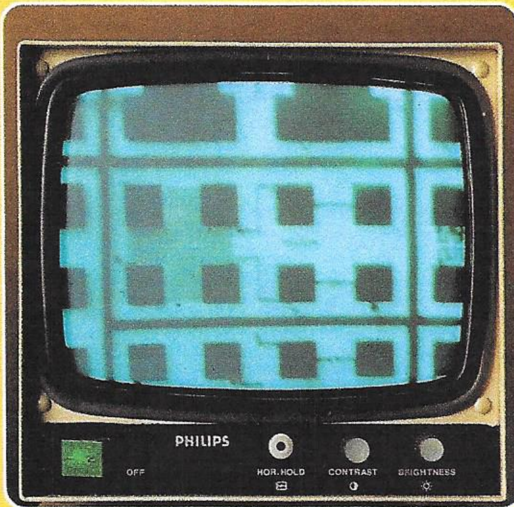
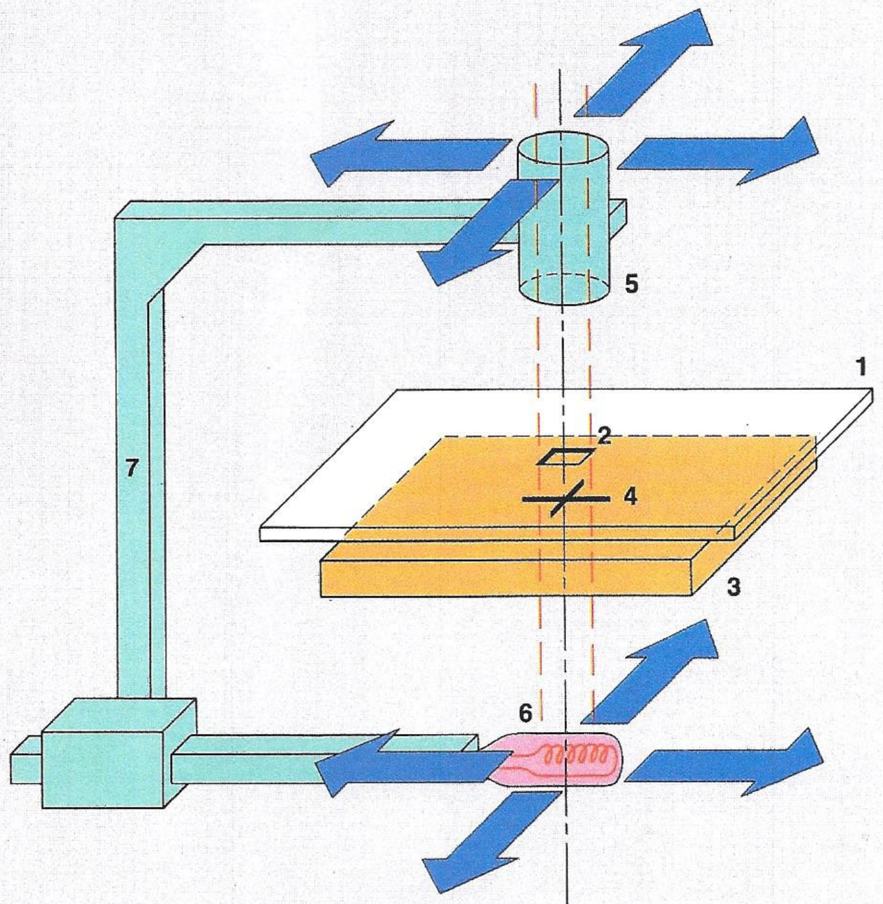


Above: The video image shows the structure on the mask and wafer. Displayed is the alignment condition. (Courtesy of TRW, Inc.)



