

a.3. Molecular beam epitaxial growth equipment using gas or solid sources;  
b. "Stored program controlled" equipment designed for ion implantation, having any of the following:

b.1. A beam energy (accelerating voltage) exceeding 1MeV;  
b.2. Being specially designed and optimized to operate at a beam energy (accelerating voltage of less than 2 keV;  
b.3. Direct write capability; or  
b.4. Being capable of high energy oxygen implant into a heated semiconductor material "substrate";

c. "Stored program controlled" anisotropic plasma dry etching equipment, as follows:

c.1. Equipment with cassette-to-cassette operation and load-locks, and having any of the following:

c.1.a. Designed or optimized to produce critical dimensions of 0.3µm or less with ±5% 3 sigma precision; or  
c.1.b. Designed for generating less than 0.04 particles/cm<sup>2</sup> with a measurable particle size greater than 0.1 µm in diameter;  
c.2. Equipment specially designed for equipment controlled by 3B001.e. and having any of the following:

c.2.a. Designed or optimized to produce critical dimensions of 0.3 µm or less with ±5% 3 sigma precision; or

c.2.b. Designed for generating less than 0.04 particles/cm<sup>2</sup> with a measurable particle size greater than 0.1 µm in diameter;

d. "Stored program controlled" plasma enhanced CVD equipment, as follows:

d.1. Equipment with cassette-to-cassette operation and load-locks, and having any of the following:

d.1.a. Designed or optimized to produce critical dimensions of 0.3µm or less with ±5% 3 sigma precision; or

d.1.b. Designed for generating less than 0.04 particles/cm<sup>2</sup> with a measurable particle size greater than 0.1 µm in diameter;

d.2. Equipment specially designed for equipment controlled by 3B001.e. and having any of the following:

d.2.a. Designed or optimized to produce critical dimensions of 0.3µm or less with ±5% 3 sigma precision; or

d.2.b. Designed for generating less than 0.04 particles/cm<sup>2</sup> with a measurable particle size greater than 0.1 µm in diameter;

e. "Stored program controlled" automatic loading multi-chamber central wafer handling systems, having all of the following:

e.1. Interfaces for wafer input and output, to which more than two pieces of semiconductor processing equipment are to be connected; and

e.2. Designed to form an integrated system in a vacuum environment for sequential multiple wafer processing;

**Note:** 3B001.e. does not control automatic robotic wafer handling systems not designed to operate in a vacuum environment.

f. "Stored program controlled" lithography equipment, as follows:

f.1. Align and expose step and repeat (direct step on wafer) or step and scan (scanner) equipment for wafer processing using photo-optical or X-ray methods, having any of the following:

f.1.a. A light source wavelength shorter than 350 nm; or

f.1.b. Capable of producing a pattern with a minimum resolvable feature size of 0.5 µm or less;

**Technical Note:** The minimum resolvable feature size is calculated by the following formula:

$$\text{MRF} = \frac{(\text{an exposure light source wavelength in } \mu\text{m}) \times (\text{K factor})}{\text{numerical aperture}}$$

where the K factor = 0.7.

MRF = minimum resolvable feature size.

f.2. Equipment specially designed for mask making or semiconductor device processing using deflected focused electron beam, ion beam or "laser" beam, having any of the following:

f.2.a. A spot size smaller than 0.2 µm;  
f.2.b. Being capable of producing a pattern with a feature size of less than 1 µm; or  
f.2.c. An overlay accuracy of better than ± 0.20 µm (3 sigma);

g. Masks and reticles designed for integrated circuits controlled by 3A001;

h. Multi-layer masks with a phase shift layer.

**3B991 Equipment not controlled by 3B001 for the manufacture of electronic components and materials, and specially designed components and accessories therefor.**

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**List of Items Controlled**

Unit: \* \* \*

Related Controls: \* \* \*

**Related Definitions:** 'Sputtering' is an overlay coating process wherein positively charged ions are accelerated by an electric field towards the surface of a target (coating material). The kinetic energy of the impacting ions is sufficient to cause target surface atoms to be released and deposited on the substrate. (**NOTE:** Triode, magnetron or radio frequency sputtering to increase adhesion of coating and rate of deposition are ordinary modifications of the process.)

**Items:** a. Equipment specially designed for the manufacture of electron tubes, optical

elements and specially designed components therefor controlled by 3A001 or 3A991;

b. Equipment specially designed for the manufacture of semiconductor devices, integrated circuits and "electronic assemblies", as follows, and systems incorporating or having the characteristics of such equipment:

**Note:** 3B991.b also controls equipment used or modified for use in the manufacture of other devices, such as imaging devices, electro-optical devices, acoustic-wave devices.

b.1. Equipment for the processing of materials for the manufacture of devices and components as specified in the heading of 3B991.b, as follows:

**Note:** 3B991 does not control quartz furnace tubes, furnace liners, paddles, boats (except specially designed caged boats), bubblers, cassettes or crucibles specially designed for the processing equipment controlled by 3B991.b.1.

b.1.a. Equipment for producing polycrystalline silicon and materials controlled by 3C001;

b.1.b. Equipment specially designed for purifying or processing III/V and II/VI semiconductor materials controlled by 3C001, 3C002, 3C003, or 3C004, except crystal pullers, for which see 3B991.b.1.c below;

b.1.c. Crystal pullers and furnaces, as follows:

**Note:** 3B991.b.1.c does not control diffusion and oxidation furnaces.

b.1.c.1. Annealing or recrystallizing equipment other than constant temperature furnaces employing high rates of energy

transfer capable of processing wafers at a rate exceeding 0.005 m<sup>2</sup> per minute;

b.1.c.2. "Stored program controlled" crystal pullers having any of the following characteristics:

b.1.c.2.a. Rechargeable without replacing the crucible container;

b.1.c.2.b. Capable of operation at pressures above 2.5x10<sup>5</sup> Pa; or

b.1.c.2.c. Capable of pulling crystals of a diameter exceeding 100 mm;

b.1.d. "Stored program controlled" equipment for epitaxial growth having any of the following characteristics:

b.1.d.1. Capable of producing a layer thickness uniformity across the wafer of equal to or better than +3.5%; or

b.1.d.2. Rotation of individual wafers during processing;

b.1.e. Molecular beam epitaxial growth equipment;

b.1.f. Magnetically enhanced 'sputtering' equipment with specially designed integral load locks capable of transferring wafers in an isolated vacuum environment;

b.1.g. Equipment specially designed for ion implantation, ion-enhanced or photo-enhanced diffusion, having any of the following characteristics:

b.1.g.1. Patterning capability;

b.1.g.2. Beam energy (accelerating voltage) exceeding 200 keV;

b.1.g.3. Optimized to operate at a beam energy (accelerating voltage) of less than 10 keV; or

b.1.g.4. Capable of high energy oxygen implant into a heated "substrate";

b.1.h. "Stored program controlled" equipment for the selective removal (etching) by means of anisotropic dry methods (e.g., plasma), as follows: