China Technology

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Implications of Dutch additional export control

Dutch government announced additional export restrictions of semiconductor equipment on 30 Jun (link), focusing on advanced chip manufacturing technology, including advanced deposition and immersion lithography tools (EUV; wavelength<193nm; wavelength≥193nm, MRF≤45nm and DCO≤1.5nm), which is largely in-line with expectations and its earlier announcement in March. The new rule will become effective on 1 Sep 2023. ASML also announced (link) that new export controls only pertain to TWINSCAN NXT:2000i and subsequent immersion systems, implying 1) no impact on shipments of NXT:1980Di DUV equipment for 14nm or above processes and 2) no impact to capacity expansion of mature processes (28nm or above) in China. In our view, the new rule is better than feared that sales of NXT:1980Di will also be impacted, and we believe localization of semi equipment/foundry will accelerate in China given supply chain security and push for breakthroughs in advanced processes.

- **Dutch's new restriction has no material impact to ASML's business.** As the global leader in lithography equipment with 80%+ DUV market share, ASML stated that 1) it will need to apply for export licenses with Dutch govt. for advanced immersion DUV systems (TWINSCAN NXT:2000i and subsequent immersion systems), 2) it will continue to comply with export regulations, incl. Dutch, EU and US, 3) and it expected no material impact on ASML's financial outlook for 2023 or in the longer term. Overall, we think it is better than feared as shipments of NXT:1980Di DUV equipment for 14nm and above processes are not impacted (given its DCO≤1.6nm). As such, given ASML's immersion DUV sales mix of 15% and China's exposure of 14% in FY22, we expect limited impact to ASML's revenue in near term.
- **Limited impact on Chinese foundry/IDM capacity expansion on mature processes.** The scope of Dutch new export controls focuses on leading-edge process (14nm or below), which aligns with Japan/US's restrictions. Since equipment used for mature processes (14nm above) is not impacted, Chinese semiconductor foundry/IDM can continue to purchase equipment for mature-node manufacturing. We expect limited impact to SMIC (981 HK) and Hua Hong Semi (1347 HK) given their focus on mature processes.
- **SPE localization set to accelerate in China.** We expect recent export controls will accelerate semi/SPE localization in China, benefiting platform players, such as Naura (002371 CH) and AMEC (688012 CH), and industry leaders below. **1) For DUV,** Shanghai Microelectronics's (private) 90nm ArF Dry entered mass production, and 28nm ArFi is under R&D; **2) For ALD,** global leader, ASMI (55% global mkt shr), will be impacted and Chinese leader, Leadmicro (688147 CH), successfully mass produced high-k atomic ALD for 28nm; **3) For CVD/PVD,** Japan's Tel/KE are key players (20%/10% mkt shr), and Chinese leader, Piotech (688072 CH), is set to benefit given low localization of 15% in China. **4) For Silicon carbon epitaxial,** global leaders include Italy's LPE with limited capacity (30 units/yr), Germany's AIXTRON with no China exposure and Japan's Nuflare focusing on US. Chinese supplier, Jingsheng Mechanical (300316 CH), has developed 8-inch single-chip silicon carbide epitaxial equipment for local supply chain.

Valuation Table

Name	Ticker	Mkt Cap (US$ mn)	Price (LC)	P/E (x) FY23E	P/E (x) FY24E	P/B (x) FY23E	ROE FY23E
SMIC	981 HK	29167	20.4	16.9	16.6	0.99	8.7
Hua Hong Semi	1347 HK	4273	25.6	10.1	9.5	1.12	11.8

Source: Company data, CMBIGM estimates

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1. Implications of US's new chip export restrictions to China – 10 Oct 2022 (link)
2. U.S. may broaden AI chips export restrictions - 14 Sep 2022 (link)
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Figure 1: Details of Dutch Government export control on advanced chip-making equipment (translated version)