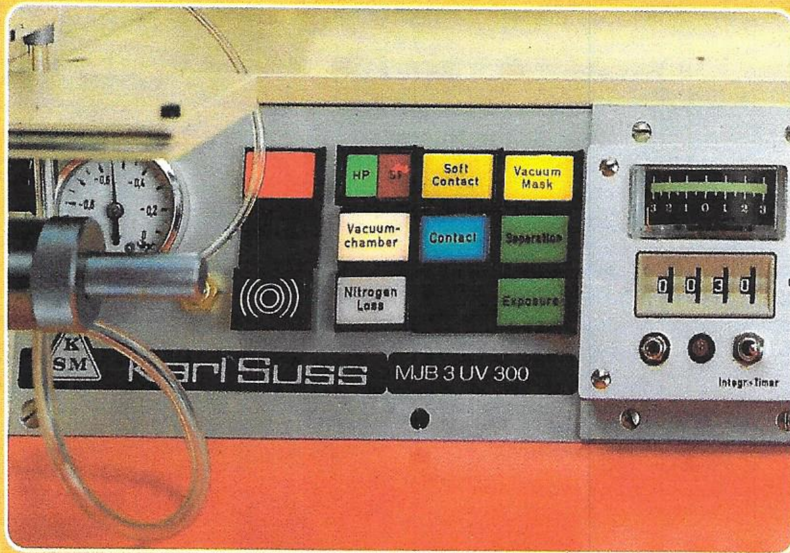
Principle of Infrared Alignment

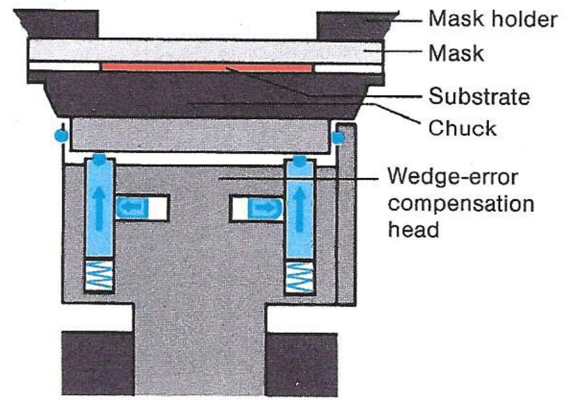
1 Mask
2 Structure on the mask
3 Wafer
4 Structure on the wafer
5 Microscope
6 Infrared light source
7 Connection between 5 and 6, the manipulator moves both simultaneously

a) The infrared transmissivity of the substrate.
b) The contrast of the existing features, to which it is desired to align (metal provides the best contrast).
c) The roughness of the substrate surfaces (polished surfaces provide the best images).
d) Above all the thickness of the substrate. (The greater the depth of focus of an objective, the lower the resolution and magnification and therefore the alignment accuracy).

In order to image simultaneously both the mask and the features on the other side of the substrate, it is necessary to use an objective whose depth of focus is greater than the thickness of the substrate plus the alignment gap. Very thin substrates may be mounted on a carrier which is transparent in the same range as the substrate.

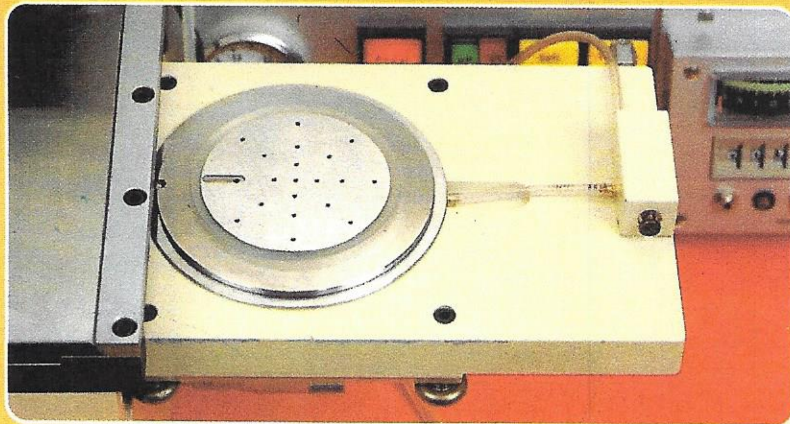
In most applications an alignment accuracy of ±5 μm is achievable. Under very favorable circumstances ±2 μm is possible.





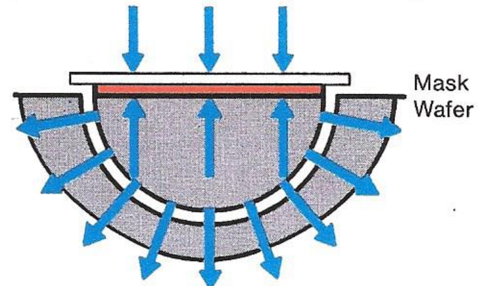
SUSS Chuck System in the Alignment Stage
Soft contact for the wedge-error compensation.

Horizontal pneumatic clamping: no shifting.



Vacuum chuck

Conventional Calotte Chuck System
Hard contact for the wedge-error compensation.



Forces in all directions for the chuck clamping: shifting problems.

