Moreover, wafers need to be inspected not only after the lithography process, but also after etching, after the deposition process and after CMP. Semiconductor manufacturers need separate inspection equipment for each step in the production process. Currently, these inspection tools are all optical tools (except for the minimal sales of e-beam equipment by HMI). Since ASML is only selling lithography machines and not etching, deposition or CMP equipment, the merged entity has no ability post-Transaction to engage in tying with respect to inspection equipment for use after etching, deposition and CMP.[148]

98. Even within the lithography process, e-beam is only likely to be used for the critical layers of the wafer.[149] Non-critical layers do not require high resolution inspection and

[144] Paragraph 12.20 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[145] Paragraph 12.22 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[146] Paragraph 34.10 of Form M1.
[147] Paragraph 19.16 of Form M1.
[148] Paragraphs 34.11 and 34.12 of Form M1.
[149] Paragraph 34.13 of Form M1.

manufacturers will most likely continue to use optical scanning solutions which will remain faster and cheaper. As a result e-beam and optical scanning will co-exist.[150] The Parties added that optical inspection tool developers are continuously advancing the optical inspection technology to compensate for the technological advantage of e-beam inspection tools. Ultimately, when it comes to the inspection of high-end semiconductors, it will be up to the customer to strike a balance between the higher productivity and lower capture rate of optical inspection tools, and the lower productivity and higher capture rate of e-beam inspection tools.[151]

99. The Parties submitted that the wafer inspection market is a competitive market environment with large players that are active across different segments, both in processing equipment and in process control. Moreover, the wafer inspection industry is expected to grow in the near future, and the main competitors in the semiconductor industry are focusing on securing positions and expanding into related areas through innovation and consolidation. This will inevitably lead to increased competition within the semiconductor industry, and especially in the wafer inspection segment.[152]

100. **Bundling of lithography equipment and wafer inspection equipment.** The Parties submitted that merged entity will also not be able to tie or bundle e-beam inspection tools to lithography machines because these machines are, in the majority of the cases, not purchased at the same time and through different procurement processes. Lithography machines have a lifecycle of (much) more than 20 years, whereas e-beam inspection tools do not have a parallel lifecycle. There is also a large installed machine park of lithography machines, while e-beam inspection tools are just on the verge of entering the market. Thus, many e-beam inspection tools will be sold to semiconductor manufacturers that do not necessarily need a new lithography machine.[153] Moreover, this also implies that if the merged entity wants to further penetrate the wafer inspection tool market, it is only commercially feasible to ensure that post-Transaction the e-beam inspection tools are, and remain compatible with, competing lithography machines and use the best data available regarding (layers imprinted by) those machines, in particular because there is a large installed machine park of non-ASML lithography machines.[154]

101. Further, the Parties noted that ASML is not active in the wafer inspection market yet and is currently only a minor player in the wider process control market. ASML only offers an overlay inspection tool, YieldStar, which is unrelated to defect inspection, and it is not even the main supplier of such inspection equipment on the market. Through the Transaction, ASML will gain a position in one particular segment, which is under development, i.e. the e-beam inspection tool. The e-beam inspection tool is still in the development stage (currently predominantly used in R&D environments and in the actual production process mainly for Voltage Contrast). Thus, while ASML has a strong position in the lithography equipment segment, it does not have any activities in any

[150] Paragraph 34.13 of Form M1.
[151] Paragraph 11.1 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[152] Paragraph 34.15 of Form M1.
[153] Paragraph 34.14 of Form M1.
[154] Paragraph 14.4 of Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.

other processing equipment segment and does not have a well-established position in the process control market, and is not active at all in the wafer inspection market.[155]

102. By contrast, there are several competitors within the semiconductor industry that do have well-established positions in both the processing equipment market and in the process control market, such as Lam, AMAT and Hitachi.[156]

103. The Parties also submitted that although the players in the semiconductor industry specialise in different areas and offer diverse types of equipment, they exert significant competitive pressure on one another. On the overall processing equipment market, the combined ASML/HMI entity would still be the number four player on that wider market.[157]

