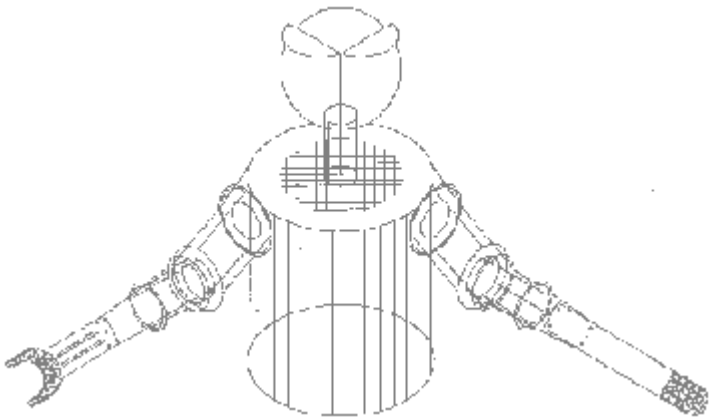
END-
EFFECTORS,
INC.

Giving Robotics A Hand©

Post Office Box 242
Santa Clara, CA 95052-0242
Tel: 408/727-0100 Fax: 408/727-2100
www.fjaind.com

Ceramic
Vacuum Clamping
End-Effectors

Vacuum Clamping Factors
Ceramic End-Effector Product Line
SC Series
CC Series



"Giving Robotics A Hand"

Rev: 10-21-02

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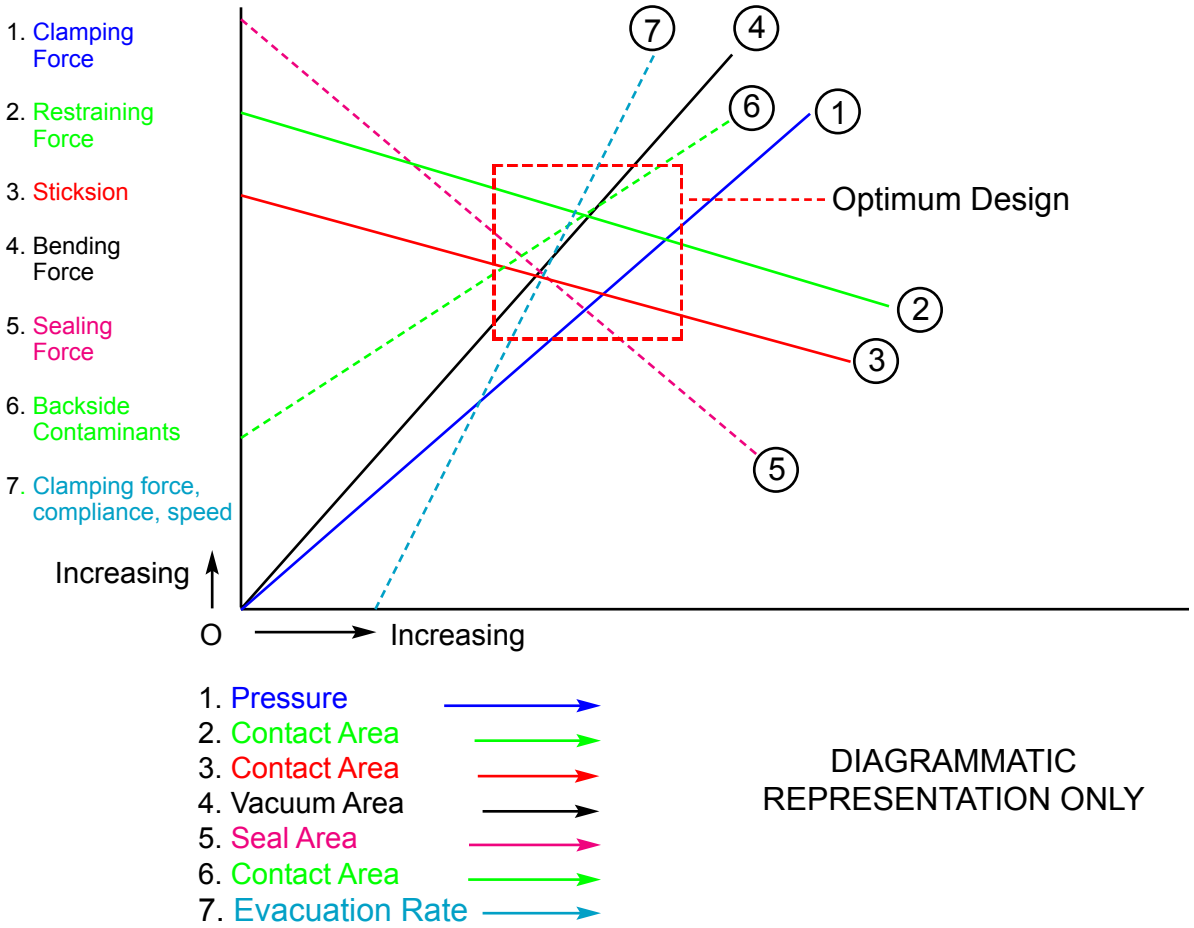
Vacuum Clamping Factors

The use of vacuum as a clamping force has been implemented for many years — 1650, Otto von Guericke. While we speak of vacuum clamping we are really using the pressure of the atmosphere as the driving force and eliminating the atmosphere in the areas we want to clamp. This understood, it should be clear that we can only achieve a force which is equal to the pressure of the atmosphere as a maximum force. This is true only if all factors of the design are absolute and our pumps can produce an absolute vacuum. It is not practical to assume that we can achieve an absolute seal or vacuum, nor can we control the pressure of the atmosphere which varies from minute to minute and is tied directly to geographical location (altitude above seal level). Therefore, we present those factors which are responsible for the creation of a clamping force and their relationship to one another in graft form and discuss their significance.



1. As the pressure exerted on the substrate (and between the substrate and clamping mechanism) is increased the clamping (holding) force also increases. The pressure is supplied by the atmosphere and only that portion of atmospheric pressure is available which can be evacuated and maintained by a vacuum system.