Additional Technical Details

XYΘZ Alignment Stage

Alignment of wafer to mask using high precision, backlash-free double micrometers with coarse and fine alignment spindles for X, Y and Θ. Defined movement directions are guaranteed (no Y-movement during X-positioning). Separate controls for thickness compensation, wedge error compensation (parallelity) and separation/contact. Separation distance easily and continuously adjustable externally. Shift-free separation/contact movement (<0.1 µm). Mechanically clamped mask holder, with vacuum clamping for the mask. Easily interchangeable mask holders and chucks for different mask and wafer sizes. Fast, safe substrate loading and unloading with optional prealignment, without removing mask holder or mask. For vacuum contact (except SUSS MJB 3 Standard), hard contact (adjustable nitrogen pressure under the substrate) or soft contact. Quartz, glass or film masks usable.

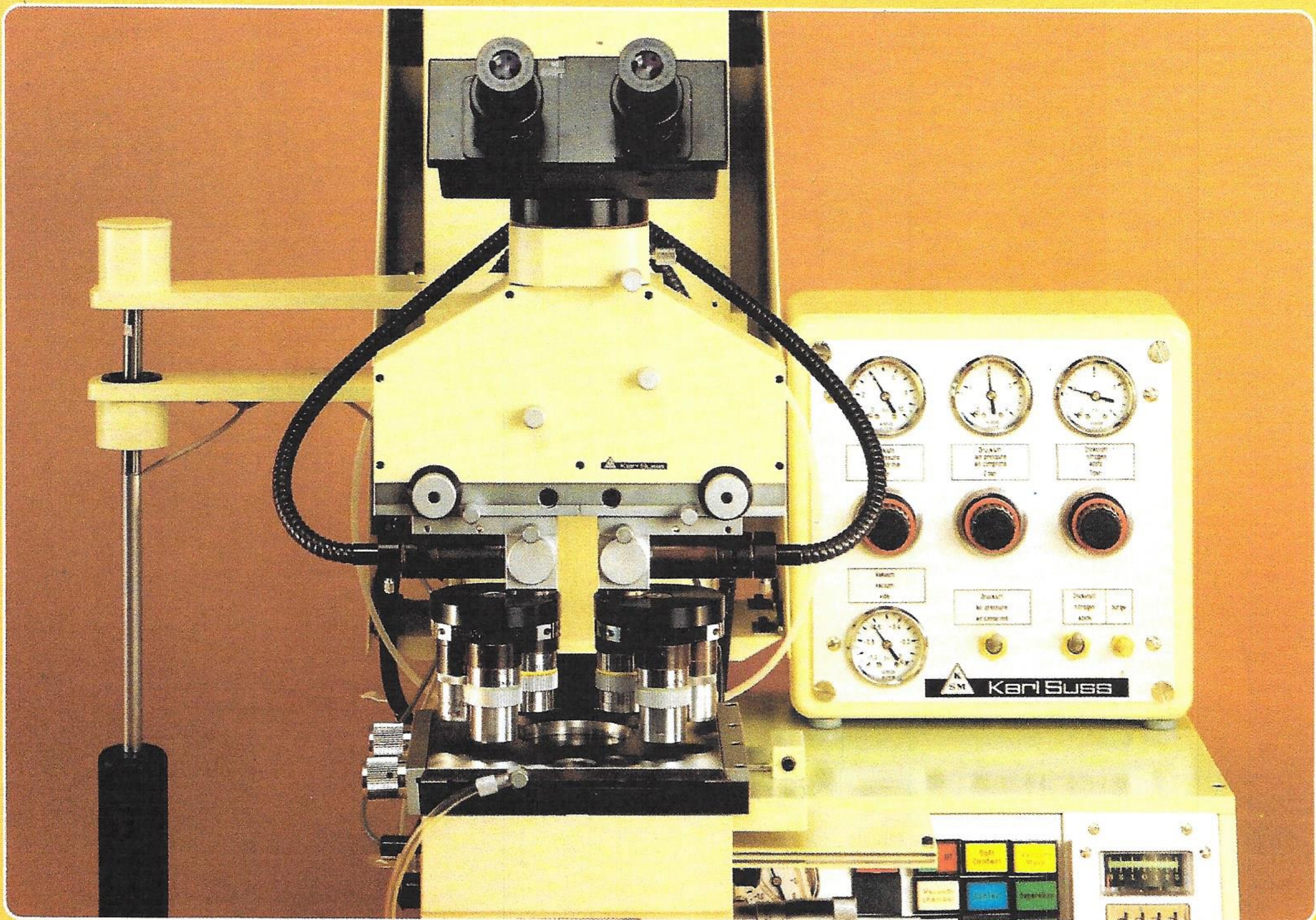
Exposure Systems

SUSS MJB 3 Standard

Lamphouse with 200 W super pressure Hg lamp. Spherical evaporated aluminum mirror. Electromagnetic shutter. AC or DC constant power supply or constant intensity supply (standard in USA). Digital timer, light integrator optional. Parallel light path, double lens system.