104. The Parties added that although [✂].[158] The Parties also noted that a number of players on the market such as AMAT and KLA-Tencor are investing in developing e-beam technology. As such, the merged entity will not be able to foreclose competing lithography machines.[159] As such, the Parties submitted that the ongoing industry consolidation and competitive pressure from other major players in the industry will prevent the merged entity from tying or bundling lithography equipment and e-beam inspection tools in a way that would ultimately be detrimental to customers.[160]

105. **Countervailing buyer power.** Lastly, the Parties noted that their customers are large and sophisticated customers who would be capable of constraining the ability of the merged entity to engage in anticompetitive conduct (i.e., tying or bundling ASML's products and services with respect to HMI's e-beam inspection tools) in any the relevant markets, to the detriment of customers.[161] These reasons are listed in paragraphs 75 to 77 above.

106. The Parties therefore surmised that the Transaction is not intended to, and will not give rise to, portfolio or conglomerate effects that substantially lessen competition in the Relevant Markets.[162]

<u>CCS's assessment of non-coordinated effects</u>

107. CCS is of the view that non-coordinated effects are unlikely to arise as there are no overlapping products sold by the Parties globally, including in Singapore.

[155] Paragraph 34.16 of Form M1.
[156] Paragraph 34.17 of Form M1.
[157] Paragraph 34.19 of Form M1.
[158] Paragraph 14.3 of Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[159] Paragraph 14.5 of Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[160] Paragraph 34.20 of Form M1.
[161] Paragraph 34.25 of Form M1; and paragraph 12.22 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[162] Paragraph 14.6 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.

CCS's assessment of conglomerate effects

108. In relation to wafer inspection tools, CCS notes the Parties' submissions and third-party feedback that e-beam technology for such tools are currently only used for very advanced processing and at present, mainly employed in R&D applications. According to the Parties' submissions, HMI's e-beam inspection equipment is essentially deployed for R&D purposes, and IC features below 14 nm which potentially require e-beam inspection tools, is expected to enter into commercial production starting from the year 2017.[163]

109. Third-party feedback indicates the same. For instance, one third-party noted that e-beam technology is [✂].[164] Another third-party commented that the [✂].[165]

110. E-beam inspection tools are only expected to gain a larger market penetration as the customers (i.e., IC manufacturers) transit to the next technology stages in which the IC structures are becoming increasingly smaller. [166] CCS also notes that HMI is not the only business active in the development of e-beam inspection equipment. Competitors such as AMAT and KLA-Tencor are also active in the development of e-beam inspection tools.[167] In particular, [✂]. [✂].[168]

111. CCS further notes third-party feedback that [✂].[169] Another third-party commented that optical and e-beam wafer inspection tools are [✂]. [170] Consequently, in the wafer inspection market, it appears that optical technology acts as an existing competitive constraint on e-beam technology. Further, existing competitors active in developing e-beam inspection tools, will continue to exert a competitive constraint on the merged entity.

112. In relation to the lithography equipment market, CCS notes that large customers may be able to sponsor, and have in the past sponsored, the development of lithography technology to cater to their specific business needs. For example, Intel Corporation, Taiwan, Semiconductor Manufacturing Company Limited and Samsung Electronics Co., Ltd. committed to contributing €1.38 billion (approximately S$2.07 billion)[171] between 2012 and 2017 to ASML's research and development of next generation lithography technologies.[172] The Parties also submitted that if a large customer wants a competitor such as Canon to manufacture a high-end lithography machine, it would be within technical reach of the competitor to do so.[173]

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[163] Paragraph 9.1 of the Parties' Response dated 1 August 2016 to CCS's RFI dated 27 July 2016.
[164] Response from [✂].
[165] Response from [✂].
[166] Paragraph 19.20 of Form M1.
[167] Paragraph 18.23 of Form M1.
[168] Response from [✂].
[169] Response from [✂].
[170] Response from [✂].
[171] Exchange rate S$/€ used is €1 to S$1.4969. Paragraph 13.3 of Form M1.
[172] ASML's Press Release "Samsung joins ASML's Customer Co-Investment Program for Innovation", 27 August 2012. Source: https://www.asml.com/press/press-releases/samsung-joins-asmls-customer-coinvestment-program-for-innovation-completing-the-program/en/s5869?rid=46974
[173] Paragraph 14.1 of Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.