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2. As the pressure exerted on the substrate (and between the substrate and clamping mechanism) is increased the clamping (holding) force also increases. The pressure is supplied by the atmosphere and only that portion of atmospheric pressure is available which can be evacuated and maintained by a vacuum system.
3. As the area in contact goes up, the force per unit area goes down for a constant clamping force. In many cases a designer will increase the contact area in order to provide a better seal. In so doing the load is distributed over a larger area and a poor seal is produced, the concept of a larger sealing area applies to compliant surfaces not rigid seals.

4. Sticksion is the resistance to sliding which is a function of surface finish on both parts and the force applied pressing the surfaces together. As the area in contact increases, the clamping force per unit area decreases and the sticksion value also decreases.

5. When the area of vacuum is increased there is an increase in clamping force for any given vacuum level and any given atmospheric pressure. However, it must be noted that the clamping force can be large enough to damage the substrate being held. When holding standard semiconductor wafers a support should be placed at .200 inch increments to avoid deflection and creaking of wafers. This rule applies to standard wafers which range in thickness from .013 inches to .031 inches.

6. In order to provide adequate evacuated area to hold the part in question the seal area must be increased . When this is done the quality of the seal is increased in importance because the leakage rate is increased in direct proportion to the seal length for any given seal quality. Therefore, the nature of the seal is paramount as the mass (weight) of the object being clamped increases. It is possible to form optically polished surfaces to reduce seal leakage for non-conforming seals. The result of an optically polished surface on both parts is retention of the part without vacuum. This necessitates the use of pressure to separate the parts. A surface finish of between 10 and 12 micro-inch is the finish which should be used to avoid unwanted clamping and minimize leakage.

7. Backside contaminants are the result of contact with contaminated end-effectors or the dislodgement of particles from either the wafer or end-effector. If an end-effector is properly designed and properly implemented (positioning and vacuum level) the production of particles is minimized or eliminated. The transfer of particles requires the clean-up of the environment in which the end-effector and wafer exist. It should be obvious that the reduced contact area will reduce transferred particles. However, an optimum contact area will eliminate slippage of the part and that will reduce to a minimum particle generation. The material of choice is a very important issue in particle generation and contaminant control but it is not in and of itself a solution.

8. Evacuation rate is “the” most important factor affecting the performance of a vacuum type end-effector. Due to the design requirements of the industry and the real world manufacturing practices, there will be a small amount of leakage present when using end-effectors in the semiconductor industry. The greater the evacuation rate the less significant is the leakage rate. The greater the evacuation rate the greater the wafer non-flatness can be and the faster the system can function.

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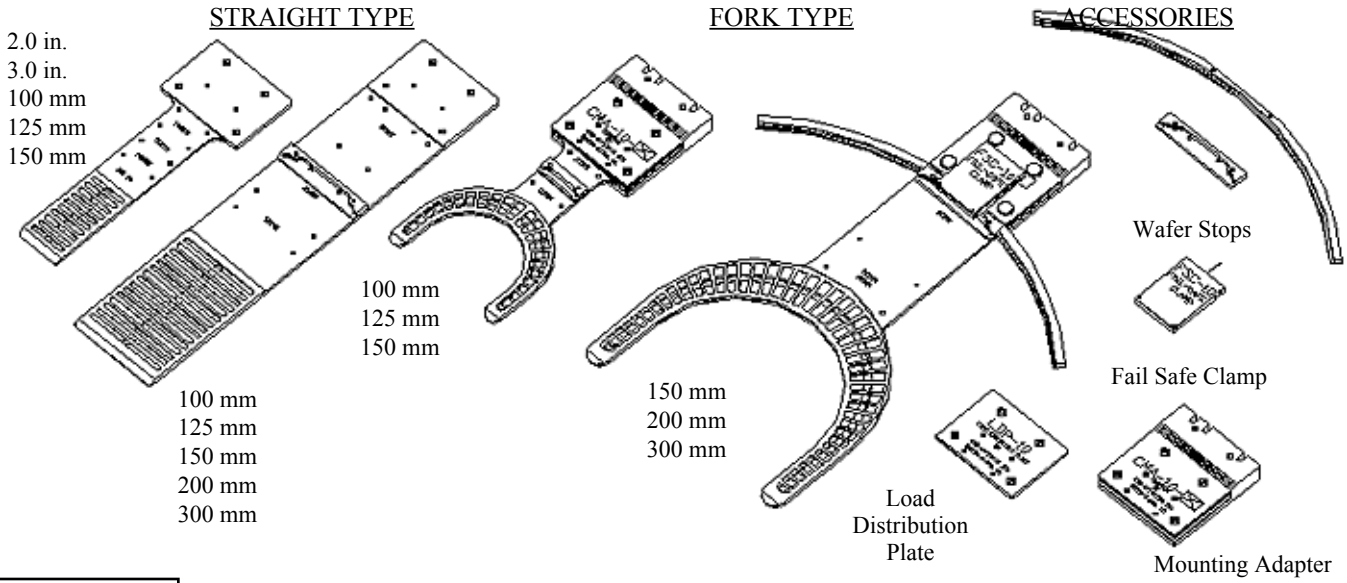
Ceramic End-Effector Product Line

Ceramic end-effectors are essentially the hands of robots. Our product line has been created to provide unique solutions for high-tech industries, those customers whose needs require special "hand-holds".

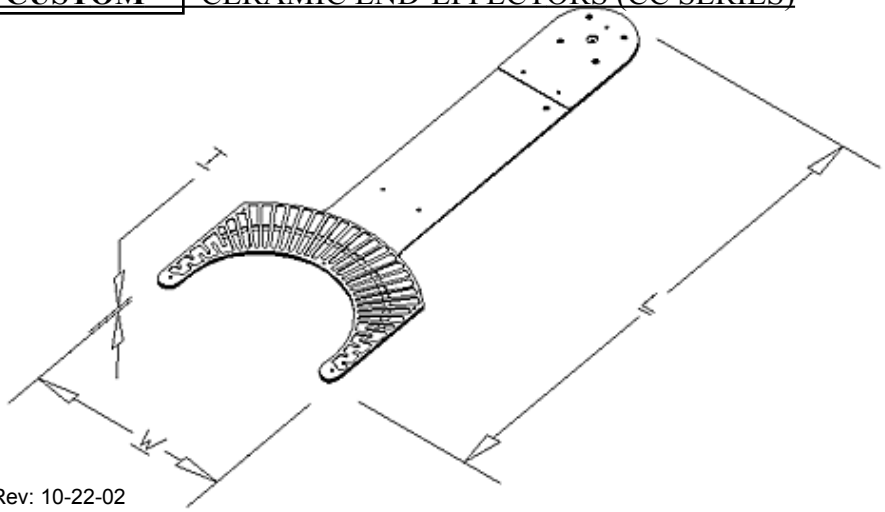
Our vacuum clamping, ceramic end-effector product line consists of two major types: 1) The standard products which are designed as a generic tool to provide the lowest cost and highest quality part from off the shelf stock, and: 2) the custom designed products which address special customer issues not answered by our standard product line.