SUSS MJB 3
UV 400/UV 300/UV 250

Lamphouse with 350 W super pressure Hg lamp (UV 400, UV 300), 350 W Cd-Xe lamp (UV 250). Constant intensity power supply. Simple alignment of lamp and optics, and interchange of exposure system. Ellipsoidal mirror for optimum light intensity. Cold light mirror. Exposure repeatability ±1%. Pneumatic shutter. Digital timer, light integrator optional. Diffraction reducing exposure system, optimized for the individual exposure range.



SUSS M 234 SP Splitfield Microscope

Microscope Manipulator

For fast microscope scanning of mask and wafer. Precise, pneumatic brakes, vibration-, shift- and backlash-free positioning in each desired direction (movement in X and Y simultaneously or in X or Y only). Convenient combined control for coarse and fine focus. Automatic microscope lift to protect high magnification, short working distance objectives during exposure (with the SUSS M 400 normalfield microscope).

Alignment Microscopes

SUSS M 204 SP Splitfield Microscope

Clear bright image with long working distance and large depth of focus. Combined controls for adjustment of the objective separation distance and individual fine focus. Switchable splitfield/single field. Fiber optic halogen illumination. Brightfield standard, darkfield and interference contrast optional.

SUSS M 234 SP Splitfield Revolver Microscope

SUSS M 204 SP equipment with two objective revolvers. Three pairs of Leitz special, very long working distance objectives with high numerical aperture for optimum resolution. Locks to prevent undesired displacement of the objective field. 80 W fiber optic halogen illumination. Brightfield standard, interference contrast optional.

SUSS M 400 Normalfield Microscope

Direct illuminator with objective revolver. Leitz special high resolution objectives with large depth of focus. Interchangeable objectives and eyepieces. Brightfield standard, darkfield and interference contrast optional. Magnifications up to 510x (possible due to the high precision separation/contact mechanics).

Trinocular Head for Video Camera

A trinocular head allowing adaption of a video camera may be delivered with the three microscopes above.

Magnification · Field of View · Working Distance · Depth of Focus

SUSS M 204, SUSS M 234 Splitfield Microscopes

(Tube factor = 1.2x) Overall magn. = magn. obj. x magn. eyepiece x 1.2

Objective * BF (Aperture) ** BF / IC	PL 3.2x* 0.06	NPL 5x*/** 0.09	NPL 10x*/** 0.20 (0.22**)	LL 20x IC** 0.40	Plan L 25x* 0.40	
Eyepieces	6.3x 10x 12.5x	6.3x 10x 12.5x	6.3x 10x 12.5x	6.3x 10x 12.5x	6.3x 10x 12.5x	
Overall magnification	25 38 48	38 60 72	76 120 150	150 240 300	190 300 375	
Field of view (mm)	4.6	3.0	1.5	0.75	0.6	
Working distance (mm)	12	12	17 (12 IC)	10	11	
Depth of focus ... µm	100 80 80	80 60 60	25 20 20	8 4 4	5 3 3	
at a resolution of ... µm	5 3.5 3.5	4 2.5 2.5	1.6 1.25 1.25	1.2 1.0 1.0	1.2 0.8 0.8	

SUSS M 400 Normal Field Microscope

(Tube factor = 1x) Overall magn. = magn. obj. x magn. eyepiece

Objective * BF (Aperture) ** BF / IC *** BF / DF	PL 3.2x* 0.06	NPL 5x*/** 0.09	NPL 10x*/** 0.20 (0.22**)	LL 20x IC** 0.40	Plan L 25x* 0.40	H 32x* 0.60
Eyepieces	6.3x 10x 16x	6.3x 10x 16x	6.3x 10x 16x	6.3x 10x 16x	6.3x 10x 16x	6.3x 10x 16x
Overall magnification	20 32 51	31 50 80	63 100 160	126 200 320	160 250 400	200 320 512
Field of view (mm)	5.6 5.6 5.0	3.6 3.6 3.2	1.8 1.8 1.6	0.9 0.9 0.8	1.1 0.7 0.65	0.6 0.6 0.5
Working distance (mm)	12	12	17 (12 IC)	10	11	5.8
Depth of focus ... µm	120 80 80	100 70 70	25 20 20	10 5 5	5 3 3	3.5 2 2
at a resolution of ... µm	5 3.5 3.5	4 2.5 2.5	1.6 1 1	1.4 0.8 0.8	1.2 0.8 0.8	0.8 0.5 0.5

Manual Alignment

For manual alignment the full depth of focus of the objective is normally used. Damage to the mask or wafer during alignment is thereby largely avoided.