113. CCS has also considered whether any SLC concerns may arise from the merged entity's expanded range of products. CCS understands that the rationale of the Transaction is to better serve the Parties' customers and offer them the tools they need to achieve higher yields at the most advanced nodes.[174] In this regard, a customer has indicated that [✂].[175] CCS understands that customers purchase products [✂].[176] Third-party feedback indicates that [✂].[177] There is no evidence from the submissions of the Parties that they intend to bundle or tie their lithography equipment with e-beam inspection tools post-Transaction. There is also no evidence from third-party feedback indicating that the Parties will have a significant prospect of bundling or tying their lithography equipment with e-beam inspection tools.

114. In view of the foregoing assessment and CCS's assessment of the degree of countervailing buyer power (as noted in paragraphs 78 to 81 above), it is unlikely that the Transaction will give rise to conglomerate effects which lead to SLC concerns in the Relevant Markets.

Coordinated effects

115. CCS has also assessed whether the Transaction may lead to coordinated effects. A merger may lessen competition substantially by increasing the possibility that, post-merger, firms in the same market may coordinate their behaviour to raise prices, or reduce quality or output. Given certain market conditions, and without any express agreement, tacit collusion may arise merely from an understanding that it will be in the firms' mutual interests to coordinate their decisions. Coordinated effects may also arise where a merger reduces competitive constraints in a market, thus increasing the probability that competitors will collude or strengthen a tendency to do so.[178]

Parties' submissions

116. The Parties submitted that the Transaction will not give rise to coordinated effects in the relevant markets, in view of:

(a) competing suppliers globally who will be able to disrupt any coordinated behaviour; and

(b) the strong countervailing buyer power of end customers, who will be able to disrupt any coordinated behaviour.[179]

[174] ASML Press Release "ASML to Acquire HMI to Enhance Holistic Lithography Product Portfolio", 16 June 2016. Source: https://www.asml.com/press/press-releases/asml-to-acquire-hmi-to-enhance-holistic-lithography-product-portfolio/en/s5869?rid=53782.
[175] Response from [✂].
[176] Response from [✂].
[177] Responses from [✂].
[178] Paragraph 6.7 of *CCS Guidelines on Substantive Assessment of Mergers*.
[179] Paragraphs 35.2.1 and 35.2.2 of Form M1; and paragraph 12.24 of Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.

CCS's assessment of coordinated effects

117. As there are no overlapping products supplied by the Parties, CCS notes that the market structure in relation to each of the Relevant Markets is not materially affected by the Transaction. Accordingly, CCS considers that the Transaction is unlikely to raise concerns in terms of coordinated effects on competition in the Relevant Markets.

IX. Efficiencies

Parties' submissions

118. The Parties have submitted that the Transaction is envisaged to bring about considerable efficiencies, as it will allow the Parties to increase the speed of innovation of e-beam technology. In addition, e-beam defect inspection will deliver accurate data, which ASML can use to optimise the lithography process.[180]

119. [✂].[181]

CCS's assessment of efficiencies

120. Given that the above competition assessment did not raise SLC concerns in any of the Relevant Markets, CCS is of the view that it is not necessary to make an assessment on the efficiencies claimed by the Parties.

X. Conclusion

121. For the reasons above and based on the information available, CCS assesses that the Transaction is unlikely to lead to SLC concerns and is accordingly unlikely to infringe the prohibition under section 54 of the Act. In accordance with section 57(7) of the Act, this decision shall be valid for a period of one year from the date of this decision.

Toh Han Li
Chief Executive
Competition Commission of Singapore

[180] Paragraph 42.1 of Form M1.
[181] Paragraph 42.2 of Form M1.