All our products are fabricated from the highest quality Al_2O_3 ceramic and utilize our proprietary high temperature assembly process.

STANDARD CERAMIC END-EFFECTORS (SC SERIES)



CUSTOM CERAMIC END-EFFECTORS (CC SERIES)



MAXIMUM SIZE STOCKED
L = 16.0 inches (400 MM)
W = 5.0 inches (125 MM)
T = .160 inches (4 MM)

Special sizes beyond the standards are possible and depend upon final design details as well as material availability

Custom made fail-safe options are also available. Contact us for

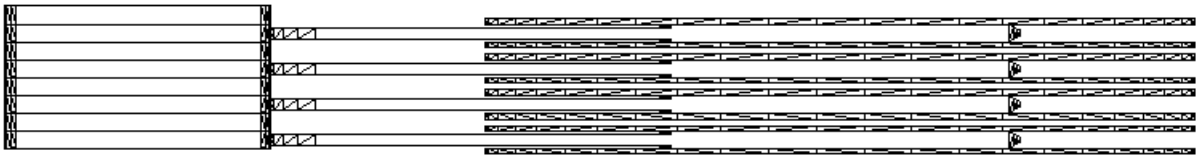
VACUUM CLAMPING CONFIGURATIONS

SINGLE

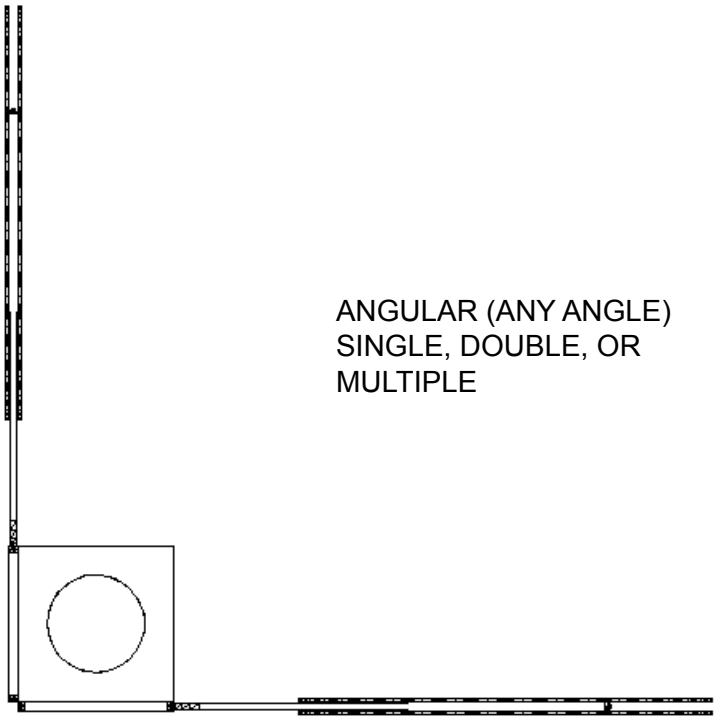
DOUBLE
1 WAFER

DOUBLE
2 WAFERS

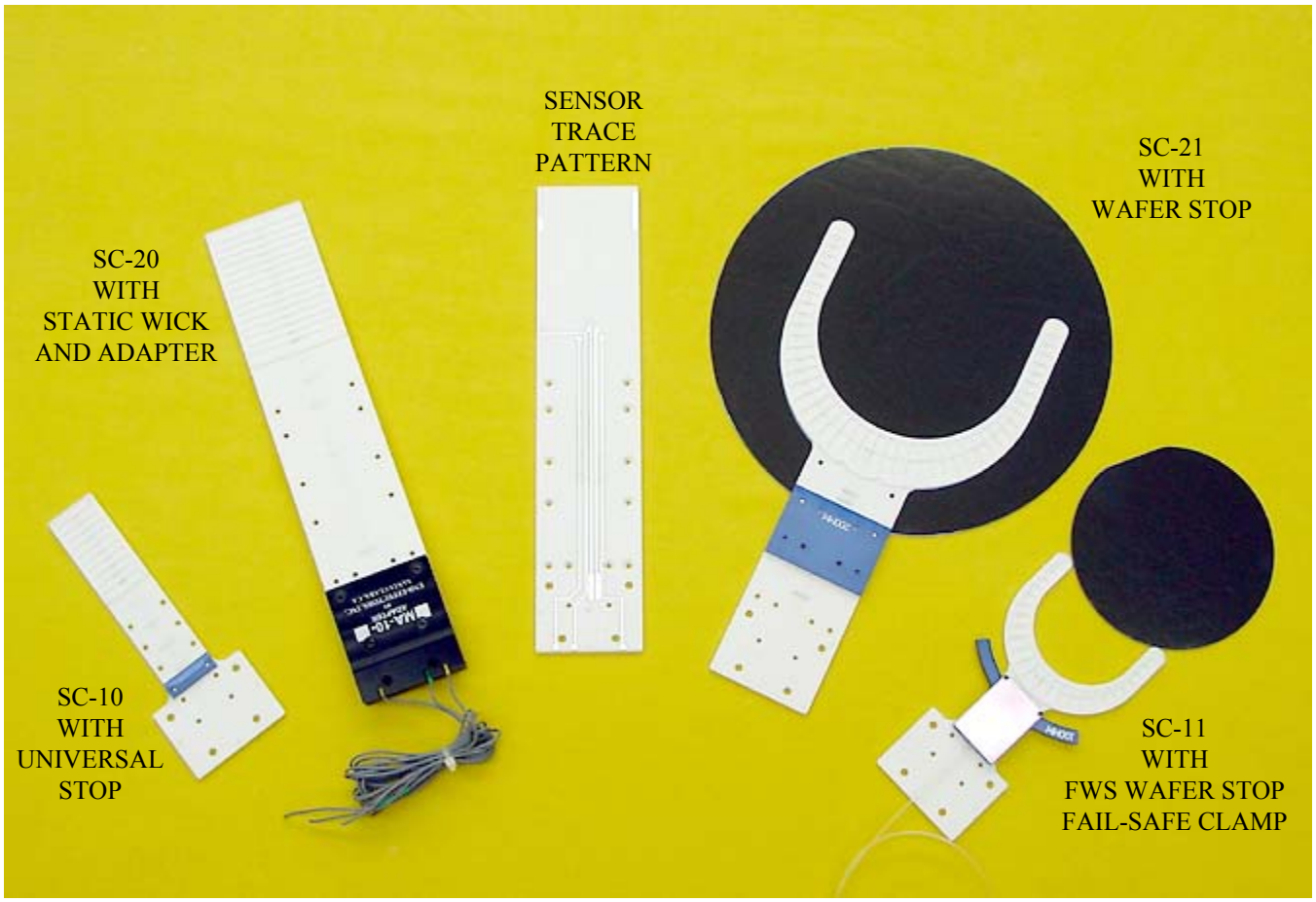
MULTIPLE
SINGLE



MULTIPLE
DOUBLE



ANGULAR (ANY ANGLE)
SINGLE, DOUBLE, OR
MULTIPLE



END-EFFECTORS

SC SERIES

STANDARD CERAMIC DESIGNS

FEATURES

- Reduction of back-side scratches to near zero levels
- Elimination of defusible contamination (no metal contaminants)
- Highest rigidity material for similar cross-sections
- Virtual elimination of thermal shock to the substrate handled (unheated)
- Elimination of thermal shock (heated)
- Ability to operate continuously at elevated temperatures without warpage
- No tape or epoxy and no out-gassing
- Infinite life without vacuum leakage
- Elimination of ESD damage
- Proprietary fabrication process

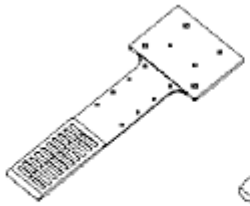