Rules	Content
3B001.l	EUV pellicle
3B001.m	Production equipment for EUV pellicle
3B001.f.4	Lithographic equipment, as follows: a. Direct step-on-wafer or scanner equipment for aligning and exposing wafers, using photooptical or X-ray methods, having either or both of the following: 1. **wavelength of light source shorter than 193nm, or** **2. wavelength of light source equal to or greater than 193 nm:** a. capable of producing patterns with **minimum resolvable feature size (MRF) of 45nm or less**; and b. a maximum dedicated chuck overlay (DCO) value less than or equal to 1.50 nm. Technical note: $'MRF' = \frac{(golflengte\ van\ de\ lichtbron\ in\ nm) \times (K\ factor)}{maximale\ numerieke\ apertuur}$ 1. The minimum resolvable feature size (MRF) is calculated according to the following formula: where the K factor0,25; (MRF) is the same as resolution. 2.DCO is the degree of accuracy of aligning a new pattern on an existing pattern exposed on a wafer by the same lithographic system.
3B001.d.12	Atomic-layer deposition (ALD) equipment of metal scrap a) having all of the following characteristics: 1. More than one metal source, one of which has been developed for an aluminium (Al) precursor; and 2.Raw material vessel designed for temperatures above 45°C; and b. Designed for deposition of 'step out' metals having all of the following characteristics: 1. Deposition of titanium aluminium carbide (TiAlC); and 2. The possibility of a "exit work" higher than 4.0eV. Technical note: 1. "Metal discharge" is a material that regulates the threshold voltage of a transistor.
3B001.a.4	Equipment designed for epitaxial growth of silicon (Si), carbon-doped silicon, silicon germanium (SiGe), or carbon-doped SiGe a) having all of the following characteristics: 1.Maintain multiple chambers and means for high-vacuum (less than or equal to 0.01 Pa) or an inert atmosphere (water and oxygen partial pressure less than 0.01 Pa) between process steps; 2.At least one pretreatment chamber designed for surface preparation intended to clean the surface of wafers; and 3.Epitaxial deposition working temperature of 685 °C or below.
3B001.d.19	Equipment designed for depositing a low-k dielectric enhanced by void-free plasma without voids in spaces less than 25 nm wide with a depth-to-height ratio (AR) equal to or greater than 1:1 between metal lines having a dielectric constant lower than 3.3
3D007	Software specially designed for the development, production or use of equipment specified in this Regulation in 3B001.l., 3B001.m., 3B001.f.4, 3B001.d.12, 3B001.a.4 or 3B001.d.19
3E005	Technology necessary for the development, production or use of equipment specified in this Regulation in 3B001.l., 3B001.m., 3B001.f.4, 3B001.d.12, 3B001.a.4 or 3B001.d.19.

Source: Netherland Government Official website (zoek.officielebekendmakingen.nl/stcrt-2023-18212)

Figure 2: Details of Dutch Government export control on advanced chip-making equipment (Original)

BIJLAGE BEHORENDE BIJ DE REGELING VOOR GEAVANCEERDE PRODUCTIEAPPARATUUR VOOR HALFGELEIDERS

Productieapparatuur, programmatuur en technologie voor halfgeleiderelementen of materialen, niet gecontroleerd onder 3B001, 3D001, 3D002 en 3E001 van bijlage I bij de Verordening producten voor tweeërlei gebruik, als hieronder, en speciaal ontworpen onderdelen en toebehoren daarvoor:

3B001.l	EUV pellicles
3B001.m	Productieapparatuur voor EUV pellicles
3B001.f.4	Lithografische apparatuur, als hieronder: a. repeteerapparatuur (<step and repeat> (<direct step on wafer>) apparatuur of <step and scan> (scanner) apparatuur) voor uitrichten en belichten ten behoeve van het bewerken van wafers, waarbij gebruik wordt gemaakt van foto-optische of röntgenmethoden, met één of beide van de volgende eigenschappen: 1. golflengte van de lichtbron korter dan 193 nm, of 2. golflengte van de lichtbron gelijk aan of groter dan 193 nm: a. in staat om patronen te produceren met een <minimum resolvable feature size> (MRF) van 45 nm of minder; en b. een maximale <dedicated chuck overlay> (DCO) waarde kleiner dan of gelijk aan 1.50 nm. *Technische noot:* *1. De <minimum resolvable feature size> (MRF) wordt berekend volgens de volgende formule:* $'MRF' = \frac{\text{(golflengte van de lichtbron in nm) x (K factor)}}{\text{maximale numerieke apertuur}}$ *waarbij de K-factor = 0,25* *(MRF) is zelfde als resolutie.* *2. DCO is de mate van accuraatheid van uitlijning van een nieuw patroon op een bestaand patroon belicht op een wafer door hetzelfde lithografische systeem.*
3B001.d.12	Apparatuur voor atomaire-lagen-afzetting (ALD) van 'uittreearbeid' metalen a. met alle van de volgende eigenschappen: 1. Meer dan één metaalbron waarvan één is ontwikkeld voor een aluminium (Al) uitgangsstof (<precusor>); en 2. Uitgangsstofvat ontworpen voor temperaturen hoger dan 45 °C; en b. Ontworpen voor afzetting van 'uittreearbeid' metalen met alle van de volgende eigenschappen: 1. Afzetting van titanium aluminium carbide (TiAlC); en 2. De mogelijkheid tot een 'uittreearbeid' hoger dan 4.0eV. *Technische noot:* *1. 'uittreearbeid metaal' is een materiaal dat de drempelspanning van een transistor reguleert.*
3B001.a.4	Apparatuur ontworpen voor epitaxiale groei van silicium (Si), koolstof-gedoteerd silicium, siliciumgermanium (SiGe), of koolstof-gedoteerd SiGe a. met alle van de volgende eigenschappen: 1. Meerdere kamers en middelen voor hoog-vacuüm (minder dan of gelijk aan 0.01 Pa) of een inerte atmosfeer (water en zuurstof partieeldruk minder dan 0.01 Pa) te handhaven tussen processtappen; 2. Tenminste één voorbehandelingskamer ontworpen voor oppervlaktevoorbereidingen bedoeld om de oppervlakte van wafers te reinigen; *en* 3. Epitaxiale afzettingswerktemperatuur van 685 °C of lager.
3B001.d.19	Apparatuur ontworpen voor het middels void-vrije-plasma versterkt afzetten van een laag diëlektricum met lage-K zonder leegtes in ruimten van minder dan 25 nm breed met een diepte/hoogte verhouding (<aspect ratio, AR>) gelijk aan of groter dan 1:1 tussen metalen lijnen met een diëlektrische constante lager dan 3.3
3D007	Programmatuur speciaal ontworpen voor de ontwikkeling, de productie of het gebruik van de apparatuur die is vermeld in deze regeling onder post 3B001.l, 3B001.m, 3B001.f.4, 3B001.d.12, 3B001.a.4 of 3B001.d.19.
3E005	Technologie die noodzakelijk is voor de ontwikkeling, productie of het gebruik van apparatuur, vermeld in deze regeling onder post 3B001.l, 3B001.m, 3B001.f.4, 3B001.d.12, 3B001.a.4 of 3B001.d.19.