ANNEX A

Front-end Processes: Processing Equipment and Process Control Equipment and Software

1. Front-end processing equipment for ICs comprises sophisticated types of equipment each of which covers a specific stage in the manufacture of semiconductors. There are several types of equipment, the main ones among which are the following, schematically set out in Figure 1 below:[182]

Figure 1

(a) **Lithography equipment** is used to imprint a specific pattern on the wafer. The process starts by applying a light-sensitive material called 'photoresist' onto the wafer surface. Then, in a device called a lithography machine, light passes through a mask (or reticle) and subsequently through a lens to shrink the image and expose select regions of the wafer below to short wavelength light, making the photoresist in these regions soluble. This photoresist is then washed away by a developer solution;

(b) **Etching equipment** is used to etch away layers on parts of the wafer that are now unprotected by the photoresist or where the photoresist is not illuminated, thereby generating the structures of the current switches on the wafer. Etching techniques include wet etching and dry etching;

(c) **Deposition equipment** is applied in any process that grows, coats or otherwise transfers a material onto a wafer. The equipment is mainly used in applying conductive material into the structures of the wafer that have been formed in the etching process; and

(d) **CMP equipment** is used to polish off excess material from the wafer. Manufacturers use a corrosive substance in conjunction with a polishing pad. This removes material and tends to even out any irregular topography, making the wafer flat.[183]

2. The processing equipment in a fab is supported by process control equipment and software. This comprises M&I equipment, as well as process control software that are usually used together with the equipment. M&I equipment is used to detect deviations, defects and other irregularities that may harm the functioning of the IC; process control software is used to control the processing equipment and to provide feedback on the basis

[182] Paragraph 18.9 of Form M1.
[183] Paragraphs 18.9.1 to 18.9.4 of Form M1.

of output of M&I equipment to optimize processing equipment.[184]

3. Process control software uses the output of the M&I equipment, but may also use statistical data, to optimise the settings of the processing equipment. For instance, virtual metrology is used to predict wafer properties based on statistical methods without performing the physical measurement itself.

4. Every step of the production process for ICs requires specific process control software. There are broadly two types of process control software:

   (a) software used to operate the processing equipment; and

   (b) software that uses the output of M&I equipment and provides feedback to optimise the settings of the processing equipment.[185]

5. The Parties submitted that with respect to process control software, a distinction should be made between software associated with a certain type of equipment and software that is not associated with a certain type of equipment. Software that is associated with equipment is needed for the proper functioning of such equipment and therefore normally sold as an integrated part (i.e., as one product) to customers. In exceptional cases, customers have their own software that can be used to control equipment and in such cases the equipment may be sold without the software.[186]

6. The Parties added that semiconductor manufacturers also develop their own process control software in-house. This software controls a whole wafer fab (and sits on a server inside a wafer fab) and is used for instance to control parameters in one part of the fab based on data derived from other parts of the fab, or to shut down a fab if there are yield issues. This type of software is one of the factors that differentiates a given semiconductor manufacturer compared to another, which is the reason why they prefer to develop such software in-house. It is only since relatively recently (i.e., about five years ago) that third parties entered this field. At present, a number of semiconductor manufacturers still only use proprietary process control software, while others complement their proprietary process control software with third-party software, such as the software developed by ASML. Semiconductor manufacturers never use only third-party software for these purposes, but only use third-party software as add-ons to their own software.[187]

[184] Paragraph 18.12 of Form M1.
[185] Paragraph 19.5 of Form M1.
[186] Paragraph 5.1 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.
[187] Paragraph 12.5 of the Parties' Response dated 13 July 2016 to CCS's RFI dated 5 July 2016.

7. Figure 2 below provides an overview of the various process control software and type of M&I equipment and interaction with the processing equipment.[188]