EEI has designed a line of *standard* ceramic end-effectors which provides the user with all the advantages of a custom design without the design cost or inventory requirements. With nearly a decade of fabricating custom ceramic end-effectors, a recurrent pattern of design features has evolved which dictated the design parameters for our standard ceramic end-effectors. The attributes of ceramic end-effectors have been well established and the superior performance of our 3 "G" design rules is unmatched in the world. Utilization of standard mounting hardware and standard design configurations delivered from stock, reduces cost and optimizes performance. Now any robot can be easily adapted to utilize standard ceramic end-effectors of any size, and custom ceramic end-effectors using the same mounting adapter.

EEI END-EFFECTORS, INC.
1230 Coleman Avenue, Santa Clara, California 95050-4338
408/727-0100 FAX 408/727-2100 www.fjaind.com

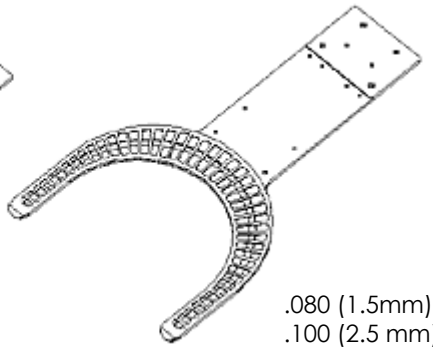
"Giving Robotics A Hand"

STANDARD CERAMIC END-EFFECTOR DETAILS

STANDARD TYPES: ALL DESIGNS ARE "3G" Minimum Vacuum Clamping Force

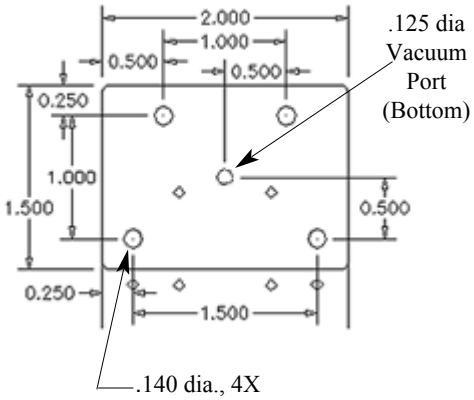


Straight Type
SC-10 Series



Fork Type
SC-20 Series

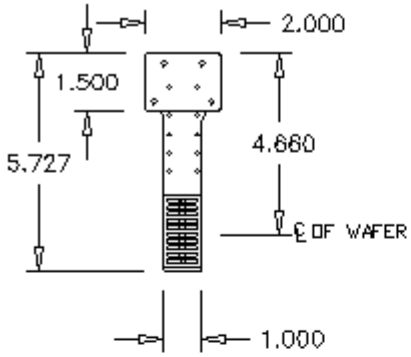
Two thickness'
for series

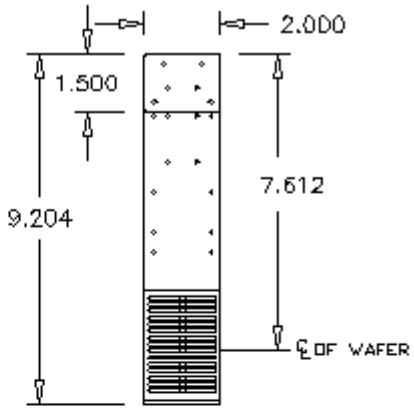


Universal Mounting
Hole Layout

STANDARD SIZES: Two sizes (-10 for 1 inch wide body and -20 for 2 inch wide body) and two styles for each size cover the entire range from 3 inch to 300 mm diameter or square.