Source: Netherland Government Official website (zoek.officielebekendmakingen.nl/stcrt-2023-18212)

Figure 3: Timeline of US/Japan/Netherlands semi-related export control

Time	Sanction body	Published Documents/ Restrictions	Main content & Impact
2019	Netherlands	EUV export control	1) ASML's all EUV systems were prohibited to export to China
Dec.2020	US Department of Commerce	SMIC added to Entity list	1) limits SMIC's ability to acquire certain U.S. technology by requiring U.S. exporters to apply for a license to sell to the company. 2) Items uniquely required to produce semiconductors at advanced technology nodes—10 nanometers or below—will be subject to a presumption of denial
Oct. 2022	US Department of Commerce	US new chip export restrictions	1) Tighten existing restrictions on logic IC of 16nm/14nm or below (FinFET or GAAFET); 2) Extends restrictions to memory IC category (DRAM of 18nm or below, and NAND with 128-layer or more); 3) Foreign-owned production facilities located in China will need to apply for approval for related equipment on a case-by-case basis; Second rule: added China's memeory chipmaker Yangtze Memory and 30 other Chinese entities to "Unverified list"
Mar.2023	Netherlands	Most advanced DUV export control	1) Restricting the sale of deep ultraviolet systems lithography systems 2) ASML said in a statement that only their "most advanced" immersion lithography tools are affected by the export controls, ASML interprets this as 'critical immersion' which ASML defined as the TWINSCAN NXT:2000i (5-7nm) and subsequent immersion systems
May.2023	Japan	Japan's semiconductor export restriction	1) Japan announced the amendment to Foreign Exchange and Foreign Trade Act, and will add 23 types of advanced semiconductor equipment to the export control list. It will become effective on July 23 after two-month notification period; 2) The 23 categories include equipment for wafer cleaning, deposition, thermal treatment, etching, and testing. METI noted that equipment related to extreme ultraviolet (EUV) and 3D-stacked memory are included; 3) 3) The scope of Japan's restriction focuses on leading-edge process (14nm below), similar to US/Netherlands's restriction
Jun.2023	Netherlands	Additional export restriction	The specific restrictions on materials, equipment, software and technologies include: 1) EUV pellicles; 2) Production equipment for EUV pellets; 3) Lithography equipment with specific characteristics listed below; 4) Metal scrap atomic-layer deposition (ALD) equipment; 5) Equipment designed for epitaxial growth of silicon (Si), carbon-doped silicon, silicon germanium (SiGe), or carbon-doped SiGe; 6) Equipment designed for depositing a low-k dielectric enhanced by void-free plasma without voids in spaces less than 25 nm wide with a depth-to-height ratio (AR) equal to or greater than 1:1 between metal lines having a dielectric constant lower than 3.3; 7) Related software and technologies for the development, production and use of above equipment.

Source: US govt, US BIS, Japan govt, Netherlands govt, Bloomberg news, Reuters, ASML company filings

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