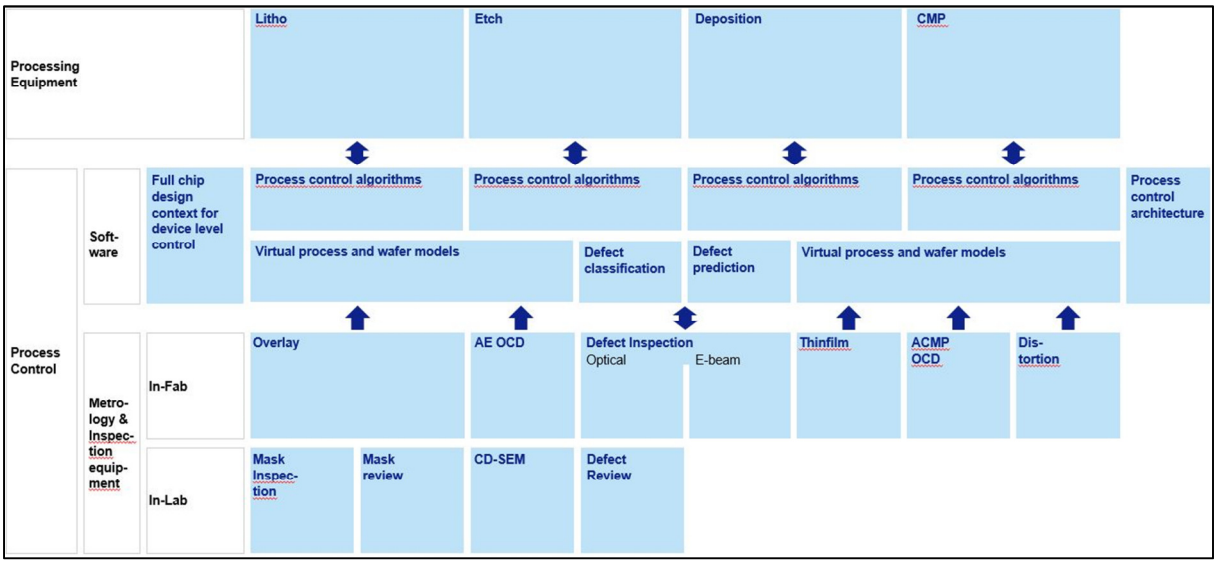

Figure 2

8. There are various types of M&I equipment, including:

(a) **Overlay metrology devices**: such equipment is used to check the arrangement of different structural levels of semiconductor devices relative to each other. This is to ensure that the appropriate specifications are met with regard to the overlay parameters, in other words, checking that the superposed planes with its structures are aligned in the intended manner upon each other. Accordingly, overlay metrology devices are used to study patterned wafers during IC manufacturing, typically as part of the lithography process to ensure that the next structural level is applied spatially correct in relation to the previous ones. Overlay metrology devices primarily use sophisticated microscopes to study correct placement of the structured planes;

(b) **Critical dimension metrology**: such equipment is used to measure the dimensions of line widths and line spacing of the IC-structures on the patterned wafer, for instance after etching or after CMP. Critical Dimension relates to the minimum level of precision with regards to the lines width and line spacing and is thus important in the continuing advancement (i.e., shrinking) of the semiconductor technology;

(c) **Wafer inspection**: such equipment is used to check the IC structures for (critical) deviations and other irregularities. Wafer inspection takes place after the lithography process, after etching, after the deposition process and after the CMP process, with each inspection step requiring specific type of measurement and

[188] Paragraph 18.15 of Form M1.

tools;

(d) **Thin-film metrology devices**: such equipment is used to measure the thickness (and optionally the composition), and for checking uniformity of the shape and other properties of films or coatings that have been applied to a wafer. These devices are mainly used by IC manufacturers for checking CVD or PVD coatings. They are also used to some extent by wafer manufacturers, e.g. for checking of epitaxial layers deposited on wafers;

(e) **Surface metrology devices (distortion)**: such equipment is used to measure the surface parameters of a semiconductor-element, such as step-height, roughness and waviness. These devices are mainly used by IC manufacturers in their production process for examination of the surface profile between production steps, for instance after CMP. For the measuring of surface topography, sensing measuring techniques or optical (interferometric) measurement methods are used. The sensing measurement techniques include so-called stylus profilers and atomic force microscopy. Distortion falls under this category of metrology devices;

(f) **Mask inspection and metrology devices**: such equipment is used for the inspection of masks or 'reticles' that are used to project images onto the wafer. The inspection systems are used to find reticle deviations prior to printing on the wafer. The metrology systems ensure quality reticle manufacturing by providing precision for reticle pattern placement and accurate measurement of reticles' critical dimensions; and

(g) **Defect review**: defect review systems capture high resolution images of the defects detected by defect inspection tools. These images enable defect classification, helping IC manufacturers to identify and resolve yield issues.[189]

[189] Paragraphs 18.16.1 to 18.16.7 of Form M1.