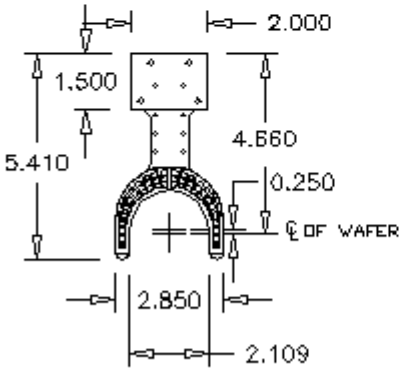
SC-10
for 3 inch, 100, 125 & 150 mm wafers (.080 thick)

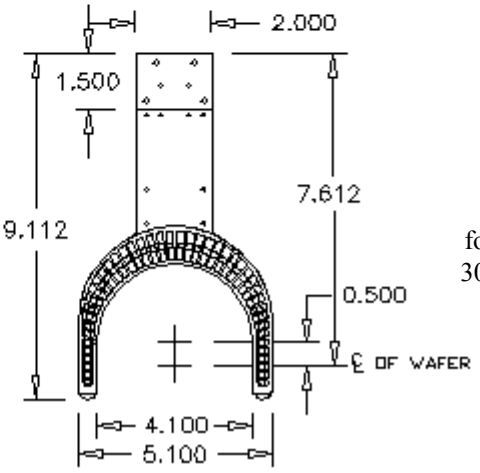




SC-20
for 100, 125, 150, 200 & 300 mm wafers (.100 thick)

SC-11
for 100, 125 & 150 mm wafers (.080 thick)





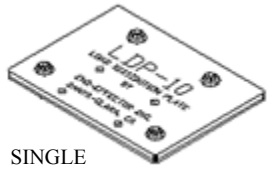
SC-21
for 150, 200 & 300 mm wafers (.100 thick)

OPTIONAL ACCESSORIES

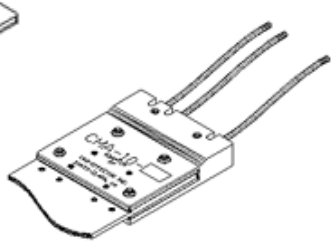
Standard off-the-shelf and customer installed:

LOAD DISTRIBUTION PLATE — LDP-10 (Compatible with FSC-10): The load distribution plate is provided for those customers who wish to design a custom mounting device. The LDP-10 is used to provide a distributed clamping load and prevent damage to the end-effector. See separate data sheet for details.

CERAMIC (END-EFFECTOR) MOUNTING ADAPTER — CMA-10 SERIES: While the standard ceramic end-effectors of the SC series can be used as supplied, we have provided a mounting adapter for easy utilization. The CMA-10 series provides for utility hook-up by simply inserting the end-effector (any of the standard series) into the Mounting Adapter and fastening. Use of the standard mounting adapter prevents damage to the ceramic end-effector from improper mounting. The mounting adapter can be fastened to any robot. See separate data sheet for product details.



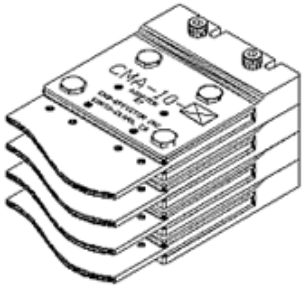
SINGLE END-EFFECTOR CLAMP FOR CUSTOMER DESIGNED MOUNTING BRACKET



SINGLE END-EFFECTOR

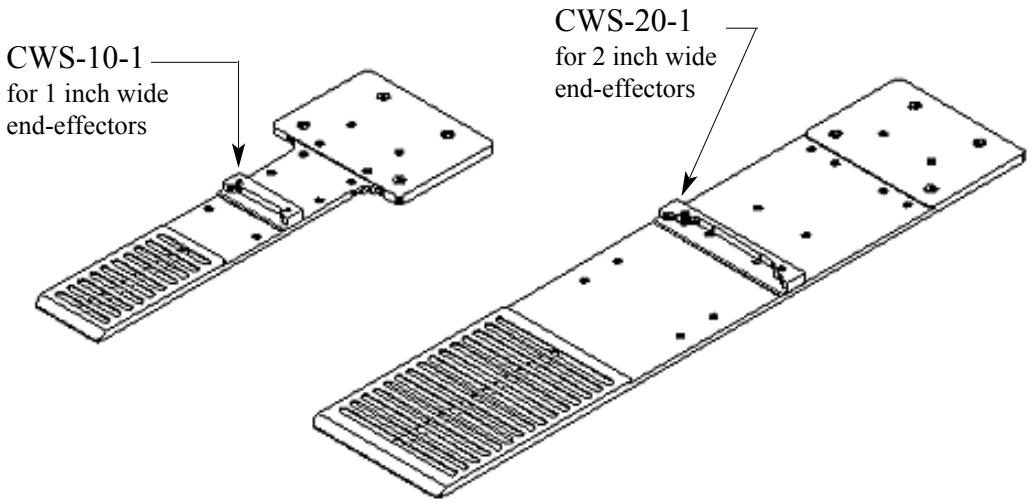
MOUNTING ADAPTERS PROVIDE AUTO HOOK-UP FOR:

1. Vacuum Line
2. Static Electric Wick
3. Electrical Sense
4. Electrical Heater



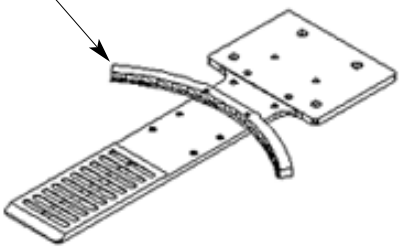
STACKABLE END-EFFECTORS

CIRCULAR WAFER STOPS (continuous periphery) CWS-10 and -20 SERIES: When the specific application is one in which the wafer flat can be positioned away from the stop or there is no discontinuity on the substrate (continuous round periphery), then a standard wafer stop can be used. The standard stop comes in two sizes. One size for the one inch wide body and another for the two inch wide end-effector body. In each case we have designed the stop to permit its use for all wafer sizes handled by the end-effector selected. Simply move the stop to the appropriately marked location and the wafer will be positioned over the center of the vacuum clamping area. Diameter compensation has been designed into the parts.