The depth of focus of an objective is directly related to its magnification. At a typical alignment distance of approximately 20 µm, which is a reasonably safe distance between mask and wafer for most applications, the microscope magnification may be approximately 180x. This may not be sufficient to obtain the desired alignment accuracy, however. If one increases the magnification to, for example 400x, the depth of focus is drastically reduced to approximately 3 µm. In practice it is no longer possible to align at such a small gap.

The line and space resolution of an alignment microscope with practical magnification is about 1.5 µm. Fortunately, it is not necessary to recognize submicron features in order to achieve submicron alignment accuracy. Instead, another approach is used.

The human eye possesses a remarkable ability to recognize symmetry. The task to produce suitable alignment keys therefore consists of finding high contrast figures where symmetry can be recognized. A simple example is placing a small cross within a large cross. The line width of the large cross is not significant, if both sides of the cross can be observed. On the other hand, the distance between the edges of the small and the large crosses when aligned is critical. This distance must be greater than the line and space resolution of the microscope and simultaneously as small as possible.

The minimum distance is approximately 2 µm, typical values lie between 3 and 5 µm, depending on contrast and edge quality. If the distance between the small and large keys is 3 µm, a 0.5 µm misalignment will result in a 3.5 to 2.5 intensity ratio recognized by the eye. A 40 % greater distance is a significant amount.

In contact exposure processes an objective/eyepiece combination with a smaller depth of focus can be used to check the alignment condition in the exposure position (before the exposure itself). A revolver microscope with at least two different objectives is ideal for such purposes.

In this case a second alignment key of smaller dimensions with approximately a 1 µm distance between the larger and smaller lines may also be employed, to ease inspection of the alignment in the exposure position. For highest demands on the alignment accuracy, it is desirable for the operator to alternate between separation and contact positions, even when the aligner exhibits no shift.

SUSS MJB 3

Technical Data

Wafer size up to	3" Ø
Substrate size up to	3" x 3" (except MJB 3 Standard: 2" x 2")
Wafer/substrate thickness	0 – 4.5 mm
Mask size up to	4" x 4"
Exposure modes	vacuum contact (except MJB 3 Standard) hard contact soft contact
Exposure optics	Standard 280 – 450 nm, 200 W mercury lamp UV 400 350 – 450 nm, 350 W mercury lamp UV 300 280 – 350 nm, 350 W mercury lamp UV 250 240 – 260 nm, 350 W Cd-Xe lamp, PMMA resist UV 248 248 nm, KrF excimer laser UV 193 193 nm, ArF excimer laser
Uniformity	±3% (2" Ø) (MJB 3 Standard ±5%) ±5% (3" Ø) (MJB 3 Standard ±10%)
Maximum exposure area	3" x 3" (MJB 3 Standard 3" Ø)
X-Y-Θ Stage	
Alignment range in X and Y	±3 mm
Micrometer thread pitch, fine	0.05 mm
coarse	1.0 mm
Alignment range in Θ	±3°
Micrometer thread pitch	0.25 mm (MJB 3 standard 0.5 mm)
Alignment Separation	0 – 50 µm or 0 – 150 µm, continuously adjustable
X-Y shift Z-movement	<0.1 µm (MJB 3 Standard <0.2 µm)

Microscopes	
Microscope manipulator range of movement	50 x 50 mm
SUSS M 204 SP Splitfield Microscope	
Objective distance, adjustable	25 – 95 mm
Illumination	fiberoptic, 20 W or 85 W
SUSS M 234 SP Splitfield Microscope	
Objective distance, adjustable	30 – 95 mm
Illumination	fiberoptic, 85 W
SUSS M 400 Normal Field Microscope	
Illumination	direct 15 W
Infrared Alignment System	
Tube type/response	silicon vidicon 400 – 1100 nm or lead sulfide 400 – 2000 nm
Utilities	
Vacuum	<150 mbar
Compressed air	5 bar (75 psi)
Nitrogen	2 bar (30 psi)
Voltage (main power)	220 V/50 Hz AC or 110 V 60 Hz AC
Dimensions (mm)	
Depth x Width x Height (w/o camera)	
MJB 3 Standard	700 x 600 x 550
MJB 3 UV 400/300	800 x 600 x 550
MJB 3 UV 250/200	820 x 650 x 550
MJB 3 Excimer Laser	2150 x 100 x 550
Weight (kg) (w/o power supply)	
All models (except SUSS MJB 3 Excimer Laser)	65 – 70
SUSS MJB 3 Excimer Laser	240

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