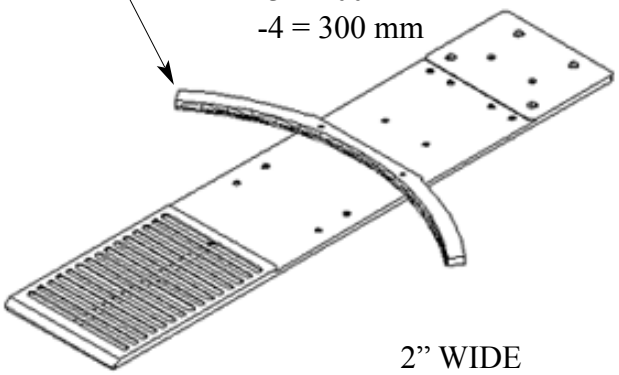
FLATTED WAFER STOPS (discontinuous periphery) — FWS-10 and -20 SERIES: When wafer flats or substrate features are random, the user can mount a large contact area wafer stop. This design permits the accurate positioning of the substrate when peripheral conditions vary randomly. In addition to positioning accuracy this wafer stop design also enhances substrate stability. There is a wafer stop designed for each specific location, since wafer diameter varies and the stop contour must match the substrate diameter or shape. There are several standard sizes and custom shapes can be fabricated.

FWS-10-1 = 3 inch
-2 = 100 mm
-3 = 125 mm
-4 = 150 mm



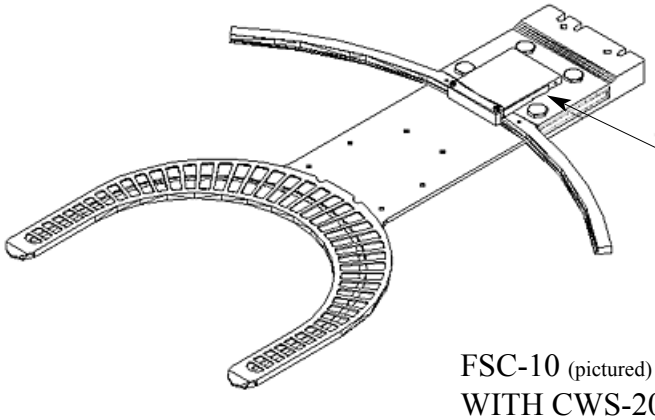
1" WIDE
END-EFFECTORS

FWS-20-1 = 125 mm
-2 = 150 mm
-3 = 200 mm
-4 = 300 mm



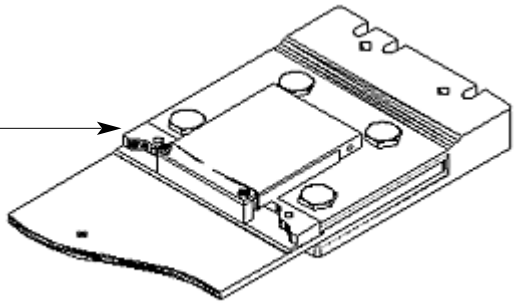
2" WIDE
END-EFFECTORS

FAIL-SAFE CLAMP — FSC-10 SERIES: To protect valuable wafers from damage due to system failures, EEI has provided a fail-safe system option. The FSC-10 can be fitted to any of the four standard ceramic end-effectors and can be used for all wafer sizes. The FSC-10 Fail-Safe Clamp will retain a wafer on the end-effector when a system failure occurs (no vacuum). A wafer stop and spacer of the proper size (1 inch or 2 inches wide) are required for employment of the Fail-safe Clamp.



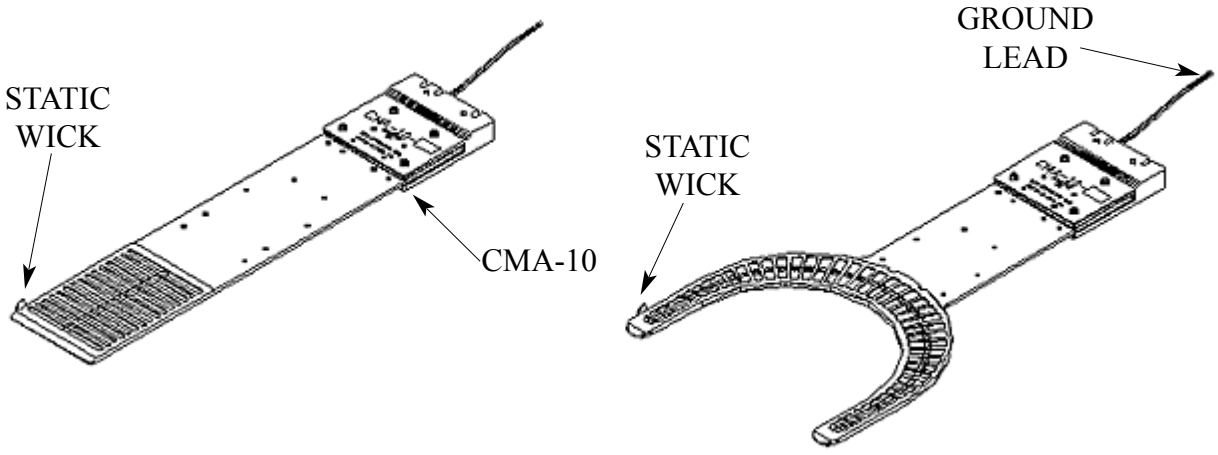
FSC-10 (pictured)
WITH FWS-10-4
WAFER STOP

FSC-10 (pictured)
WITH CWS-20-1
WAFER STOP

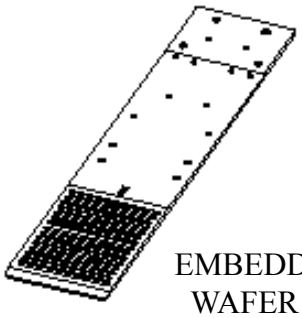


CUSTOMIZED OPTIONS
Factory Installed:

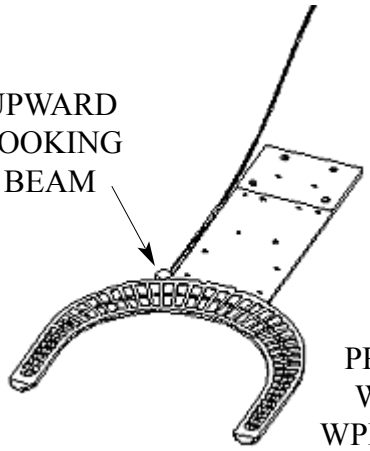
ELECTRO-STATIC DISSIPATION SYSTEM — ESD-10 SERIES: In situations where the substrate being handled can be damaged by ESD, the SC series of end-effectors can be fitted with ESD dissipation wicks. The stainless steel wicks direct the electro-static discharge through a dropping resistor to ground. Each end-effector in the SC series can be so fitted. The CMA-10 adapter with dropping resistor is recommended. (See separate flysheet).



WAFER PRESENCE INDICATORS — WPI-10 SERIES: In order to determine the presence of the substrate <u>on</u> the end-effector, EEI has provided several options. The option most often used and *not* provided by EEI is the reading of a vacuum actuated switch. When vacuum is high in the vacuum line the switch will close, since vacuum will be high when a wafer is clamped to the end-effector it infers that a wafer is present. However it is possible for a clogged vacuum line to give the same but false indication. Therefore EEI provides end-effector mounted indicators for positively sensing the substrates presence. The sensors are of two types - optical and electrical. The optical sense requires a coaxial fiber optic bundle and the electrical sense switch requires substrate contact to trip the switch. All end-effectors in this series can be fitted with these <u>substrate presence</u> indicators.

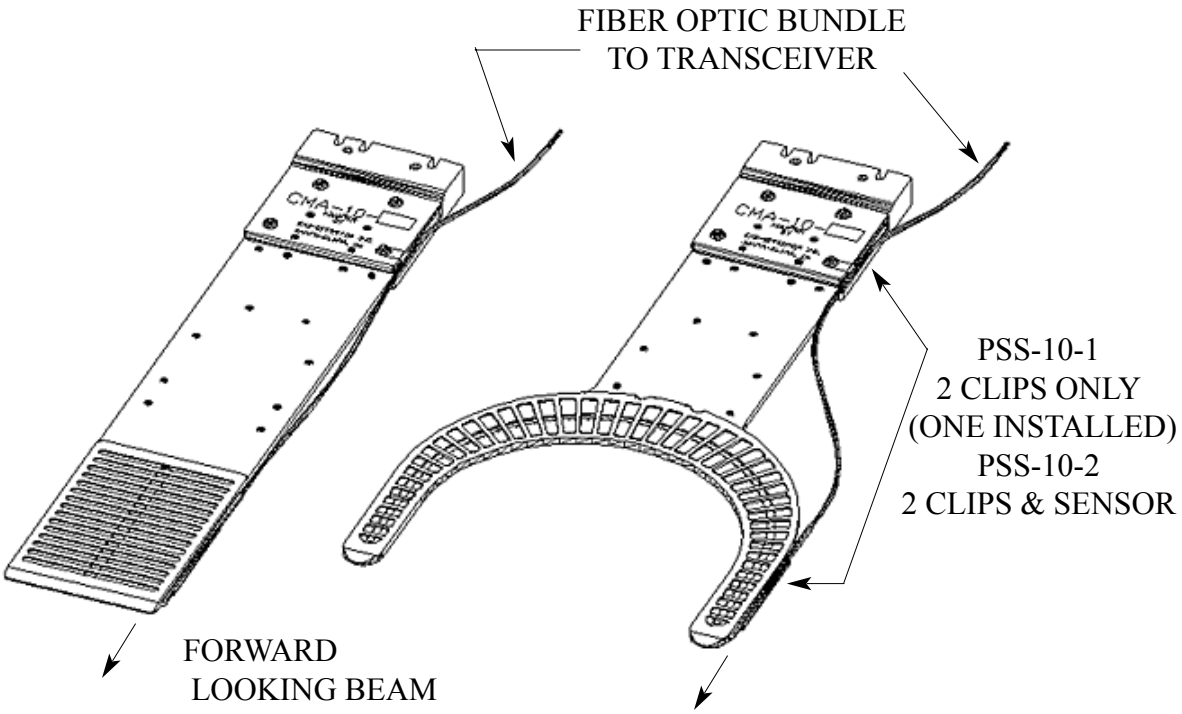


EMBEDDED SWITCH
WAFER PRESENCE
INDICATOR
WPI-10-1

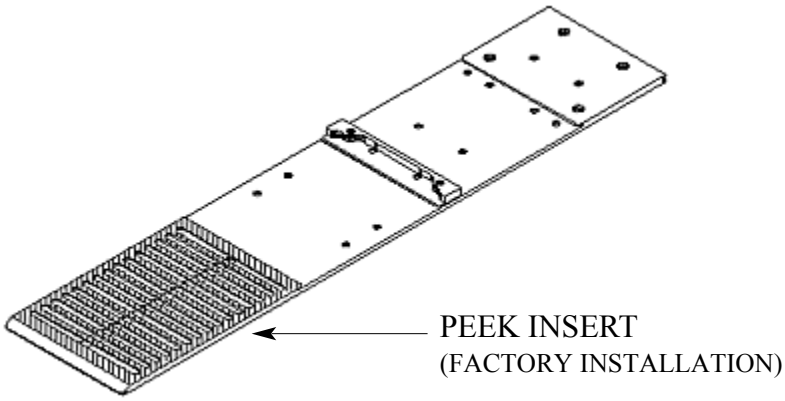


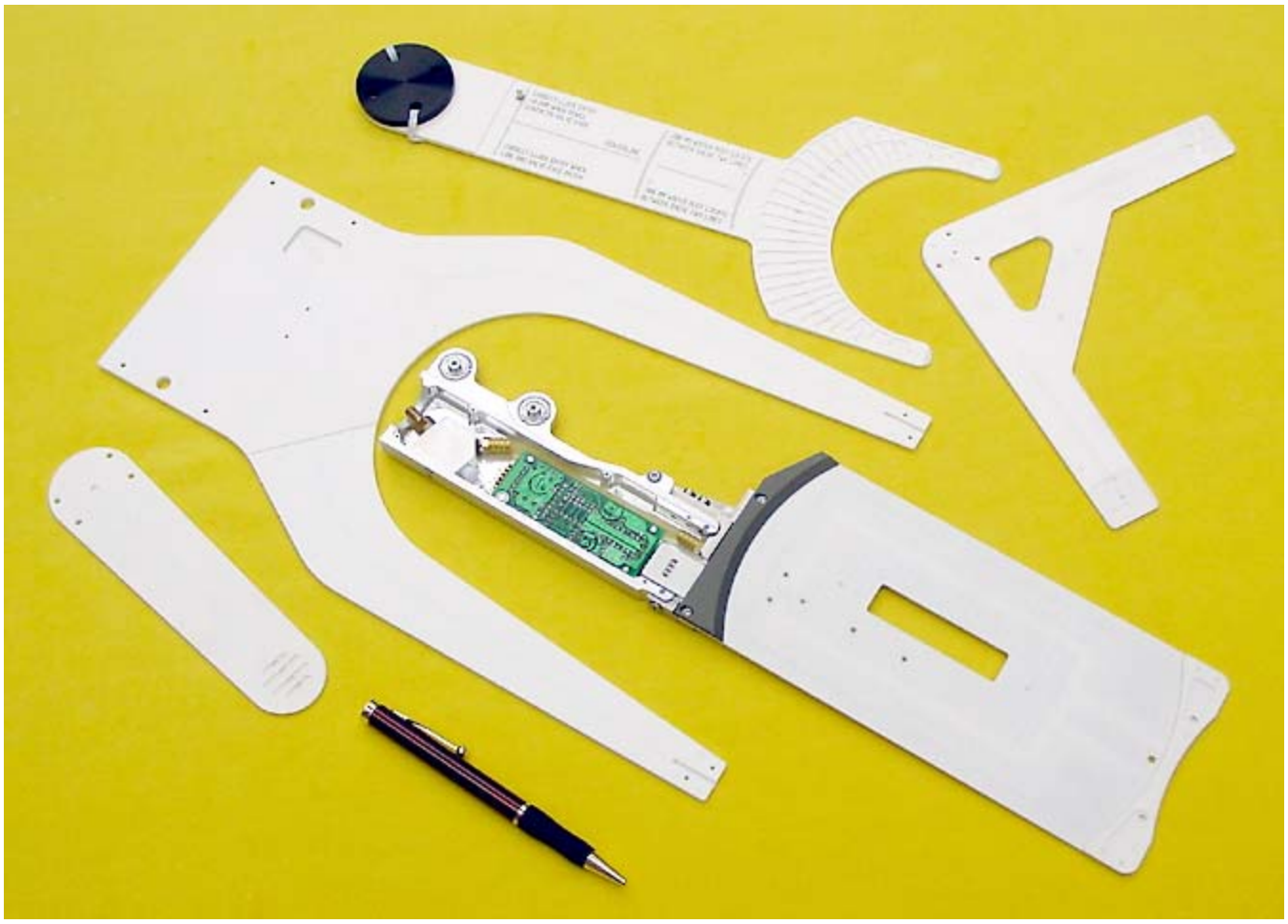
PHOTONIC WAFER
PRESENCE INDICATOR
WPI-10-2 (CLIP ONLY)
WPI-10-3 (CLIP & SENSOR)

PHOTONIC SENSING SYSTEM — PSS-10 SERIES: The PSS options permit the user to read wafer locations without contacting the substrate. The user can then count, locate vacancies in a wafer stack or holder and define precise location of the intended target. Target information need not be a wafer or data disk; the sensor can be used as a safety device to prevent collisions or to profile an object. All end-effectors can be fitted with a forward looking photonic sensing system regardless of shape or size selected. The user must write software routines to utilize this option.



SUBSTRATE CONTACT MATERIAL – Contact material options are part of the customized modification of the SC Series of end-effectors. EEI offers its products in ceramic as standard but can replace the ceramic contacting surface with peek or other materials. See “Creating A Part Number” instructions for details.





END-EFFECTORS

CC SERIES

CUSTOM CERAMIC DESIGNS

FEATURES

- Reduction of back-side scratches to near zero levels
- Elimination of defusible contamination (no metal contaminants)
- Highest rigidity material for similar cross-sections
- Virtual elimination of thermal shock to the substrate handled
- Ability to operate continuously at elevated temperatures without warpage
- No tape or epoxy and no out-gassing
- Infinite life without vacuum leakage
- Elimination of ESD damage
- Proprietary fabrication process

End-Effectors, paddles, spatulas, vacuum fingers... whatever your technology calls them, we build them. Robotic end-effectors of almost any intricate design can be produced in ceramic with or without vacuum clamping. They are normally constructed to operate to 500^{O}C and can be designed for higher temperatures. These end-effectors can be fitted with mechanical clamping devices for fail-safe operation. In addition, ceramic end-effectors can be supplied with ESD dissipation which will protect sensitive products during handling. Our end-effectors can be configured for vacuum sensing, optical sensing or electrical circuitry for capacitive sensing as well as electrical switch sensing. All EEI end-effectors are designed for "3G" or greater clamping loads to permit fast robot operation without wafer dislodgement.

EEI END-EFFECTORS, INC.
1230 Coleman Avenue, Santa Clara, California 95050-4338
408/727-0100 FAX 408/727-2100 www.fjaind.com

"Giving Robotics A Hand"

The CC series of ceramic end-effectors are all custom-designed to customer specifications. They are configured to the customer's requirements and designed using End-Effectors Inc. design rules. All products so designed will meet or exceed the EEI 3G clamping requirement and all designs are customer approved and proprietary. A custom design will only be sold to the contracting customer unless direction is given, in writing, authorizing sale to a designated party. All products designed by EEI remain the property of EEI and the contracting company. These designs cannot be replicated or produced in part or in whole without the expressed written consent of the contracting customer.

SIZE & AVAILABILITY

Size (std.)

Length up to 16 inches (400 mm)
Width up to 5 inches (125 mm)
Thickness up to .160 inches (4 mm)
(Special Larger sizes quoted)

Substrate Holding Methods

Gravity pocketed
Vacuum clamped: A - Single sided
B - Double sided
Mechanically clamped: A - Vacuum driven
B - Pressure driven
C - Electrically driven

End-Effector Mounting

Through Hole
Stainless Steel Bracket: A - Unthreaded
B - Threaded
Threaded Ceramic Insert

Sensing Methods

Vacuum sense (Remote, not end-effector mounted)
Optical sense (Fiber optic bundle)
Electrical sense
- Conductive - substrate must be conductive
- Capacitive - substrate must effect magnetic field
- Micro switch - contact to substrate

Electrical Properties

Non-conductive (standard ceramic)
ESD dissipating Contacts (stainless steel touches substrate)

Fail-Safe Options

Vacuum driven
Pressure Driven
Electrically Driven

Temperature Options

Ambient
Heated End-effecor
Cooled End-effector